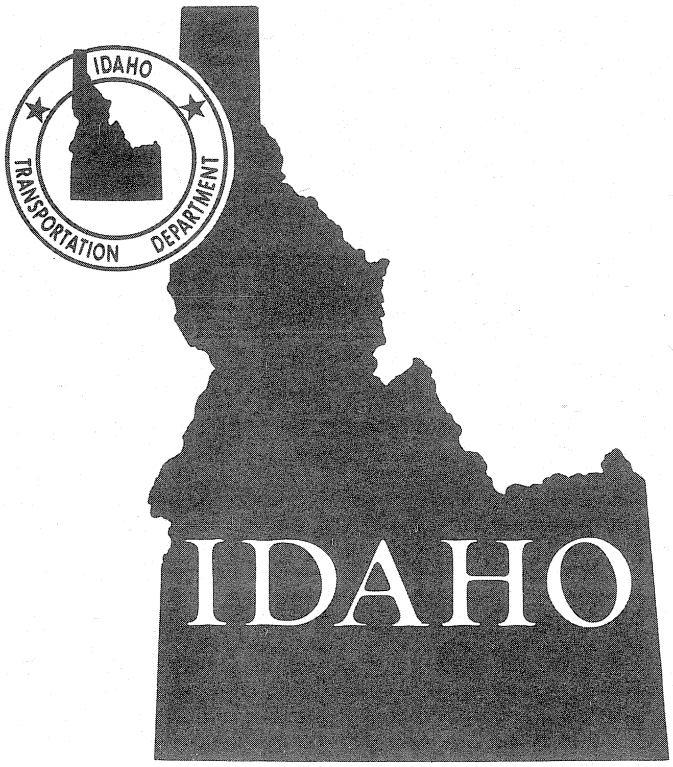
TRANSPORTATION DEPARTMENT
DIVISION OF HIGHWAYS



MATERIALS and RESEARCH SECTION

Idaho Division of Highways
Boise, Idaho

SUPPORTING DATA FOR VALUE ENGINEERING STUDY OF SHOULDER MAINTENANCE

Research Project 83

Study Team Members:

James W. Hill, Team Leader
Research Supervisor

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District Maintenance Engineer

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February 1977

This project was undertaken in cooperation with the U.S. Department of Transportation, Federal Highway Administration and the State Highway Agencies of Arizona, Iowa and West Virginia. This report consists of supporting data for Idaho's portion of the study. Findings of the Idaho study are being published separately under the title Value Engineering Study of Shoulder Maintenance. A final report summarizing the work of all four State study teams will be published by the Federal Highway Administration.

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Based on Construction and Maintenance Costs E-1

References

Idaho Division of Highways Maintenance Outline

Mileage

The following table lists Idaho's road mileage as of January, 1975:

Table 1

Administrative Agency	Centerline Miles
County	14,000
Independent Highway District	11,230
National Forest	17,475
U. S. Bureau of Land Management	5,000
Indian Reservation	600
Other Rural	300
City Streets	2,930
Idaho Division of Highways	4,950

The mileage maintained by the Division of Highways is classified into the following systems:

Table 2

Classification	Centerline Miles
Interstate	615
Federal Aid Primary	2,513
Federal Aid Secondary	1,808
Other	13

Only about 100 miles of IDH-maintained roads are unpaved.

Personnel

About 1,600 people are employed by the Division. Roughly 400 of these are assigned to the headquarters in Boise and about 200 work in each of the six districts within the Division. About 700 IDH employees are assigned to maintenance. These permanent maintenance forces are supplemented by temporary help as needed, either by temporary transfer of non-maintenance employees, by short-term hiring, or both.

Budget

Maintenance expenditures for 1974 were:

Table 3

Purpose Code	Description	Total	% of Total
1000	Unusual or Disaster Maintenance	$ 48,518.71	0.39
1005	Roadway Patrol Inspection	394,781.60	3.21
1010	Travelway Repair - Routine	871,958.62	7.09
1020	Travelway Repair - Extraordinary	1,907,666.41	15.51
1021	Tear Up & Relay	58,003.50	0.47
1022	Half Sole	102,459.75	0.83
1023	Seal Coat	1,602,520.10	13.03
1030	Shoulders & Side Approaches	253,286.54	2.06
1032	Mowing - Road & Rest Areas	133,552.70	1.09
1033	Trash Collection	277,459.45	2.26
1034	Weed Control - State Forces	64,104.54	0.52
1035	Weed Control - Contract	39,604.18	0.32
1040	Roadside Drainage - Routine	360,372.01	2.93
1045	Roadside Drainage - Extraordinary	344,328.45	2.80
1046	Landscape Maintenance	13,157.74	0.11
1050	Traffic Services	313,894.42	2.55
1051	Paint Striping	576,698.25	4.69
1052	Sign Shop Operating Costs	463,270.18	3.77
1054	Traffic Signals & Lighting	116,062.44	0.94
1055	Roadside Rest Areas	156,866.01	1.28
1060	Snow & Ice Removal	1,238,047.00	10.07
1065	Sanding Ice	999,524.99	8.13
1080	Collision Damage Repair	96,742.81	0.79
1081	Vandalism Damage Repair	30,556.66	0.25
1090	Unclassified Maintenance Expense	593,575.46	4.83
	Sub-Totals - Roadways	$11,057,012.52	89.90
1094	Building & Yard Operating Cost	292,390.30	2.38
1095	Building & Yard Maintenance & Repair	294,892.64	2.40
4281	Headquarters - Operating Expense	189,916.32	1.54
0470	Ports-of-Entry Maintenance	40,809.40	0.33
	Sub-Total - Buildings & Yards	818,008.66	6.65
151	Bridge Maintenance & Inspection	424,151.34	3.45
	TOTAL - ALL MAINTENANCE	$12,299,172.52	100.00

Maintenance Accounting System

The Division's new maintenance management system became operational July 1, 1976. Obviously, very limited cost data is available under the new system. The accounting procedures used in the past did not require costs to be itemized as completely as desired for a study of this kind.

For example, several shoulder maintenance operations were charged to purpose codes 1030 and/or 1040. This makes it difficult to separate the costs of the various shoulder maintenance activities. Another factor contributing to uncertainty in shoulder maintenance costs is Idaho's policy of constructing full-width pavement. Some pavement maintenance charges for shoulder and travel lane are not separated, making it difficult to obtain accurate costs for paved shoulder maintenance.

Selection of Maintenance Activities for Study

IDH Shoulder Design Policy

Division policy is to pave full width. This policy has been in effect for a number of years, and most of the State-maintained roads are paved full width. On new construction shoulders are paved to the same depth as the travel lanes. On some older sections, however, shoulder pavement has been built up by using BST and successive chip seal coats, resulting in thinner pavement on shoulders than travel lanes.

Itemizing Shoulder Maintenance Costs

Maintenance activity is needed both on the paved shoulder and on the unpaved foreslope adjacent to the pavement. Maintenance of paved shoulders is no different than other pavement maintenance. Some paved shoulder maintenance costs are included in the charges listed under items 1010, 1020, 1021, 1022, 1023, and possibly 1030. The exact amounts chargeable to the paved shoulder area would be impossible to determine. For estimating purposes in this report, a range of 15% to 20% of the charges for items 1010, 1020, 1021, 1022, and 1023 has been assigned to paved shoulder maintenance. Items 1030 and 1040 have been assumed to apply only to unpaved portions of the roadway cross-section.

In view of the incomplete cost breakdown provided by the accounting summary, only an estimate of the relative importance of the various shoulder maintenance activities was possible. To develop the estimate, maintenance foreman in two of the six IDH districts were asked to estimate the relative shoulder maintenance cost applicable to various activities. The combined results are presented in the following table:

Table 4

Activity	Percent of Overall Shoulder Maintenance
Sod Cutting	3-5
Hand Patching	15-25
Crack Filling	1-5
Ditching	20-30
Seal Coat (1)	2-15
Shoulder Pulling	30-40

Notes: (1) Includes only seal applied to shoulder alone. Does not include shoulder portion of full width seal.

Selection Procedure

Shoulder maintenance was preselected from among the various maintenance operations before IDH became involved in this project. Discussion of the reasons for its selection is beyond the scope of this report. As a point of possible interest, however, one technique for selecting candidates for value engineering study has been applied to the 1974 IDH maintenance costs. This procedure consists of seeking high cost items, on the basis that the greatest money savings can be realized by improving the high cost activities. Using data from the 1974 maintenance expenditures list, the following table has been prepared to show the estimated relative cost of shoulder maintenance.

Table 5

	Unpaved Shoulder Maintenance (1)	Sum of Paved and Unpaved Shoulder Maintenance (2)
Percent of Total Maint. Expense (3)	5	10 to 12
Percent of Roadway Maint. Expense (4)	11	23 to 27

Notes:
(1) Unpaved shoulder maintenance taken as purpose codes 1030 and 1040.
(2) Lower bound taken as purpose codes 1030 and 1040 plus 15% of purpose codes 1010, 1020, 1021, 1022, and 1023. Upper bound taken as purpose codes 1030 and 1040 plus 20% of purpose codes 1010, 1020, 1021, 1022, and 1023.
(3) Total maintenance expense is total for all types of highway maintenance.
(4) Roadway maintenance expense taken as items 1000, 1005, 1010, 1020, 1021, 1022, 1023, 1030, and 1040.

It is seen that shoulder maintenance is not a particularly large fraction of the IDH maintenance program. When only roadway maintenance is considered, however, shoulder maintenance becomes a larger percentage.

A second observation from the preceding table is that maintenance of paved shoulders is a relatively high percentage of the overall IDH shoulder maintenance effort. This high cost would seemingly make paved shoulder maintenance a candidate for value analysis. Maintenance of paved shoulders is, however, the same as pavement maintenance and a separate FHWA-sponsored study of pavement patching is in progress. Therefore paved shoulder maintenance has been omitted from further consideration here to avoid duplication.

The next step in the selection procedure involves Table 4. When the activities involving paved shoulders are removed, shoulder pulling and ditch cleaning are seen to account for the bulk of the remaining shoulder maintenance work. The portion of ditch cleaning chargeable to shoulder maintenance is very similar to a shoulder pulling operation, and many points of analysis would apply to both activities. Therefore ditching will not be considered separately.

In summary, the activities chosen for study are shoulder pulling with no material added and shoulder pulling with material added. Because of Idaho's paved shoulder policy these activities are usually performed on the foreslope rather than the actual shoulder.

An additional shoulder maintenance item discussed at the coordination meeting for this project is maintenance of the longitudinal joint between PCC travel land and AC shoulder. Slight joint separation or differential settlement has sometimes occurred with this pavement-shoulder combination in Idaho, but no significant maintenance problem has developed. This type of construction is not common in the State. A recent construction project featured PCC pavement both for travel lane and shoulder in an effort to eliminate any potential difficulty with the travel lane-shoulder joint.

Data on Three Maintenance Areas

The three maintenance areas chosen as examples of IDH maintenance facilities and highway sections are headquartered at Blackfoot and Dubois in the southeastern part of the state and Coeur d'Alene in the north.

Personnel

Classification	Salary Range	Number of Employees		
		Blackfoot	Dubois	Coeur d'Alene (North & West)
Foreman	$981-1335/mo	1	1	1
Leadworker	$813-1103/mo	1	0	1
Operator	$745-1004/mo	6	8	7

Terrain

The Blackfoot area is relatively flat with a few rolling hills. Elevation is about 4500 feet. Part of the area is covered by Snake River alluvium and part by wind-deposited material, underlain by basalt in both cases. The climate is semi-arid, with cold winters.

Terrain near Dubois ranges from flat to mountainous. Highway elevation varies from 4800 to 6900 feet. The highways cross alluvium and occasional lava outcrops. The climate is semi-arid with very cold winters.

The area North and West of Coeur d'Alene is a glacial plain bordered by low mountains. Elevation of the plain is about 2200 feet. Most roads are built on glacial deposits. Highway 95 Southwest of Coeur d'Alene passes through weathered basalt hills. Toward the South end of the maintenance section some wind-blown deposits occur. Climate is moderately wet with cold winters.

Highway Mileage

Highway Classification	Lane-Miles		
	Blackfoot	Dubois	Coeur d'Alene (North & West)
Interstate	128	126	48
Primary	126	76	39
Secondary	50	154	138

Shoulder Maintenance Equipment and Rental Rates*

Item	Rental Rate, Dollars per Hour except as noted	Number per Maintenance Area Blackfoot	Dubois	Coeur d'Alene (North & West)
1/2 T. Pickup	.08/mi.	1	1	1
Med. Dump Truck 2 axle	3.50	7	7	7
Heavy Dump Truck 3 axle	6.50	3	2	0
Wheel Tractor incl. broom, backhoe, mower	7.50	1	2	0
F. E. Loader 1/2 yd incl mower	6.80	0	0	4
F. E. Loader 1 1/2 yd	8.00	1	1	0
Med. Grader	8.00	1	1	2
Asphalt Kettle	5.00	0	2	1
Truck Mounted Asphalt Distrib.	9.00	0	1	0
Tilt Bed Trailer	7.00	0	1	0

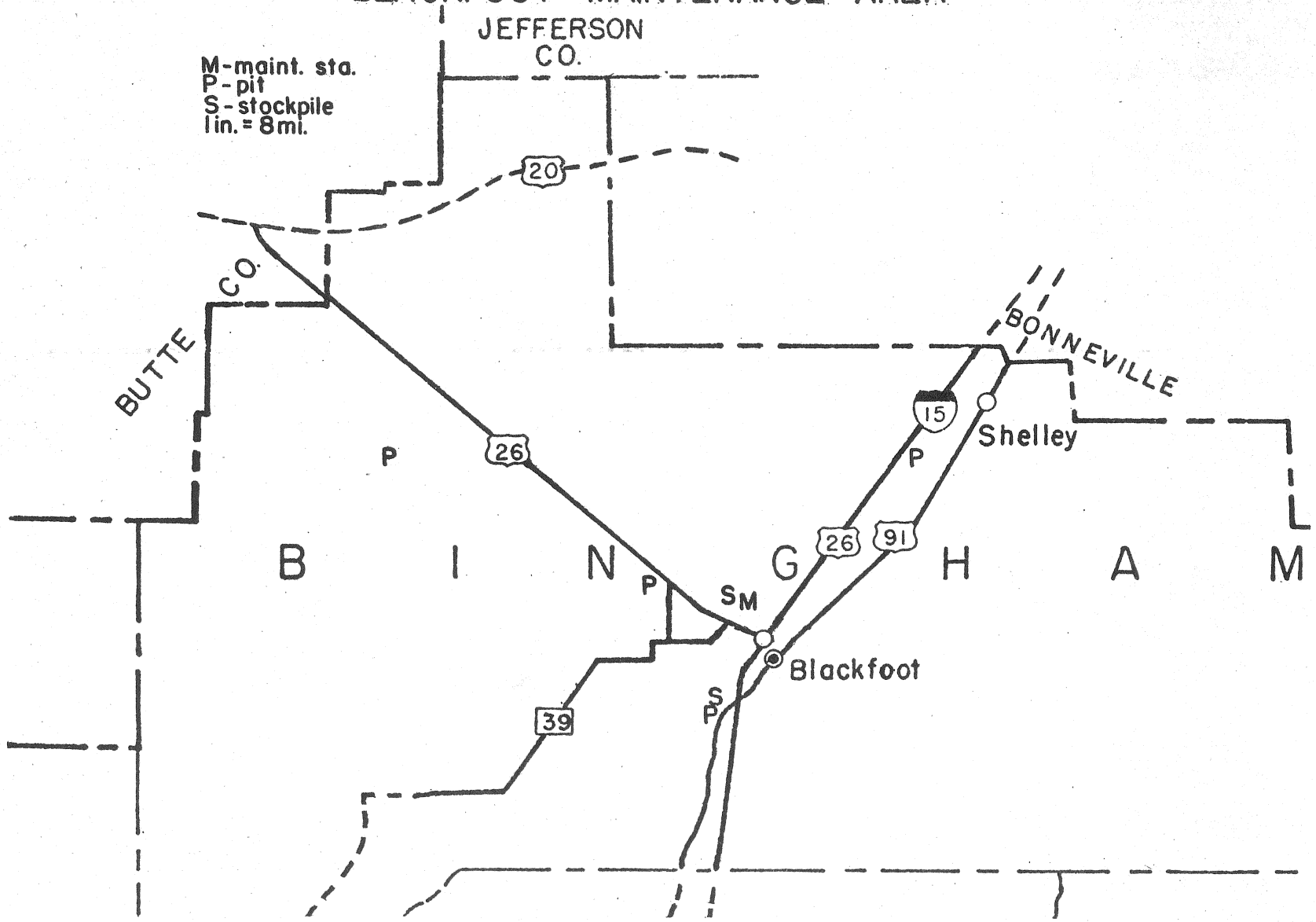
* Rates from Maintenance Management System Unit Cost List dated 5-5-76

Other equipment is available from each district headquarters. Typical items include pneumatic or steel wheel rollers at $7.00/hr., self propelled chip spreader at $12.00/hr., truck or trailer mounted water tanks at $6.00/hr., truck mounted asphalt distributors at $9.00/hr., (1250 gal.) or $9.10/hr. (2500 gal.), and compressors at $4.00/hr.

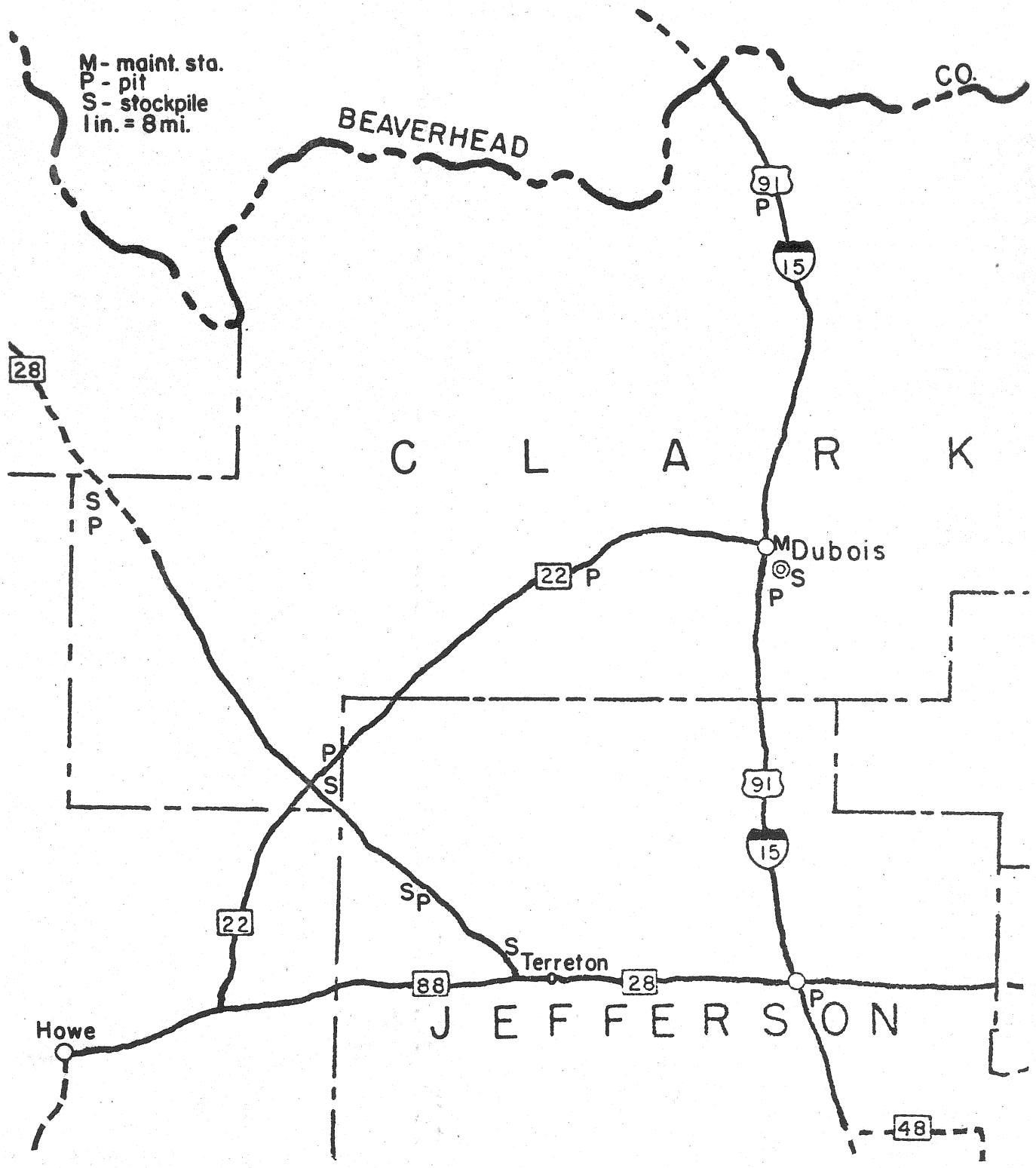
Maintenance Area Maps

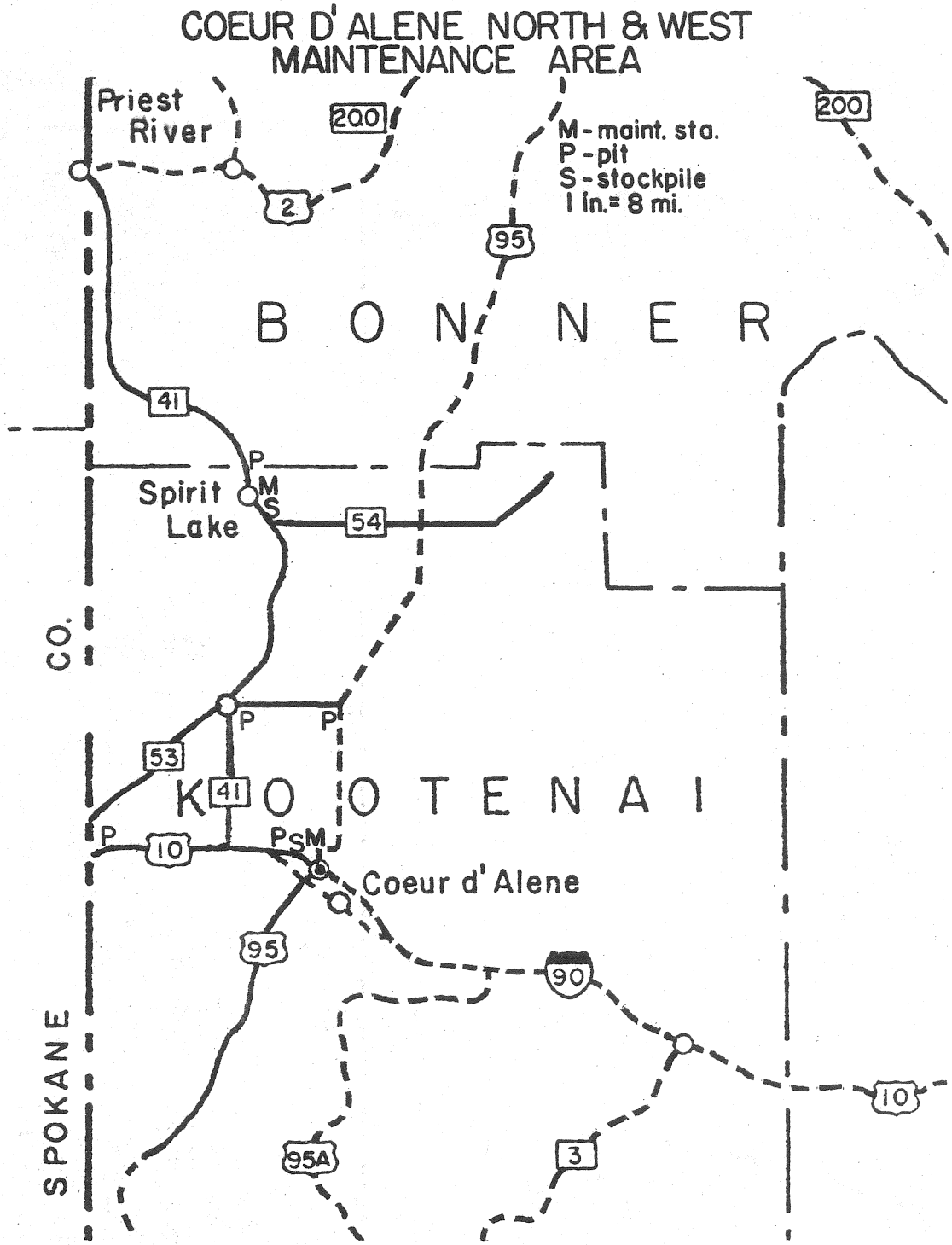
The three example maintenance areas are all drawn to the same scale on the following maps. Roads shown as dashed lines are in other maintenance areas.

BLACKFOOT MAINTENANCE AREA



DUBOIS MAINTENANCE AREA




COEUR D'ALENE NORTH & WEST
MAINTENANCE AREA
Priest River
200
2
M - maint. sta.
P - pit
S - stockpile
1 in.= 8 mi.
95
200
BONNER
41
P
Spirit Lake
M
S
54
CO.
P
P
53
41
KOOTENAI
P
10
PSM
Coeur d'Alene
95
90
SPOKANE
10
95A
3

Description of Physical Facilities

The Blackfoot maintenance station is located on 10.5 acres just West of the city. Six vehicle bays and 1140 square feet of office space are contained in the headquarters building, which was built in 1974.

At Dubois the headquarters building is located in a 10 acre yard and was built in 1964. The building contains three vehicle bays and 1140 square feet of office space.

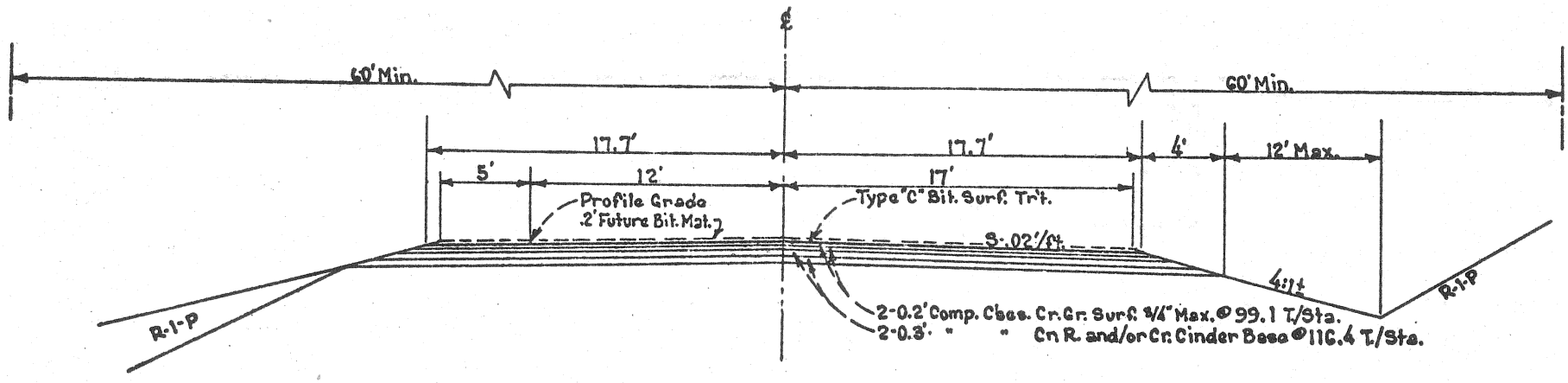
The Coeur d'Alene North & West foreman shares office and storage space with district headquarters in Coeur d'Alene. Some additional storage for asphalt and salvaged items is provided at the pit just North of Coeur d'Alene. A wood frame 3 bay maintenance shed built in 1935 is located at Spirit Lake on 8 acres.

Pavement Cross-Sections

Representative pavement cross-sections are illustrated on the following pages, together with construction dates.

Blackfoot

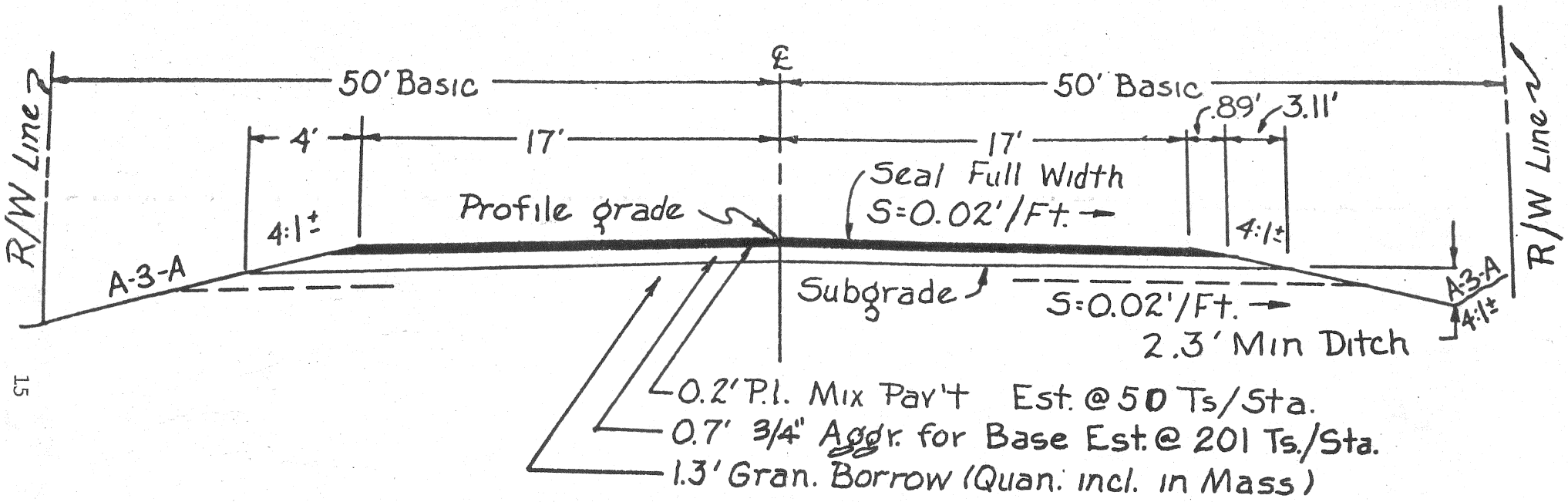
US-26



Constructed 1952

Blackfoot

SH-39

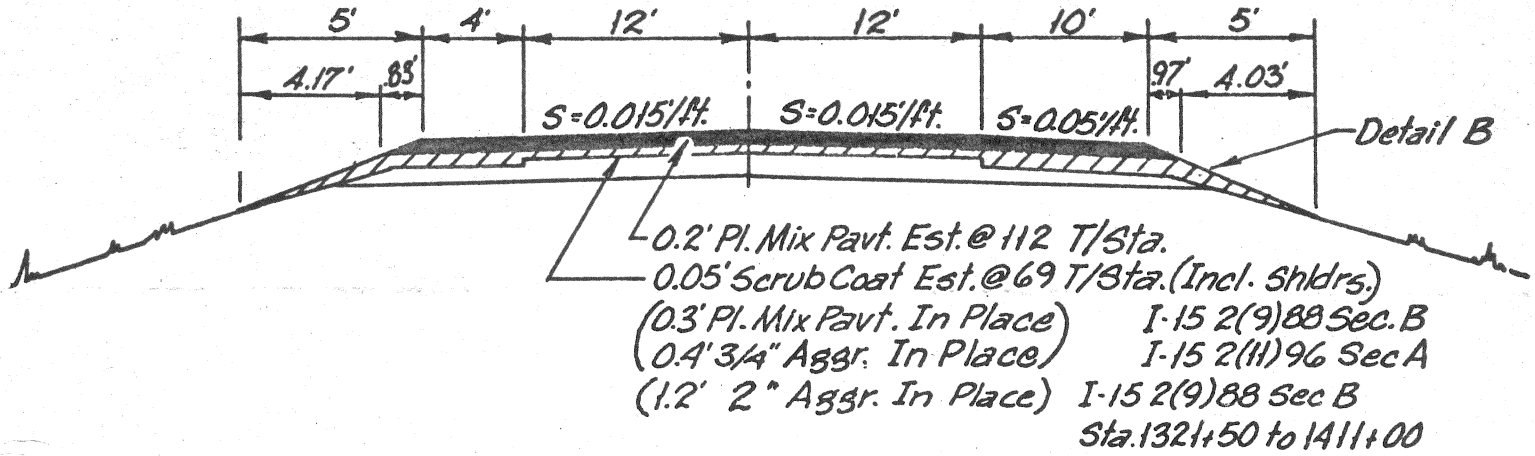


Constructed Late 1960's

4 Projects

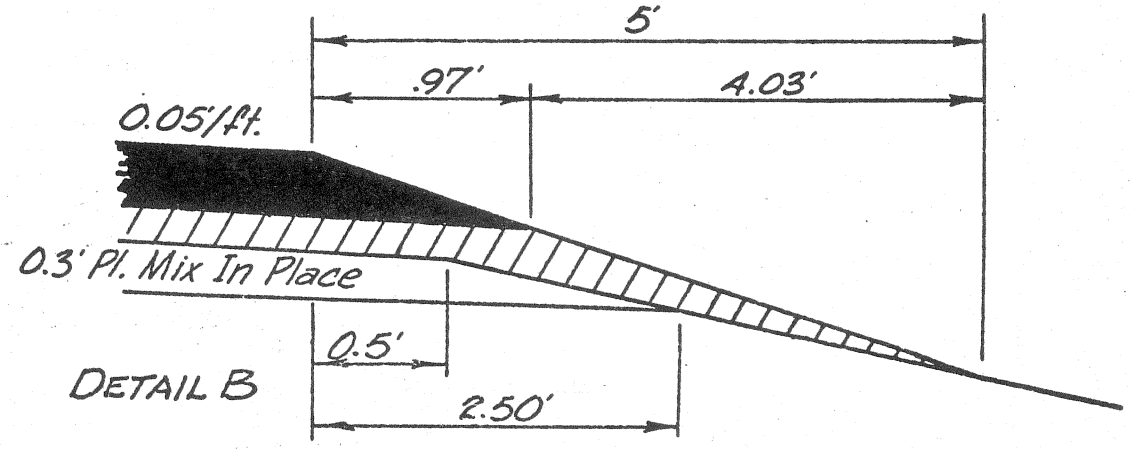
Blackfoot

I-15



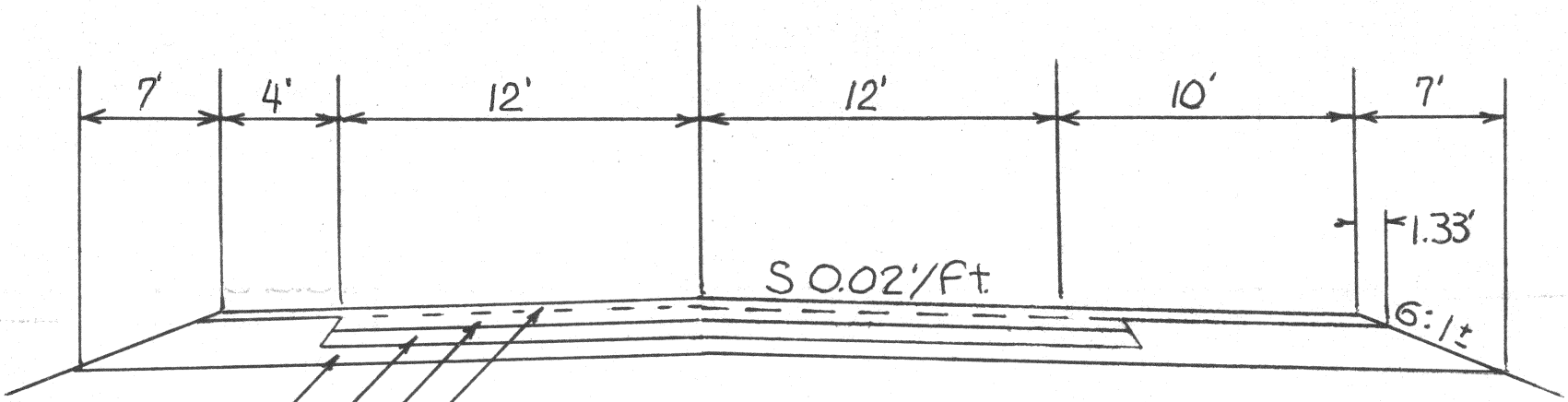
Constructed 1962

0.25' Overlay 1968



Dubois

INTERSTATE I-15



0.20 ft. Plant Mix Pavement

0.20 ft. Plant Mix Pavement

0.40 ft. 3/4" Plant Mix Base

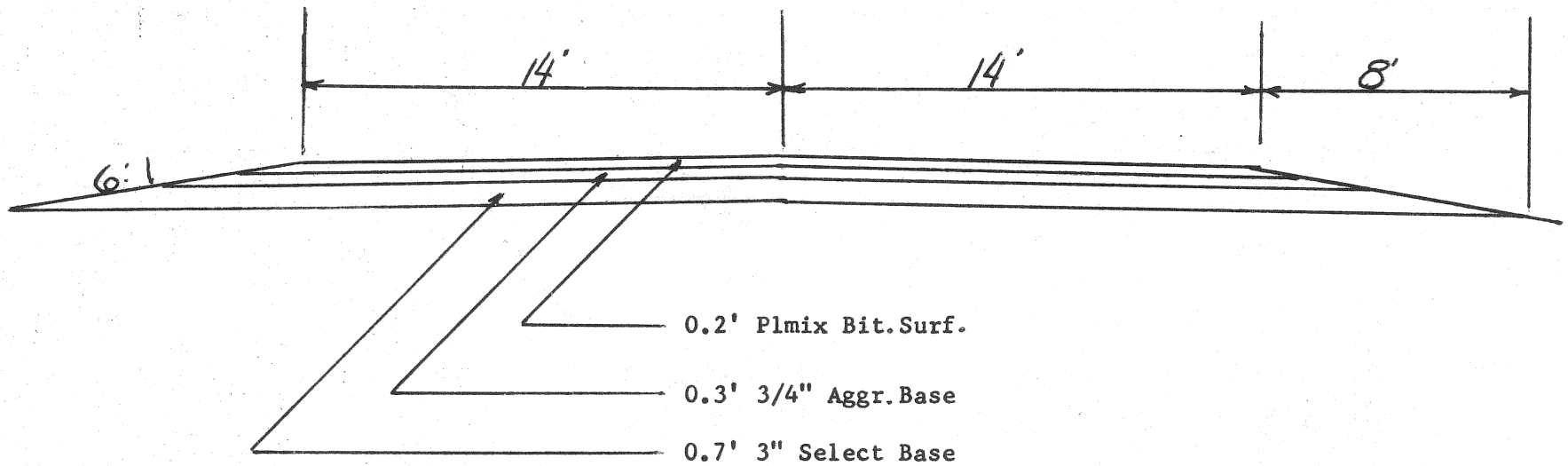
0.30 ft. 3/4" Aggr. for Base

Construction: between 1958-1969

Dubois

TYPICAL SECTION

STATE HIGHWAY 88

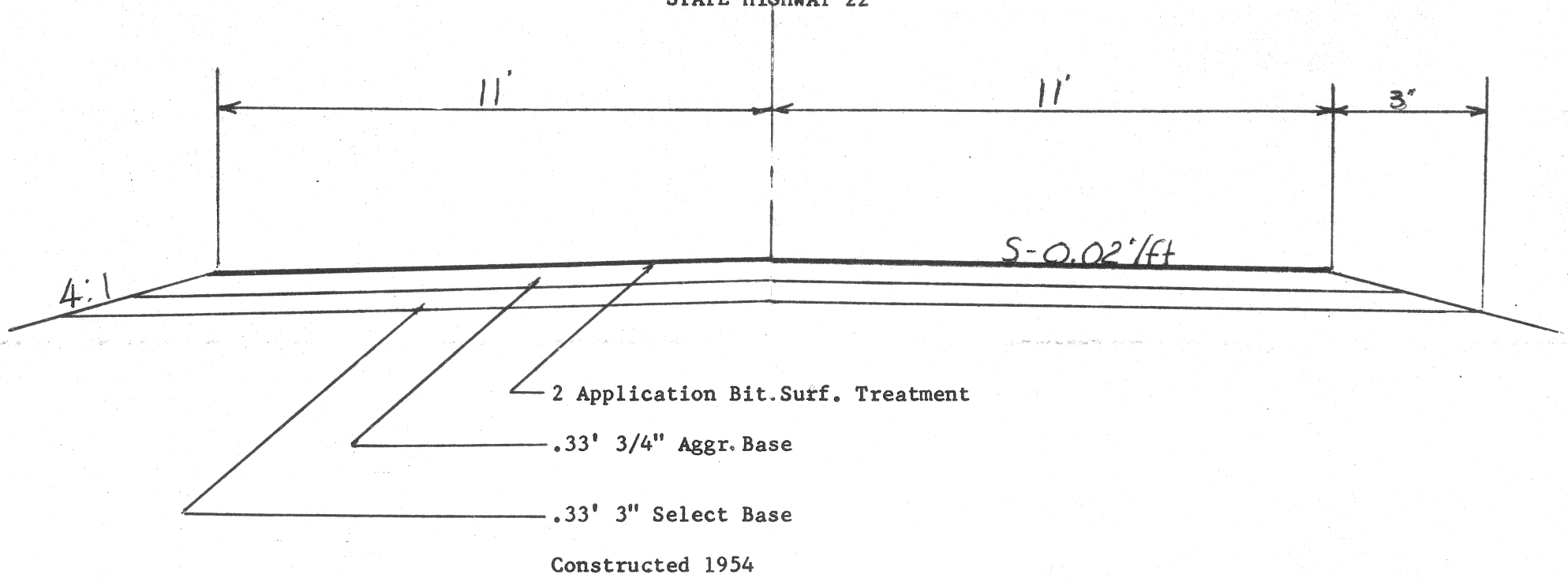


Constructed 1959

Dubois

TYPICAL SECTION

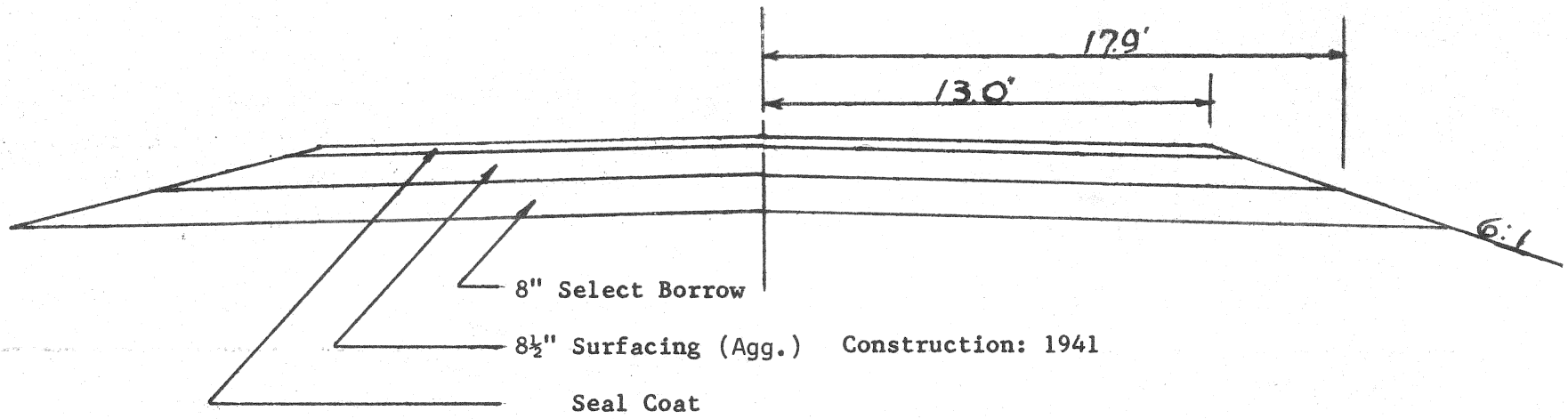
STATE HIGHWAY 22

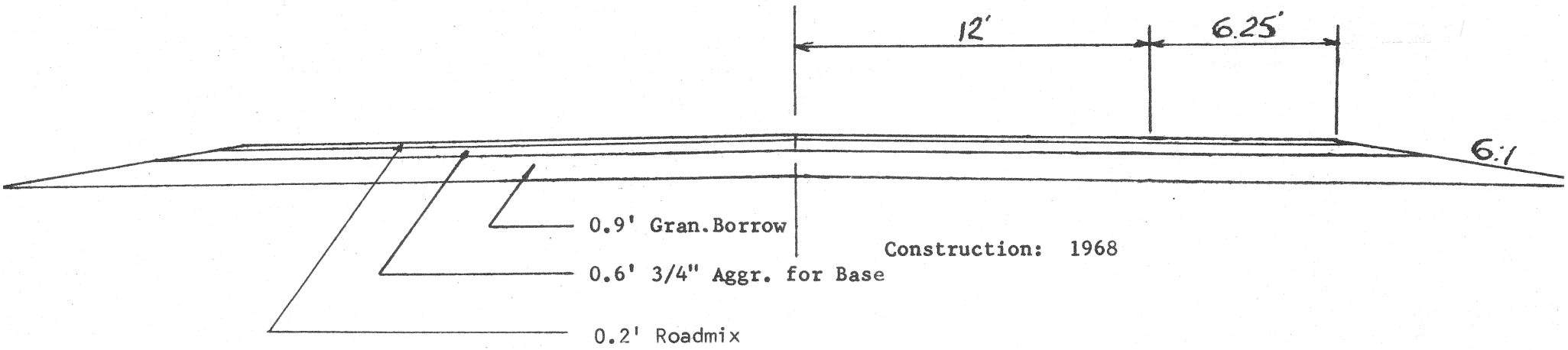


Constructed 1954

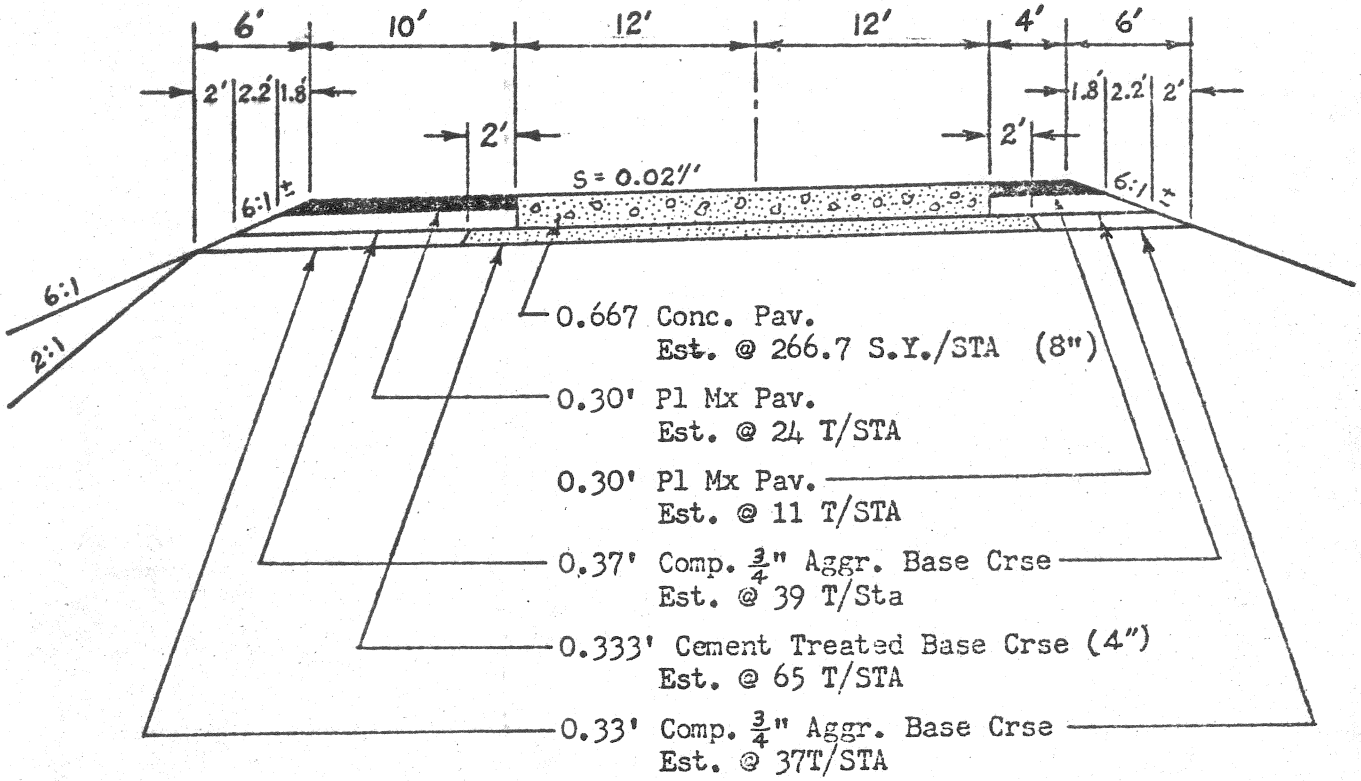
Dubois

STATE HIGHWAY 28
TYPICAL CROSS SECTIONS





COEUR D'ALENE



I - 90

COEUR D'ALENE - POST FALLS

TYPICAL SECTION	2 @ 38' divided (var.) (4-12-12-10)
PROJECT NO.	I-IG-90-1(70)5 Paving I-IG-90-1(48)5 PE, GR., STR.
MILE POST LIMITS	5.48 - 11.0
DATE COMPLETED	Aug. 1972

Man-Hours per Unit Accomplished

The three example maintenance areas have been described only to illustrate the general IDH maintenance operation at the local level. For several reasons, these areas were not used to derive man-hours per accomplishment unit. First, no long-term data is available because accomplishment units were not reported before adopting the new maintenance management system. Second, the new system has been in operation for such a short time that almost no data is available from the accounting section. Finally, shoulder maintenance is not a regularly scheduled, frequent operation in most IDH maintenance areas. For this reason the short study time available within the contract period was not believed sufficient to obtain representative data directly from the maintenance areas.

As an alternative to collecting field data, the IDH maintenance procedures book has been used as an information source. This book lists a standard accomplishment rate for each maintenance activity. To develop these rates, maintenance foremen and supervisors statewide estimated man-hours per accomplishment unit based on their experience. Only one IDH maintenance activity is directly applicable to this study. This activity, known as reshaping foreslope (shoulder) and backslope, is defined on the next page. Note that the activity description covers the case where material is added as well as the case where no material is added. In addition, the same accomplishment rate has been estimated for both cases. As records are accumulated and analyzed under the new maintenance management system, the accomplishment rate will be revised if the estimate is found to be significantly different from actual accomplishment.

ITD-DH

MOP

RESHAPING FORESLOPE (SHOULDER) & BACKSLOPE

Work Quantity - Unlimited

CODE 5-252

DESCRIPTION AND PURPOSE:

CLEANING AND RESHAPING OF ROADSIDE WITH MOTOR GRADER INCLUDING REMOVING, RESTORING GRADE LINE, AND RESHAPING FRONT AND BACK SLOPES, IF NECESSARY. REPLACING MATERIAL IF REQUIRED.

SCHEDULING:

SCHEDULE WORK IN THE SPRING AND FALL ON SLOPES WHERE EXCESSIVE EROSION HAS TAKEN PLACE.

CREW/EQUIPMENT	WORK ACCOMPLISHMENT
RECOMMENDED CREW SIZE: OPERATOR - 1 FLAGMEN AS REQUIRED EQUIPMENT: NO. DESCRIPTION 1 PICKUP 1 MOTOR PATROL	WORK UNIT: ROAD MILE DAILY PRODUCTION: 3 ROAD MILES AVERAGE PRODUCTIVITY: 2.7 MAN HR./MILE **MATERIAL** ANY AVAILABLE MATERIAL THAT IS SUITABLE.

RECOMMENDED PROCEDURE:

1. PLACE SIGNS AND OTHER SAFETY CONTROL DEVICES.
2. DRESS FORESLOPE AND BACKSLOPE BY PULLING MATERIAL UP FROM THE FORESLOPE AND BACKSLOPE.

ACTIVITY REPORTING

1. THIS ACTIVITY SHALL BE REPORTED AS A FROM-TO LOCATION DESIGNATED BY MILEPOST.
2. ALL LABOR, EQUIPMENT AND MATERIALS MUST BE REPORTED.
3. THE REPORTED WORK UNITS SHALL BE ROAD MILES. IF A ONE-MILE SECTION OF ROAD WAS BLADED ON BOTH SIDES, THE WORK ACCOMPLISHMENT WOULD BE ONE ROAD MILE. IF ONLY ONE SIDE WAS GRADED AND SHAPED, THE ACCOMPLISHMENT WOULD BE 0.5 MILE.

Note: Modified 9-8-76 to provide for crew size up to 4 men and for 2 dump trucks when material is replaced.

VALUE ENGINEERING FOR HIGHWAYS

FEDERAL HIGHWAY ADMINISTRATION

STUDY WORKBOOK

Value Engineering Analysis of Selected Maintenance Activities

Reshaping Foreslope (Shoulder), Idaho

name of study

Transportation Dept., Div. of Hwys. Maint. Oper. Procedure 5-252

1st Case: No Material Added

STUDY ID	STUDY NO.	STUDY DATE
	DOT-FH-11-8596	1976

STUDY TITLE: Value Engineering Analysis of Selected Maintenance Activities – Reshaping Foreslope (Shoulder): No Mat'l. Added

TEAM MEMBERS

NAME	TITLE	ORGANIZATION	TELEPHONE
Team Leader James W. Hill	Research Supervisor	Idaho Trans. Dep't.	208-384-3600
E.M. Harding	District Engineer	ITD Div. of Highways	208-664-8181
D.R. Greene	Dist. Maint. Engr.	ITD Div. of Highways	208-232-4270
Clyde Gillespie	Dist. Maint. Engr.	ITD Div. of Highways	208-745-7781
A.F. Stanley	Assoc. Mat'ls. Engr. I	Idaho Trans. Dep't.	208-384-3600

DESCRIBE THE PROBLEM TO BE STUDIED (Reason for selection, requirements & limitations)

Topic selected as result of highway maintenance research needs study made by Transportation Research Board (Report No. FHWA-RD-75-511).

The requirement is indepth study of shoulder maintenance operation by highly qualified engineers in a minimum of three state districts.

This study is limited to the case where no material is added to the foreslope.

DESCRIBE PROBLEM TO BE STUDIED (Existing, procedure, system, design)

The study problem is reshaping the foreslope to eliminate edge rut & restore foreslope surface & grade, thus improving traffic safety and drainage. Existing procedure is first to move material up foreslope with motor grader to fill rut, spreading the excess on pavement. Next, the grader removes the excess from the pavement. Then the fresh material is compacted with the grader wheels, truck tires, or standard compaction rollers. Finally any loose material remaining on the pavement is removed if it is judged to be a traffic hazard. Traffic control is included in the operation as defined in the ITD Div. of Hwys. maintenance procedures manual.

WHO: has approval authority for changes, maintains or operates the item, can be contacted for further information

NAME	POSITION/ORGANIZATION	TELEPHONE
E.D. Tisdale	State Highway Administrator/Idaho Trans. Dept.	208-384-3769
Roy Jump	Maintenance Supervisor/ITD Div. of Hwys.	208-384-3690

STUDY ID Reshape Foreslope: No Mat'l. Added	INVESTIGATION PHASE CONSULTATION RECORD

CONTACT (name, title, organization)	TELEPHONE (incl area code)	NOTES
Steve Hutchison, EIT,	208-384-3690	provided background information on
ITD Div. of Hwys.		newly implemented maint. management system
A.C. Bybee, Maint. Foreman,	208-852-1712	demonstrated existing maint. procedures
ITD Div. of Hwys.		
all members of shoulder	see	brainstorming, comparative
maint. VE study teams	presentations	data from other states
from Arizona, Iowa, W.	of other	
Va. participating in	states	
this study.		
William Froscher	208-384-3690	equipment information
Road Equip't. Superintendent		
ITD Div. of Hwys.		
Stanley Carper, Special	208-384-3663	VE consultant
Assignments Engr., Idaho		
Trans. Dep't.		

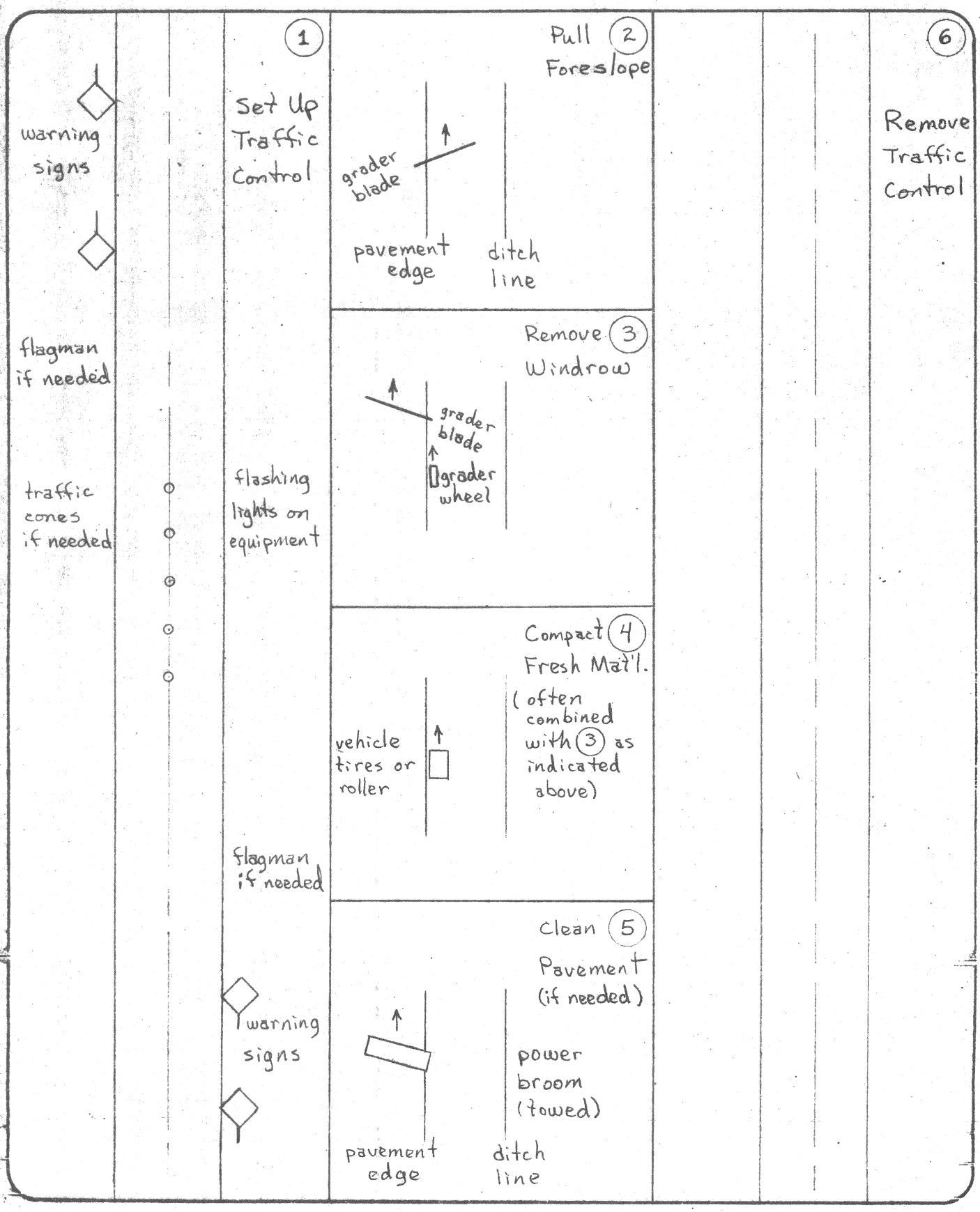
DOCUMENT ABSTRACT: List all books, specifications and drawings used when it is impractical to bind them into the workbook.

REFERENCES (title, author, data & location)	NOTES
1974 Maint. Report, ITD Div. of Hwys.	source of some Idaho maintenance statistics
Maint. Operation Procedures Book; ITD Div. of Hwys.	reference for standard maint. procedures
Maintenance Manual, ITD Div. of Hwys.	definitions, maintenance procedures
Value Engr. for Hwys., FHWA VE text	VE procedures
ITD Div. of Hwys. Maint. Management System Unit Cost List dated 5-5-76	equipment rental rates
Value Engineering and Analysis, VE text by CVS, Inc., Portland, Oregon	VE procedures

STUDY ID
Reshape Foreslope:
No Mat'l. Added

INVESTIGATION PHASE

SKETCH OF PRESENT DESIGN



STUDY ID	INVESTIGATION PHASE
Reshape Foreslope: No Mat'l. Added	ESTIMATE OF PRESENT DESIGN COST

ITEM	QUANTITY		LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL	
per day (8hr., 3 road mi.)	—	—					
pickup (assume 30 mi. rnd. trip)	30	mi.			0.08	2.40	2.40
med. motor grader	8	hr.			8.00	64.00	64.00
1 operator, 1 flagman (avg.)	16	hr.	7.80	124.80			124.80
total per day							191.20
per shoulder mile (single grader)							31.87
Notes: Accomplishment rate is based on an estimate agreed upon by maintenance foreman statewide. No accounting records are presently available to check the accuracy of the estimate. Assume cleanup left to weather & traffic. Wage rate of $7.80/hr. is 1976 statewide avg. for maint. field personnel, incl. leave, holidays & fringes.							
per day (8 hr., 6 road mi.)							
pickup (assume 30 mi. rnd. trp.)	30	mi.			.08	2.40	2.40
med. motor grader	16	hr.			8.00	128.00	128.00
2 operators, 1 flagman (avg.)	24	hr.	7.80	187.20			187.20
total per day							317.60
per shoulder mile (2 graders in tandem)							26.47
Note: Accomplishment rate is estimated assuming tandem operation doubles the basic rate. Assume cleanup left to weather & traffic							

STUDY ID	INVESTIGATION PHASE
Reshape Foreslope: No Mat'l. Added	PERFORMANCE CRITERIA

REQUIRED CRITERIA

Smooth transition between pavement edge and unpaved foreslope. No dropoff and no ridge at pavement edge. Restore foreslope surface and grade.

DESIRED CRITERIA

Same as required criteria except that reduced unit cost is desired.

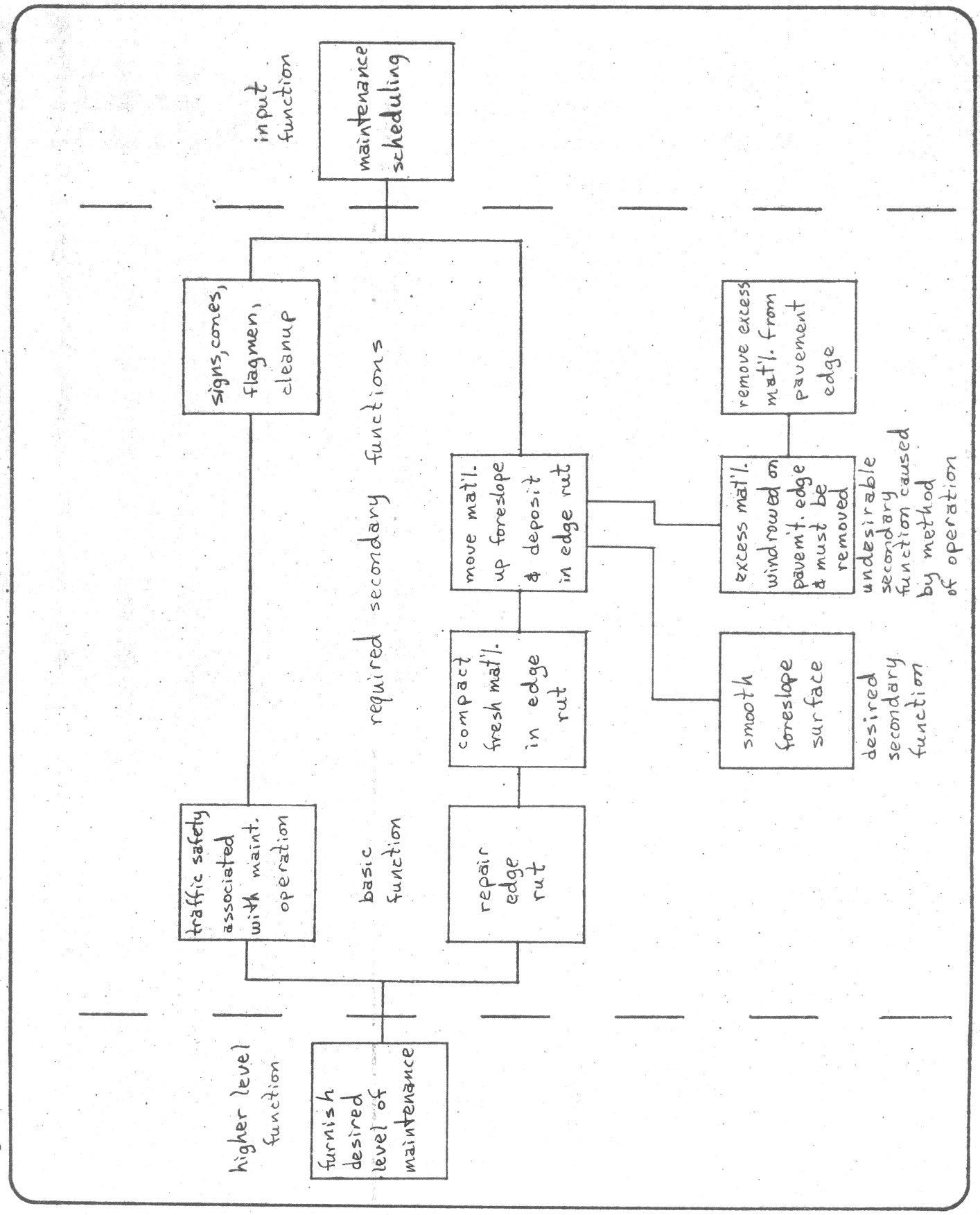
WHAT IS NOW ACCOMPLISHED?	FUNCTION	
	VERB	NOUN
① signs, cones, flagmen emplaced	control	traffic
② material bladed up foreslope, filling edge rut, smoothing foreslope & depositing excess on pavement	pull	foreslope
③ excess mat'l bladed off pavement onto foreslope and spread, avoiding creation of a windrow	redistribute	excess
④ fresh mat'l on foreslope next to pavement is compacted with grader wheel, truck tires, roller, or a combination of these	compact	fresh mat'l
⑤ mat'l. residue on pavement is removed if it is judged to present a significant dust or mud hazard to traffic	clean	pavement
⑥ traffic control removed	restore	traffic

WHAT MUST BE ACCOMPLISHED?	FUNCTION	
	VERB	NOUN
traffic safety	control	traffic
mat'l on foreslope moved up to fill edge rut and smooth foreslope surface	pull	shoulder
compact fresh mat'l. in edge rut	compact	fresh mat'l.
restore free traffic flow	restore	traffic

STUDY ID
Reshape Foreslope:
No Mat'l. Added

INVESTIGATION PHASE

FAST DIAGRAM OF EXISTING DESIGN



STUDY ID: Reshape Foreslope: No Mat'l. Added

ANALYSIS PHASE

VALUE INDEX

FUNCTION			COST		WORTH		VALUE INDEX
VERB	NOUN	B/S	Item, system or operation	Present Cost	FUNCTIONAL COMPARATIVE	EST COST OF COMPARATIVE	COST / WORTH
control	traffic	S	flagman	10.40	flagman	5.20	2
carry	people & signs	S	pickup	0.40	pickup	0.20	2
pull	shldr	S	operator	5.20	operator	5.20	1
			motor grader	5.34	motor grader (compact while pulling)	5.34	1
remove & compact	windrow fresh mat'l.	S	operator	5.20	eliminate *	0	∞
		S	motor grader	5.33	eliminate *	0	∞
			total per shldr-mi. (single grader)	31.87	total per shldr-mi	15.94	2.00
			6 shldr-mi/day		assume 12 shldr-mi/day		

* eliminate windrow by using wing plate on grader blade or combine pulling & windrow removal by attaching auxiliary drag blade to grader for removing windrow - use of Iowa-type drag box behind wheel tractor would cost about the same as grader but gives less compaction & has less capacity.

Notes: Cost breakout assumes single grader pass for pulling and single pass for removing windrow. Compaction assumed by grader wheel during windrow removal. Functional comparative ignores possible interference caused by delineator posts. These might have to be removed or relocated further from pavement edge to make the functional comparative workable. Assume cleanup left to weather & traffic.

STUDY ID: Reshape Foreslope: No. Mat'l. Added

ANALYSIS PHASE

VALUE INDEX

FUNCTION			COST		WORTH		VALUE INDEX
VERB	NOUN	B/S	Item, system or operation	Present Cost	FUNCTIONAL COMPARATIVE	EST COST OF COMPARATIVE	COST / WORTH
control	traffic	S	flagman	5.20	flagman	5.20	1
carry	people & signs	S	pickup	0.20	pickup	0.20	1
pull	shldr	S	1st operator	5.20	operator	5.20	1
			1st motor grader	5.34	motor grader	5.34	1
remove	windrow	S	2nd operator	5.20	driver	5.20	1
& compact	fresh mat'l	S	2nd motor grader	5.33	dumptruck w/snowplow, under-body plow, or steel tine broom	2.33	2.29
			total per shldr-mi.	26.47	total per shldr-mi	23.47	1.13
			(2 graders in tandem)		(grader & dump truck)		
			12 shldr-mi/day		12 shldr-mi/day		

Notes: Cost breakout assumes single pass for pulling and single pass for removing windrow. Compaction assumed by vehicle wheel during windrow removal pass. Assume cleanup left to weather & traffic

2 graders in tandem vs. single grader	31.87/26.47	1.20
grader & dumptruck vs. single grader	31.87/23.47	1.36

STUDY 1D Reshape Foreslope: No Mat'l. Added

ANALYSIS PHASE

FUNCTION/COST VISIBILITY

DEPARTMENTS ITEMS, SYSTEMS, OR OPERATIONS	TOTAL INCREMENTAL COST	FUNCTIONS PERFORMED (VERB-NOUN)									
		V. cntrl N. traff	carry people & signs	pull shldr	remove windrow						
		B/S									
manpower	20.80	10.40	0	5.20	5.20						
motor grader	10.67	0	0	5.34	5.33						
carry people & signs	0.40	0	0.40	0	0						
total per shldr-mi (single grader)	31.87	10.40	0.40	10.54	10.53						
manpower	10.40	5.20	0	5.20	0						
motor grader	5.34	0	0	5.34	0						
carry people & signs	0.20	0	0.20	0	0						
total per shldr-mi (grader w/wing plate or aux. blade)	15.94	5.20	0.20	10.54	0						
manpower	15.60	5.20	0	5.20	5.20						
motor grader	10.67	0	0	5.34	5.33						
carry people & signs	0.20	0	0.20	0	0						
total per shldr-mi (2 graders)	26.47	5.20	0.20	10.54	10.53						
man power	15.60	5.20	0	5.20	5.20						
motor grader	5.34	0	0	5.34	0						
dump truck	2.33	0	0	0	2.33						
carry people & signs	0.20	0	0.20	0	0						
total per shldr-mi (1 grader & 1 dumptruck w/snowplow, underbody blade or steel broom)	23.47	5.20	0.20	10.54	7.53						

STUDY ID	ANALYSIS PHASE
Reshape Foreslope: No. Mat'l. Added	NOTES

ANSWER THE FOLLOWING: 1. Are all the specified criteria necessary? 2. Are all requirements realistic? 3. Does it need all its features? 4. What is accomplished unnecessarily? 5. Can any function be eliminated?

1. yes
2. yes
3. Some elements could probably be combined.
4. Windrowing on pavement edge is unnecessary.
   In some situations flagmen are unnecessary.
   In some situations cleanup is unnecessary
5. Windrowing can be eliminated.
   In some situations flagmen and cleanup can be eliminated.

STUDY ID	SPECULATION PHASE
Reshape Foreslope: No Mat'l. Added	IDEA LIST

LIST ALL IDEAS FOR THE FUNCTION

Traffic Control

Traffic control cannot be eliminated.

In some situations flagmen are unnecessary.

Moving traffic control is suitable for some operations.

Emplacement & retrieval of stationary signs could be improved by use of sign trailers similar to Iowa DOT type.

Pull Foreslope

Minimize need by filling edge rut with paving mix or by paving shoulders. This will be discussed in a separate section of the report.

Eliminate by adding mat'l. instead of pulling.

Activity could be done with: motor grader, underbody blade on dump truck, drag box pulled by tractor (Iowa DOT), bulldozer, front end loader.

Eliminate erosion by paving foreslope & ditch or by curb & gutter

Remove Windrow

Combine with compaction (grader wheel, wheel of truck using underbody blade).

Eliminate windrow by using wing plate on grader blade or Iowa design drag box for pulling operation.

Combine with pulling by using two graders in tandem or by auxiliary drag blade on single motor grader.

Use underbody blade on dump truck, use a snowplow on dump truck, use steel tine drag broom on dumptruck.

LIST ALL IDEAS FOR THE FUNCTION

Compact Fresh Material

Combine with windrow removal (grader wheel, wheel of truck on which snowplow or underbody blade is mounted).

Combine with moving traffic control if vehicles are heavy enough.

Omit this activity with some sacrifice in stability of the repair.

Use steel roller, pneumatic roller, or other compaction equipment.

Use puddling on suitable material.

Clean Pavement

Combine with removal of windrow.

Eliminate need by eliminating windrowing.

Omit cleanup if residue amount is too small to create hazard.

Activity could be done with: air blast, water blast, hand or power broom, vacuum cleaner, traffic action, weather.

STUDY ID
Reshape Foreslope:
No Mat'l. Added

EVALUATION PHASE

FEASIBILITY EVALUATION

Rank each idea from 0-~~3~~ 4
A "0" in any column eliminates that idea.
Work down.

CONSIDER ALL IDEAS	Can it be made to work ~~3~~ 4 - Excellent chance 0 - No chance	Cost to develop ~~3~~ 4 - No cost 0 - Prohibitive	Probability of acceptance ~~3~~ 4 - Excellent chance 0 - No chance	Timely implementation ~~3~~ 4 - Excellent chance 0 - No chance			TOTAL
Traffic Control							
Iowa sign trailers	4	4	3	3			14
haul signs in pickup or dumptruck	4	4	4	4			16 (1)
Pull Foreslope							
add mat'l instead of pulling	4	4	0 (2)	0 (2)			8
motor grader	4	4	4	4			16 (1)
underbody truck blade	0	4	0	3			7
tractor w/drag box (Iowa)	4	4	3	3			14
front end loader	3	4	0	0			7
paved shoulders	4	4	4	4			16 (1)
wing plate on grader blade	4	3	3	3			13
curb & gutter or paved foreslope & ditch	4	4	0	0			8
Remove Windrow							
2nd grader in tandem	4	4	3	1			12
auxiliary blade on grader	3	3	3	2			11
underbody blade on dump truck	4	4	3	3			14
snowplow on dump truck	4	4	3	4			15
steel drag broom on truck	4	4	3	3			14

(1) existing standard practice
(2) not acceptable if sufficient mat'l can be pulled - load & haul cost too high - paved vs. unpaved shoulders discussed elsewhere

Rank each idea from 0-~~3~~ 4
A "0" in any column
eliminates that idea.
Work down.

CONSIDER ALL IDEAS	Can it be made to work ~~3~~ 4 - Excellent chance 0 - No chance	Cost to develop ~~3~~ 4 - No cost 0 - Prohibitive	Probability of acceptance ~~3~~ 4 - Excellent chance 0 - No chance	Timely implementation ~~3~~ 4 - Excellent chance 0 - No chance			TOTAL
Compaction							
combine w/traff. control vehicles	4	4	1	1			10
omit	4	4	3	4			15
compacting roller	4	4	3	3			14
use puddling where applicable	4	4	0	0			8
combine w/windrow removal	4	4	4	4			16
Clean Pavement							
broom	4	4	4	4			16
air blast	4	4	2	2			12
water	4	4	1	1			10
vacuum cleaner	4	4	1	1			10
weather & traffic	4	4	4	4			16
combine w/windrow removal	3	3	3	3			

STUDY ID Reshape Foreslope: No Mat'l. Added	EVALUATION PHASE SUITABILITY EVALUATION

Select the most feasible ideas or combination of ideas for further consideration. Check the best ideas.

IDEA	ADVANTAGES	DISADVANTAGES
Traffic Control		
sign trailers	longer sign life - easier loading	additional rolling stock - 2 men may
	& unloading - better organization	be needed to load & unload
haul signs in pickup or dumptruck	no added equipment	sign damage - improper mounts
Pull Foreslope		
paved shoulders	edge rutting reduced - wider	increased first cost
	paved area for emergency	
	maneuvers - improved lateral	
	support of travel lane pavement	
add mat'l instead of pulling	decreased need for equip't	significantly increased cost
	to operate on steep foreslope	
motor grader	familiarity	excess mat'l windrowed on
	equip't well suited to task	pavement
underbody truck blade	lower rental than grader	not suitable for off-road use - poor blade control
tractor w/ drag box	lower rental than grader -	limited lateral reach - limited
	eliminates pavement windrow	capacity - no compaction
front end loader	equipment on hand	too slow - poor slope finish
wing plate on grader blade	eliminates windrow, thus	delineators must be removed &
	eliminating one grader pass	replaced or relocated
curb & gutter or paved foreslope & ditch	eliminates erosion	very high first cost
Remove Windrow		
next page		

Select the most feasible ideas or combination of ideas for further consideration. Check the best ideas.

IDEA	ADVANTAGES	DISADVANTAGES
2nd grader in tandem	doubles production rate	expensive equipment
auxiliary blade on grader	doubles production rate	unproved
underbody dumptruck blade	doubles production rate-	purchase of blades &
or steel broom on	less expensive than	controls req'd.- broom
underbody blade	2nd grader	effectiveness uncertain
snowplow on dumptruck	doubles production rate-	added wear on snowplows
or snowplow w/steel broom	less expensive than	effectiveness of broom
replacing cutting edge	2nd grader	uncertain
Compaction		
combine w/traffic control	added compactive effort	applicable only w/moving
		traffic control - heavy
		trucks req'd.
omit	simplifies operation	decreases life of
		repair
compacting roller	excellent compaction	added cost
puddling	eliminates rolling in	possibility of erosion -
	special situations	limited applicability
combine w/windrow removal	eliminate equipment	insufficient compaction
		may result

Select the most feasible ideas or combination of ideas for further consideration. Check the best ideas.

IDEA	ADVANTAGES	DISADVANTAGES
Clean Pavement.		
combine w/windrow removal	eliminate separate operation	unproven
broom	equip't. on hand	dust
air blast	—	dust - may not work on damp mat'l
water	eliminate dust	possible erosion
vacuum cleaner	eliminate dust	expensive equip't
weather & traffic	low cost	possible traffic hazard

List the best ideas from suitability evaluation. Determine which one ranks best against the desired criteria. Work down.

5 = Good
3 = Fair
1 = Poor

STUDY ID: Reshape Foreslope: No Mat'l. Added

EVALUATION PHASE

FINAL RANKING

ALTERNATIVES	WEIGHT	a: contribution to or effect on frequency of repetition	b: production rate	c: quality of service	d: operational safety	e: crew size	f: operating cost of equipt	g: purchase of additional equipt	h	i	j	k	l	TOTAL	RANKING	USE NOW	HOLD	REJECT	MODIFY NOW?
		10	10	10	10	8	8	8											
Traffic Control																			
sign trailers		n.a.	4 / 40	4 / 40	4 / 40	4 / 32	4 / 32	4 / 32						216					
present method - pickup or dump truck		n.a.	4 / 40	3 / 30	3 / 30	5 / 40	4 / 32	5 / 40						212					
Pull Foreslope																			
motor grader		2 / 20	4 / 40	3 / 30	3 / 30	5 / 40	4 / 32	5 / 40						232					
tractor w/drag box		2 / 20	4 / 40	3 / 30	4 / 40	5 / 40	5 / 40	4 / 32						242					
paved shoulders		5 / 50	2 / 20	5 / 50	5 / 50	2 / 16	2 / 16	5 / 40						242					
wing plate on grader blade		2 / 20	4 / 40	3 / 30	4 / 40	5 / 40	4 / 32	5 / 40						242					
Remove Windrow																			
2nd grader in tandem		2 / 20	4 / 40	4 / 40	3 / 30	4 / 32	3 / 24	2 / 16						202					
aux. blade on grader		2 / 20	4 / 40	4 / 40	4 / 40	5 / 40	5 / 40	4 / 32						252					
underbody blade on truck		2 / 20	4 / 40	4 / 40	3 / 30	4 / 32	4 / 32	4 / 32						226					
snowplow on truck		2 / 20	4 / 40	4 / 40	3 / 30	4 / 32	4 / 32	5 / 40						234					

STUDY ID	EVALUATION PHASE
Reshape Foreslope: No Mat'l. Added	FINAL RANKING

List the best ideas from suitability evaluation. Determine which one ranks best against the desired criteria. Work down.

5 ~~3~~ = Good
3 ~~2~~ = Fair
1 = Poor

ALTERNATIVES	WEIGHT	contribution to or effect on: a frequency of repetition	b production rate	c quality of service	d operational safety	e crew size	f operating cost of equipt	g purchase of additional equipt.	h	i	j	k	l	TOTAL	RANKING	USE NOW	HOLD	REJECT	MODIFY HOW?
Compaction																			
omit		3 / 30	5 / 50	3 / 30	5 / 50	5 / 40	5 / 40	5 / 40						280					
compacting roller		5 / 50	5 / 50	5 / 50	4 / 40	4 / 32	3 / 24	5 / 40						286					
combine w/windrow removal		4 / 40	5 / 50	4 / 40	5 / 50	5 / 40	4 / 32	5 / 40						292					
Clean Pavement																			
broom		n.a.	4 / 40	5 / 50	4 / 40	4 / 32	4 / 32	5 / 40						234					
weather & traffic		n.a.	5 / 50	4 / 40	4 / 40	5 / 40	5 / 40	5 / 40						250					

5
3

Review the three preceeding ranking results and select the best alternatives for development. Summarize each alternatives strong and weak points.

Traffic Control

Sign trailers should be tried. Wear & tear on signs would be considerably reduced. Signs with proper MUTCD mountings could be used. Loading & unloading would be easier & safer than hanging signs on side of dump truck or stacking in a pickup. The signing effort would benefit from the improved organization of rack storage vs. stacking next to a shed. Additional equipment (trailers & standardized sign bases) would need to be bought or built. Depending on trailer & sign base design, two men might be needed to load & unload signs.

Pull Foreslope - Remove Windrow - Compact

If a satisfactory auxiliary blade for a motor grader could be developed, all three could be done in one pass. The main blade would pull, auxiliary blade would remove windrow, and rear wheels of grader would compact. Development work would be needed to see whether a workable design is possible.

The existing operation could be speeded up considerably and unit cost could be reduced by using a dump truck with blade (underbody or front mount) in conjunction with a motor grader. The grader would pull mat'l. up foreslope & deposit excess on pavement. The loaded truck would follow, removing excess from pavement and compacting the freshly placed mat'l. in the edge rut. Steel broom might be substituted for cutting edge of blade. This would allow year-round use of snow equipment but would increase wear on it.

Windrowing on pavement could be eliminated by using a wing plate on the grader blade or by using an Iowa-type drag box pulled by a wheel tractor. Either may require removal of delineators. Drag box provides very little compaction, if any. Capacity of wheel tractor is limited.

Various compacting rollers can be used, but availability is limited.

Clean Pavement

Brooming should be done when needed to prevent dust or mud hazard. When hazard potential is very low, cleanup may be omitted.

STUDY ID	DEVELOPMENT PHASE
Reshape Foreslope: No Mat'l. Added	CONSULTATION RECORD

CONTACT (name, title, organization)	TELEPHONE (incl area code)	NOTES
William Froscher	208-384-3690	equipment information incl.
Road Equip't.		Rivinius & Henry Dick grader
Superintendent, ITD		blade attachment brochures
Div. of Highways		

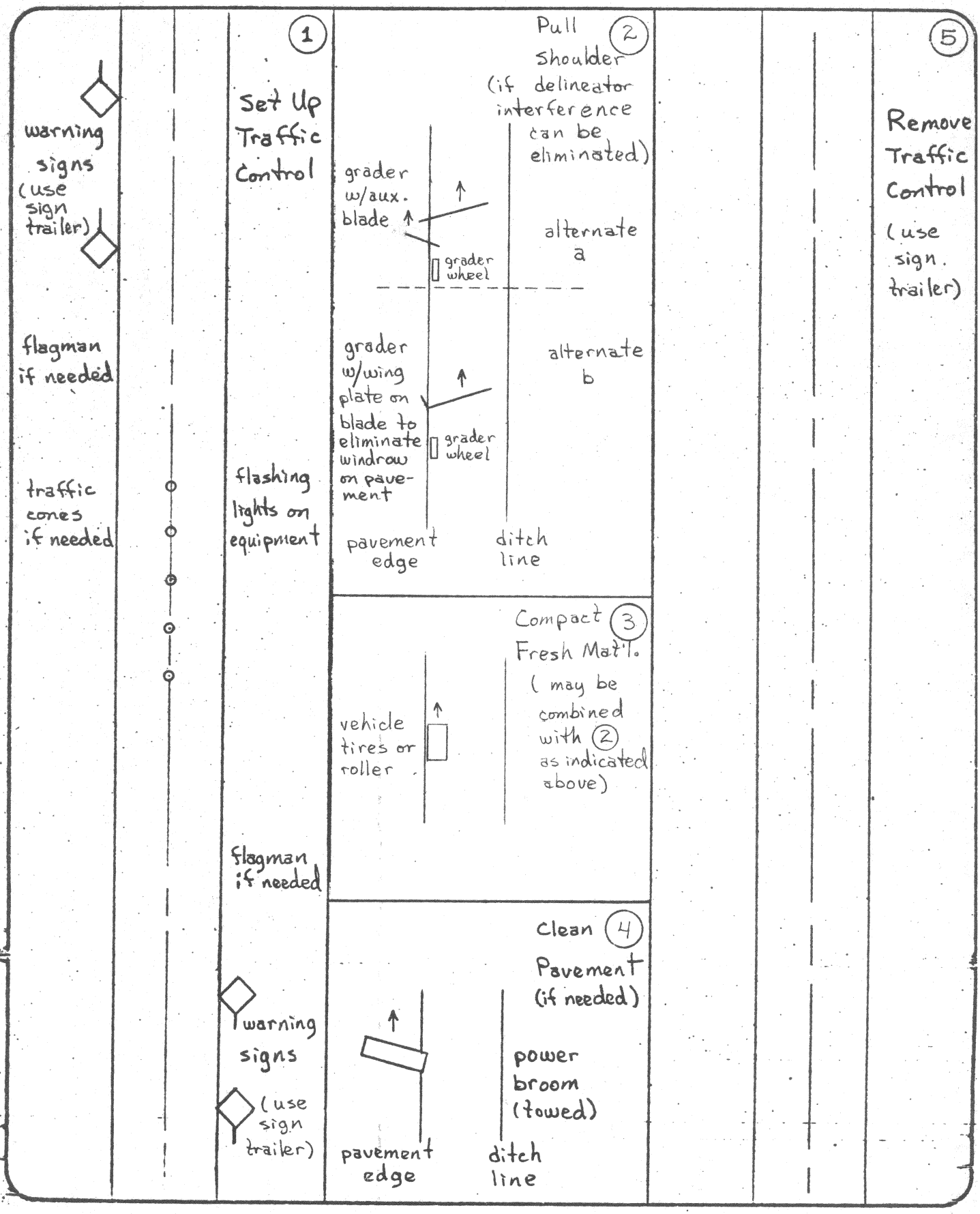
DOCUMENT ABSTRACT: List all books, specifications and drawings used when is is impractical to bind them into the workbook.

REFERENCES (title, author, data & location)	NOTES
equipment brochure, Henry Dick Inc.	end gate & horizontal shift for grader blade
equipment brochure, Rivinius Domor	wing gate for end of grader blade

Reshape Foreslope:
No Mat'l. Added

DEVELOPMENT PHASE

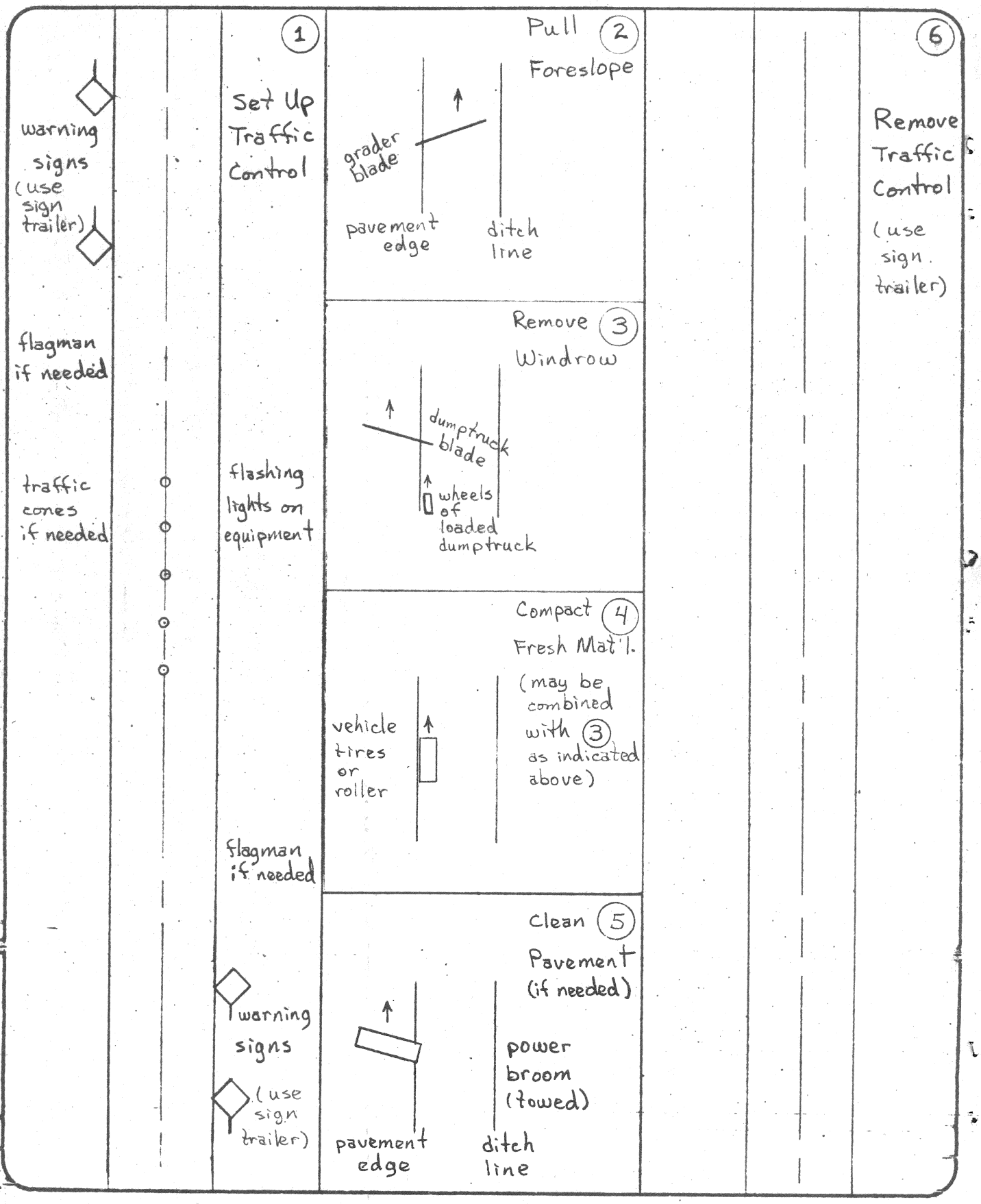
SKETCH OF PROPOSED DESIGN A



STUDY ID
Reshape Foreslope:
No Mat'l. Added

DEVELOPMENT PHASE

SKETCH OF PROPOSED DESIGN B



STUDY ID Reshape Foreslope: No Mat'l. Added

DEVELOPMENT PHASE

ESTIMATE OF PROPOSED DESIGN

ITEM	QUANTITY		LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL	
see pages 13A & 13B							

STUDY ID	DEVELOPMENT PHASE
Reshape Foreslope: No Mat'l. Added	DISCUSSION

- Discuss the technical and economic feasibility, life cycle costs, affect of proposal on environment, human factors, etc.

Technical feasibility of grader w/auxiliary blade has not been verified. Grader w/end plate on blade is technically feasible if no roadside obstructions are present. If grader operator has to dodge obstructions such as delineators, end plate will not completely eliminate pavement windrowing. Operation of truck mounted plow in echelon with grader is technically feasible.

Life cycle cost analysis would be very difficult because equip't. cost changes resulting from suggested modifications are very difficult to estimate without actual experience. It is believed the increase in productivity would more than offset any increased equipment cost.

Environmental effects of the proposed method are expected to be slightly improved compared to existing practice if the method eliminating windrowing on pavement can be used. This would eliminate some dust. If echelon operation of grader and truck mounted plow is used, environmental effects should be the same as for existing practice.

Procedural changes always involve some disruption of established routine. Improved productivity resulting from the suggested changes would hopefully overcome any initial reluctance.

no mat'l. added

Discuss: 1. How should it be implemented? 2. What should be changed? 3. Who should do it? 4. How long should it take? 5. Any deadline requirement? 6. What other areas for V.E. were found?

1. Procedural and equipment modifications should be tried on a limited basis until satisfactory results are obtained.

2. Truck mounted plow (lower rental rate than grader) should be substituted for 2nd grader pass to remove mat'l. from pavement. In suitable terrain, end plate should be used on grader blade to prevent windrowing on pavement, thus eliminating 2nd pass altogether. Blade sideshift may be needed to permit compaction by rear grader wheels.

3. Maintenance Section should coordinate field trials and implement the results.

4. One or two seasons of trial use should be enough.

5. No deadline is suggested.

6. No other VE areas are suggested.

VALUE ENGINEERING FOR HIGHWAYS

FEDERAL HIGHWAY ADMINISTRATION

STUDY WORKBOOK

Value Engineering Analysis of Selected Maintenance Activities

Reshaping Foreslope (Shoulder), Idaho Transportation

name of study

Dep't., Div. of Hwys. Maint. Oper. Procedure 5-252

2nd Case: Mat'l. Added

STUDY ID	STUDY NO.	STUDY DATE
	DOT-FH-11-8596	1976

STUDY TITLE: Value Engineering Analysis of Selected Maintenance Activities - Reshaping Foreslope (Shoulder): Mat'l. Added

TEAM MEMBERS

NAME	TITLE	ORGANIZATION	TELEPHONE
Team Leader James W. Hill	Research Supervisor	Idaho Trans. Dept.	208-384-3600
E. M. Harding	District Engineer	ITD Div. of Hwys.	208-664-8181
D. R. Greene	Dist. Maint. Engr.	ITD Div. of Hwys.	208-232-4270
Clyde Gillespie	Dist. Maint. Engr.	ITD Div. of Hwys.	208-745-7781
A. F. Stanley	Assoc. Mat'ls. Engr. I	Idaho Trans. Dep't.	208-384-3600

DESCRIBE THE PROBLEM TO BE STUDIED (Reason for selection, requirements & limitations)

Topic selected as result of highway maintenance research needs study made by Transportation Research Board (Report No. FHWA-RD-75-511).

The requirement is indepth study of shoulder maintenance operation by highly qualified engineers in a minimum of three state districts

This study is limited to the case where material is added to the foreslope.

DESCRIBE PROBLEM TO BE STUDIED (Existing, procedure, system, design)

The study problem is reshaping the foreslope to eliminate edge rut & restore foreslope surface & grade, thus improving traffic safety & drainage. Existing procedure is first to dump mat'l. on pavement. Next this mat'l. is bladed off pavement to fill edge rut & any other foreslope depressions. If needed, an additional grader pass is made to smooth the foreslope surface. Then the fresh mat'l. in the edge rut is compacted with the grader wheels, truck tires, or standard compaction rollers. Finally any loose material remaining on the pavement is removed if it is judged to be a traffic hazard. Traffic control is included in the operation as defined in the ITD Div. of Hwys maintenance procedures manual. The incidental functions of loading and hauling the added material are not detailed under maintenance procedure 5-252 and are likewise omitted from consideration in this report.

WHO: has approval authority for changes, maintains or operates the item, can be contacted for further information

NAME	POSITION/ORGANIZATION	TELEPHONE
E.D. Tisdale	State Highway Administrator / Idaho Trans. Dept.	208-384-3769
Roy Jump	Maintenance Supervisor / ITD Div. of Hwys	208-384-3690

STUDY TO
Reshape Foreslope:
Mat'l. Added

INVESTIGATION PHASE

CONSULTATION RECORD

CONTACT (name, title, organization)	TELEPHONE (incl area code)	NOTES
Steve Hutchison, EIT,	208-384-3690	provided background information on
ITD Div. of Hwys.		newly implemented maint. management system
A.C. Bybee, Maint. Foreman,	208-852-1712	demonstrated existing maint. procedures
ITD Div. of Hwys.		
all members of shoulder	see	brainstorming, comparative
maint. VE study teams	presentations	data from other states
from Arizona, Iowa, W.	of other	
Va. participating in	states	
this study.		
William Froscher	208-384-3690	equipment information incl Rivinius
Road Equip't. Superintendent		& Henry Dick blade attachment brochures
ITD Div. of Hwys.		
Stanley Carper, Special	208-384-3663	VE consultant
Assignments Engr., Idaho		
Trans. Dep't.		
William Pardew	208-384-3625	bid prices for aggregate in place
Plans, Specifications &		on the highway
Estimates Engr., ITD		
Div. of Highways		

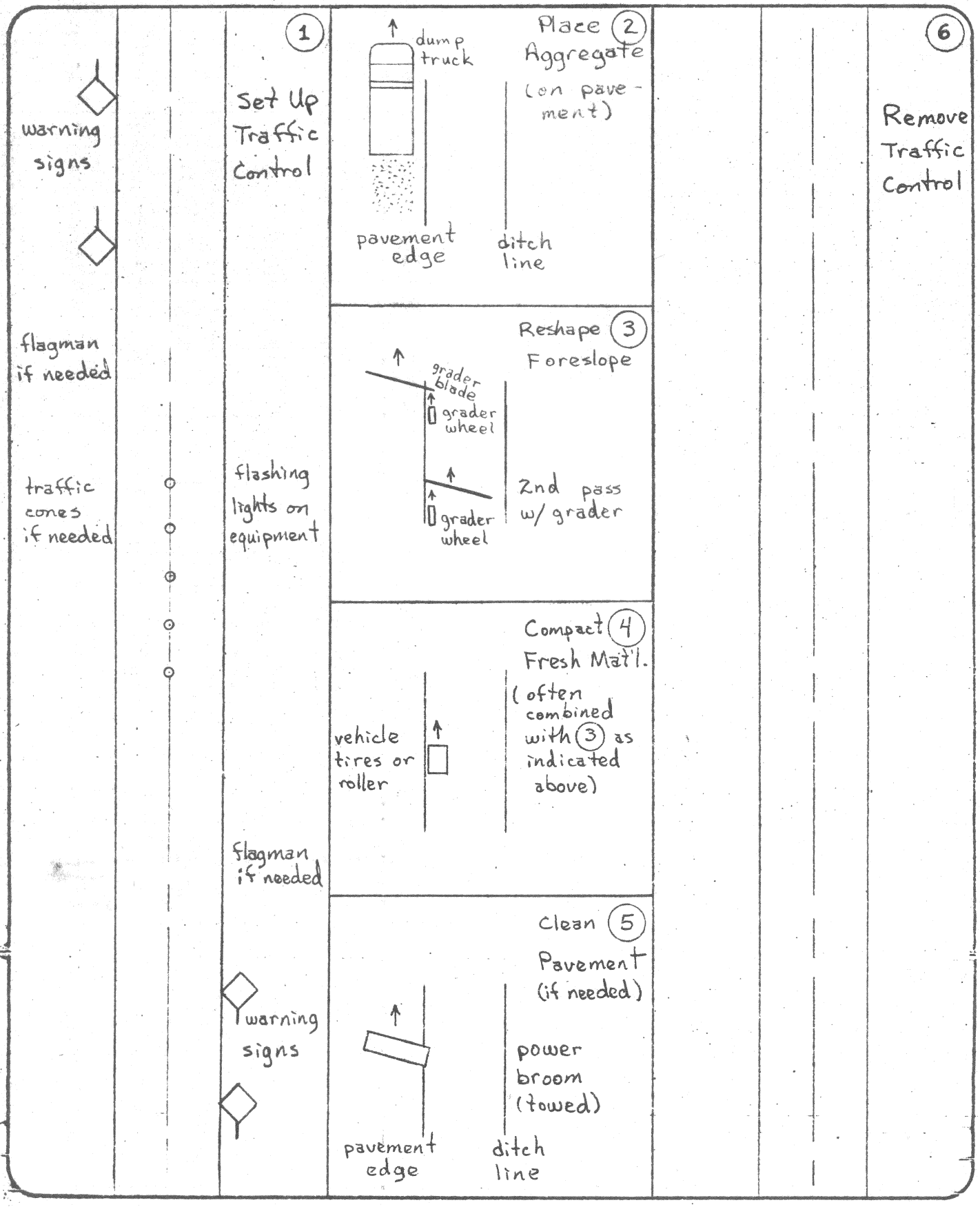
DOCUMENT ABSTRACT: List all books, specifications and drawings used when it is impractical to bind them into the workbook.

REFERENCES (title, author, date & location)	NOTES
1974 Maint. Report, ITD Div. of Hwys.	source of some Idaho maintenance statistics
Maint. Operation Procedures Book; ITD Div. of Hwys.	reference for standard maint. procedures
Maintenance Manual, ITD Div. of Hwys.	definitions, maintenance procedures
Value Engr. for Hwys., FHWA VE text	VE procedures
ITD Div. of Hwys. Maint. Management System Unit Cost List dated 5-5-76	equipment rental rates
Value Engineering and Analysis, VE text by CVS, Inc., Portland, Oregon	VE procedures

STUDY ID
Reshape Foreslope: Mat'l. Added

INVESTIGATION PHASE

SKETCH OF PRESENT DESIGN



STUDY ID	INVESTIGATION PHASE
Reshape Foreslope: Mat'l. Added	ESTIMATE OF PRESENT DESIGN COST

ITEM	QUANTITY		LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL	
per day (8hr., 3 road mi)	—	—					
pickup (assume 30 mi. rnd. trp.)	30	mi.			.08	2.40	2.40
med. motor grader	8	hr.			8.00	64.00	64.00
med. dump truck (2 axle)	16	hr.			3.50	56.00	56.00
3 operators & 1 flagman	32	hr.	7.80	249.60			249.60
aggregate	277	ton			1.50		415.50
front end loader	8	hr.			8.00		64.00
							851.50
per shoulder mi.							141.92
Notes: Accomplishment rate is based on an estimate agreed upon by maintenance foremen statewide. No accounting records are presently available to check the accuracy of estimate. Assume clean up left to weather & traffic. Wage rate of $7.80 is 1976 statewide avg. for maint. field personnel, incl. leave, holidays & fringes.							
Modified Design							
dump directly on foreslope,							
assume 4.5 road-mi/day *							
pickup	30	mi.			.08	2.40	2.40
med. motor grader	8	hr.			8.00	64.00	64.00
med. dump truck (2 axle)	16	hr.			4.00 **	64.00	64.00
3 operators, 1 flagman	32	hr.	7.80	249.60			249.60
aggregate	415.5	ton			1.50		623.25
front end loader	8	hr			8.00		64.00
total per day							1067.25
per shoulder mi.							118.58
* see p. 13					** assume reqd modifications or attachments raise rental rates by $.50 per hr. - see p. 11		

STUDY ID	INVESTIGATION PHASE
Reshape Foreslope: Mat'l. Added	PERFORMANCE CRITERIA

REQUIRED CRITERIA

Smooth transition between pavement edge and unpaved foreslope. No dropoff and no ridge at pavement edge. Restore foreslope surface and grade.

DESIRED CRITERIA

Same as required criteria except that reduced unit cost is desired.

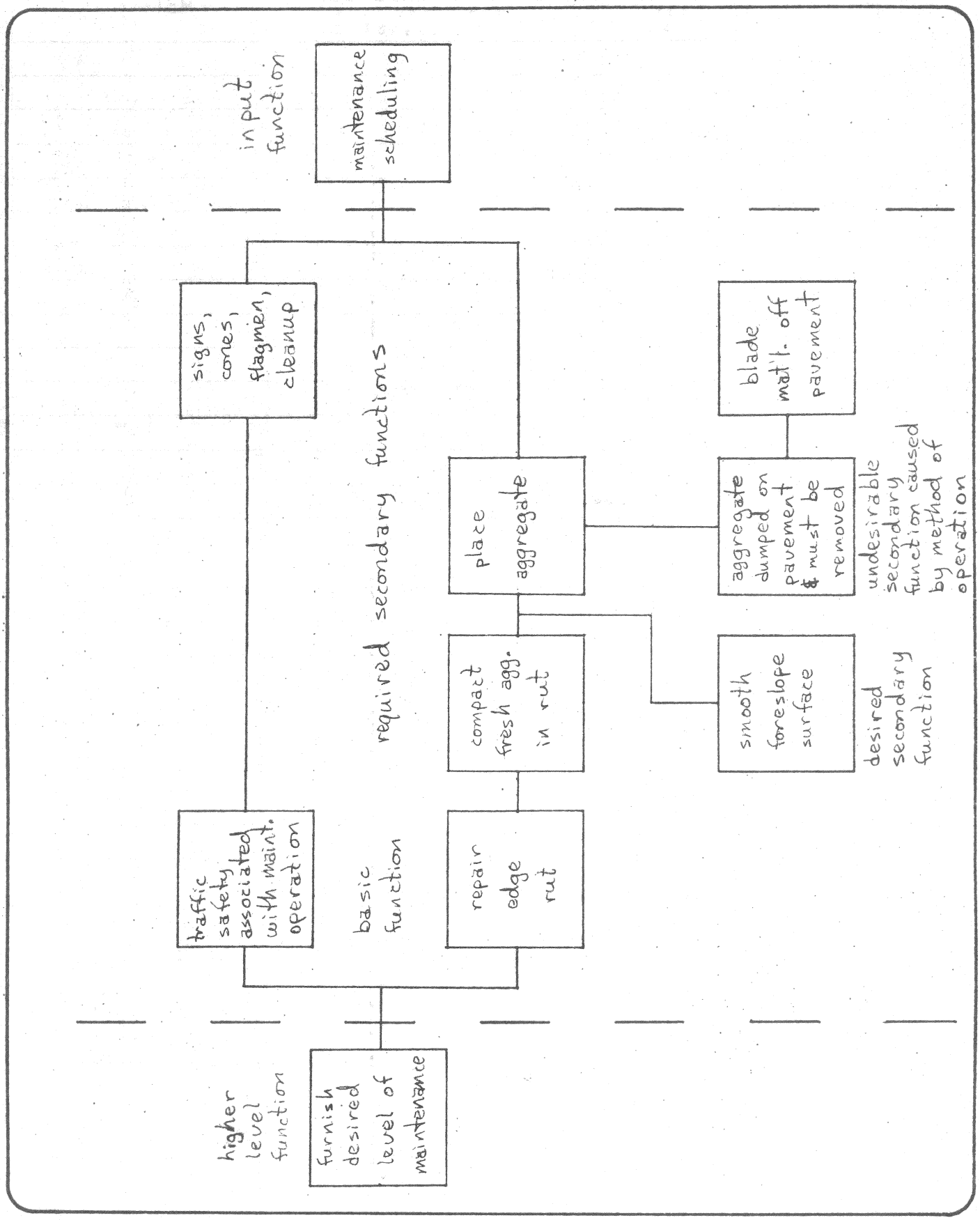
WHAT IS NOW ACCOMPLISHED?	FUNCTION	
	VERB	NOUN
① signs, cones, flagmen emplaced	control	traffic
② material dumped on pavement	place	aggregate
③ mat'l. bladed off pavement onto foreslope – second blade pass to smooth foreslope	reshape	foreslope
④ fresh mat'l. on foreslope next to pavement is compacted with grader wheel, truck tires, roller, or a combination of these	compact	fresh mat'l.
⑤ mat'l. residue on pavement is removed if it is judged to present a significant dust or mud hazard to traffic	clean	pavement
⑥ traffic control removed	restore	traffic

WHAT MUST BE ACCOMPLISHED?	FUNCTION	
	VERB	NOUN
traffic safety	control	traffic
fresh mat'l placed	place	aggregate
smooth foreslope surface	reshape	foreslope
compact fresh mat'l. in edge rut	compact	fresh mat'l.
restore free traffic flow	restore	traffic

STUDY ID
Reshape Foreslope:
Mat'l. Added

INVESTIGATION PHASE

FAST DIAGRAM OF EXISTING DESIGN



STUDY 10 Reshape Foreslope: Mat'l. Added

ANALYSIS PHASE

VALUE INDEX

FUNCTION			COST		WORTH		VALUE INDEX
VERB	NOUN	B/S	Item, system or operation	Present Cost	FUNCTIONAL COMPARATIVE	EST COST OF COMPARATIVE	COST / WORTH
control	traffic	S	flagman	10.40	flagman	6.93	1.50
carry	people & signs	S	pickup	0.40	pickup	0.27	1.50
place	mat'l	S	2 dumptrucks	9.33	2 modified dumptrucks (see notes)	7.11	1.31
		S	2 drivers	20.80	2 drivers	13.87	1.50
		S	aggregate	69.25	aggregate	69.25	1.00
blade mat'l	off pavement	S	motor grader *	5.34	eliminate (see notes)	0	∞
		S	operator *	5.20	eliminate (see notes)	0	∞
reshape	foreslope	S	motor grader *	5.33	motor grader	7.11	0.75
& compact	fresh mat'l	S	operator *	5.20	operator	6.93	0.75
load	trucks		front end loader	10.67	front end loader	7.11	1.50
			total per shldr-mi.	141.92	total per shldr-mi.	118.58	1.20
			(6 shoulder-mi./day)		(9 shoulder-mi./day)		
			* assume half grader time	spent	blading mat'l. off pavement		
			& half spent reshaping	foreslope			
			Notes: Modified dumptrucks	are	sanders w/spinners removed,	w/Do-Al beds,	
			w/Sidewinder tailgates,	or w/	A-frame blockouts in beds. Chutes or troughs may		
			also be req'd. for precise	pla	cement next to pavement, eli	minating dumping on	
			pavement.				
			Assume modifications	incr.	truck rental by $0.50/hr.		
			Assume production	rate	increased by 50% (grader	may have to	wait
			for trucks, so production		rate probably won't be	doubled.	
			Assume cleanup left	to	weather & traffic.		

STUDY 10
Reshape Foreslope:
Mat'l. Added

ANALYSIS PHASE

FUNCTION/COST VISIBILITY

DEPARTMENTS ITEMS, SYSTEMS, OR OPERATIONS	TOTAL INCRE-MENTAL COST	FUNCTIONS PERFORMED (VERB-NOUN)									
		V. cntrl	carry	place	blade mat'l	reshape & compact	load				
		N. traff	people & signs	mat'l.	off pavem't	foreslope	trucks				
		B/S									
manpower	41.60	10.40	0	20.80	5.20	5.20	0				
med. motor grader	10.67	0	0	0	5.34	5.33	0				
dump trucks	9.33	0	0	9.33	0	0	0				
front end loader	10.67	0	0	0	0	0	10.67				
carry people & signs	.40	0	.40	0	0	0	0				
aggregate	69.25	0	0	69.25	0	0	0				
total per shldr-mi. (exist. method)	141.92	10.40	.40	99.38	10.54	10.53	10.67				
manpower	27.73	6.93	0	13.87	0	6.93	0				
med. motor grader	7.11	0	0	0	0	7.11	0				
modified dump trucks	7.11	0	0	7.11	0	0	0				
front end loader	7.11	0	0	0	0	0	7.11				
carry people & signs	.27	0	.27	0	0	0	0				
aggregate	69.25	0	0	69.25	0	0	0				
total per shldr-mi. (modified dump trucks)	118.58	6.93	.27	90.23	0	14.04	7.11				

W2-17

STUDY ID	ANALYSIS PHASE
Restore Foreslope: Mat'l. Added	NOTES

ANSWER THE FOLLOWING: 1. Are all the specified criteria necessary? 2. Are all requirements realistic? 3. Does it need all its features? 4. What is accomplished unnecessarily? 5. Can any function be eliminated?

1. yes
2. yes
3. yes
4. Dumping on pavement is unnecessary.
   In some situations flagmen are unnecessary.
   In some situations cleanup is unnecessary.
5. Dumping on pavement can be eliminated.
   In some situations flagmen and cleanup can be eliminated.

STUDY ID	SPECULATION PHASE
Reshape Foreslope: Mat'l. Added	IDEA LIST

LIST ALL IDEAS FOR THE FUNCTION

Traffic Control

Traffic control cannot be eliminated.

Need for flagmen could be reduced by dumping directly on foreslope instead of dumping on pavement.

Moving traffic control can be used in some cases.

Emplacement & retrieval of stationary signs could be improved by use of sign trailers similar to Iowa DOT type.

Place Aggregate

Minimize need by filling edge rut w/paving mix or by paving shoulders. This will be discussed in a separate section of the report.

Eliminate foreslope erosion by paving foreslope & ditch or by using curb & gutter section.

Place aggregate directly in edge rut by using modified spreader (Iowa DOT), A-frame in dump bed, modified sander, Do-Al dump bed, Sidewinder tailgate, windrow machine.

Reshape Foreslope

Minimize need by filling edge rut w/paving mix or by paving shoulders. This will be discussed in a separate section of the report.

Eliminate foreslope erosion by paving foreslope & ditch or by using curb & gutter.

Combine w/aggregate placement by using modified spreader similar to Iowa DOT device.

Activity might be done by motor grader or truck mounted plow (snowplow, under body plow, wing plow)

Tractor drawn drag box similar to Iowa DOT device

LIST ALL IDEAS FOR THE FUNCTION

Compact Fresh Mat'l.
Combine with moving traffic control if vehicles are heavy enough.
Omit this activity with some sacrifice in stability of repair.
Combine with reshaping foreslope or w/ hauling.
Use steel roller, pneumatic roller, other compaction equip't.
Use puddling on suitable material.

Clean Pavement
Omit cleanup if residue amount is too small to create hazard.
Activity could be done with: air blast, water blast, broom, vacuum cleaner, weather & traffic.

STUDY ID	EVALUATION PHASE
Reshape Foreslope: Mat'l. Added	FEASIBILITY EVALUATION

Rank each idea from 0-~~3~~ 4
A "0" in any column eliminates that idea.
Work down.

CONSIDER ALL IDEAS	Can it be made to work 4 - Excellent chance 0 - No chance	Cost to develop 4 - No cost 0 - Prohibitive	Probability of acceptance 4 - Excellent chance 0 - No chance	Timely implementation 4 - Excellent chance 0 - No chance			TOTAL
Traffic Control							
Iowa sign trailers	4	4	3	3			14
haul signs in pickup or dumptruck	4	4	4	4			16 (1)
Place Aggregate							
curb & gutter or paved foreslope & ditch	4	4	0	0			8
dump on pavement & blade off	4	4	4	4			16 (1)
modified spreader (Iowa DOT)	4	4	2	2			12
A-frame in dump bed	4	4	2	3			13
Do-Al or modified sander	4	3	3	3			13
Sidewinder tailgate	4	3	3	2			12
windrow machine	4	4	2	3			13
reduce need by paving shoulders	4	4	4	4			16
Reshape Foreslope							
curb & gutter or paved foreslope & ditch	4	4	0	0			8
motor grader	4	4	4	4			16 (1)
modified spreader (Iowa DOT)	4	4	2	2			12
truck mount snowplow or underbody plow	0	4	0	3			7
tractor drawn drag box (Iowa)	4	4	3	3			14

(1) exist. standard procedure

Rank each idea from 0-~~3~~ 4
A "0" in any column
eliminates that idea.
Work down.

CONSIDER ALL IDEAS	Can it be made to work 4 - Excellent chance 0 - No chance	Cost to develop 4 - No cost 0 - Prohibitive	Probability of acceptance 4 - Excellent chance 0 - No chance	Timely implementation 4 - Excellent chance 0 - No chance			TOTAL
Compaction							
combine w/traff. control vehicles	4	4	1	1			10
omit	4	4	3	4			15
compacting roller	4	4	3	3			14
use puddling where applicable	4	4	0	0			8
combine w/reshape or haul	4	4	4	4			16
Clean Pavement							
broom	4	4	4	4			16
air blast	4	4	2	2			12
water	4	4	1	1			10
vacuum cleaner	4	4	1	1			10
weather & traffic	4	4	4	4			16

STUDY ID Reshape Foreslope: Mat'l. Added	EVALUATION PHASE SUITABILITY EVALUATION

Select the most feasible ideas or combination of ideas for further consideration. Check the best ideas.

IDEA	ADVANTAGES	DISADVANTAGES
Traffic Control		
sign trailers	longer sign life - easier loading & unloading - better organization	additional rolling stock - 2 men may be needed to load & unload
haul signs in pickup or dumptruck	no added equip't.	sign damage - improper mounts
Place Aggregate		
paved foreslope & ditch or curb & gutter	eliminates need for aggregate	very high first cost
dump on pavement & blade off	familiarity	traffic hazard - unneeded activity
modified spreader (Iowa DOT)	precise placement off pavement	specialized, relatively costly equipt. - ties up one dumptruck
A-frame in dump bed	equip't. on hand	significant reduction in truck capacity
Do-Al or modified sander	dump bed needn't be raised	some development req'd.
Sidewinder tailgate	truck stays on pavement	equip't. purchase req'd.
windrow machine	some equip't on hand	truck must run partly on foreslope w/bed raised unless spreader modified for side delivery
Reshape Foreslope		
motor grader	familiarity - equip't. well suited to task	—
truck mount snowplow or underbody plow	lower rental than grader	not suitable for off road use - poor blade control

Select the most feasible ideas or combination of ideas for further consideration. Check the best ideas.

IDEA	ADVANTAGES	DISADVANTAGES
modified spreader (Iowa DOT)	precise placement off pavement (truck stays on pavem't)	specialized, relatively costly equipt. - ties up one dumptruck
paved foreslope & ditch or curb & gutter	eliminates need for reshaping	very high first cost
tractor drawn drag box	already developed	limited capacity
Compaction		
combine w/ traffic control	added compactive effort	applicable only w/ moving traffic control - heavy trucks req'd.
omit	simplifies operation	decreases life of repair
compacting roller	excellent compaction	added cost
puddling	eliminates rolling in special situations	possibility of erosion - limited applicability
combine w/ hauling or reshaping	eliminate equipment	insufficient compaction may result

Select the most feasible ideas or combination of ideas for further consideration. Check the best ideas.

IDEA	ADVANTAGES	DISADVANTAGES
Clean Pavement.		
broom	equip't. on hand	dust
air blast	—	dust - may not work on damp mat'l
water	eliminate dust	possible erosion
vacuum cleaner	eliminate dust	expensive equip't
weather & traffic	low cost	possible traffic hazard

STUDY ID Reshape Foreslope: Mat'l. Added

EVALUATION PHASE

FINAL RANKING

List the best ideas from suitability evaluation. Determine which one ranks best against the desired criteria. Work down.

3 = Good
2 = Fair
1 = Poor

ALTERNATIVES	WEIGHT	a contribution to or effect on frequency of repetition	b production rate	c quality of service	d operational safety	e crew size	f operating cost of equipt	g purchase of additional equipt.	h	i	j	k	l	TOTAL	RANKING	USE NOW	HOLD	REJECT	MODIFY HOW?
		10	10	10	10	8	8	8											
Traffic Control																			
sign trailers		n.a.	4 / 40	4 / 40	4 / 40	4 / 32	4 / 32	4 / 32						216					
present method - pickup or dump truck		n.a.	4 / 40	3 / 30	3 / 30	5 / 40	4 / 32	5 / 40						212					
Place Aggregate																			
dump on pavement & blade off		2 / 20	3 / 30	3 / 30	3 / 30	4 / 32	4 / 32	5 / 40						214					
modified spreader (Iowa)		2 / 20	5 / 50	3 / 30	3 / 30	3 / 24	3 / 24	3 / 24						202					
A-frame in dump bed		2 / 20	3 / 30	3 / 30	3 / 30	4 / 32	4 / 32	5 / 40						214					
Do-Al or mod. sander		2 / 20	4 / 40	3 / 30	3 / 30	4 / 32	4 / 32	4 / 32						216					
Sidewinder tailgate		2 / 20	4 / 40	3 / 30	3 / 30	4 / 32	4 / 32	4 / 32						216					
windrow machine		2 / 20	4 / 40	3 / 30	3 / 30	4 / 32	4 / 32	4 / 32						216					
reduce need by paving shoulders		5 / 50	2 / 20	5 / 50	5 / 50	2 / 16	2 / 16	5 / 40						242					
Reshape Foreslope																			
modified spreader (Iowa)		2 / 20	3 / 30	3 / 30	3 / 30	4 / 32	3 / 24	4 / 32						198					
motor grader		2 / 20	4 / 40	3 / 30	3 / 30	5 / 40	4 / 32	5 / 40						232					

5.3

W2-21

STUDY ID

Reshape Foreslope: Mat'l. Added

EVALUATION PHASE

FINAL RANKING

List the best ideas from suitability evaluation. Determine which one ranks best against the desired criteria. Work down.

3=Good
2=Fair
1=Poor

ALTERNATIVES	WEIGHT	a	b	c	d	e	f	g	h	i	j	k	l	TOTAL	RANKING	USE NOW	HOLD	REJECT	MODIFY HOW?
		OBJECTIVES OR CRITERIA																	
		contribution to or effect on																	
		frequency of repetition	production rate	quality of service	operational safety	crew size	operating cost of equipt	purchase of additional equipt											
Compaction	10	10	10	10	8	8	8												
omit		5 50	3 30	5 50	5 40	5 40	5 40							280					
compacting roller		5 50	5 50	4 40	4 32	3 24	5 40							286					
combine w/reshape		5 50	4 40	5 50	5 40	4 32	5 40							292					
Clean Pavement																			
broom		4 40	5 50	4 40	4 32	4 32	5 40							234					
weather & traffic		5 50	4 40	4 40	5 40	5 40	5 40							250					

Review the three preceeding ranking results and select the best alternatives for development. Summarize each alternatives strong and weak points.

Traffic Control

Sign trailers should be tried. Wear & tear on signs would be considerably reduced. Signs with proper MUTCD mountings could be used. Loading & unloading would be easier & safer than hanging signs on side of dump truck or stacking in a pickup. The signing effort would benefit from the improved organization of rack storage vs. stacking next to a shed. Additional equipment (trailers & standardized sign bases) would need to be bought or built. Depending on trailer & sign base design, two men might be needed to load & unload signs.

Place Aggregate

An Iowa-type modified spreader (side delivery) or the Sidewinder sidecasting tailgate attachment could be used to eliminate dumping on pavement, while still permitting dump trucks to operate on the pavement. However both these equipment items would be relatively costly and would be used only a small part of the year.

Each district has one windrow sizer. More of these would have to be obtained if adopted for adding mat'l. to foreslope. The dump truck would have to drive with the right or left side wheels off the pavement to dump off pavement, and the bed would have to be raised. The truck would therefore be unstable, because foreslope is usually considerably steeper than pavement.

A-frame or corner blockout could be used in conjunction with a trough or chute to allow side delivery off pavement with truck operating entirely on pavement. However the A-frame significantly decreases truck capacity. A simple towed side delivery spreader might be devoloped instead.

A Do-Al type bed with side delivery chute or a sander bed with spinner removed & side delivery chute added would allow truck to operate on pavement, eliminate dumping on pavement, & allow multiple use of equipment. A satisfactory side delivery chute would have to be developed. Sander body might have to be modified for increased delivery rate & larger size mat'l.

Review the three preceeding ranking results and select the best alternatives for development. Summarize each alternatives strong and weak points.

Reshape Foreslope

The motor grader is a satisfactory machine for this purpose. The equipment is on hand. Rear wheel of grader can be used to aid compaction, thus combining two activities.

The Iowa type spreader is unattractive for the same reasons mentioned under Place Aggregate.

The Iowa type tractor drawn drag box is made chiefly from scrap parts, so would be inexpensive to build. The device has limited capacity compared to a motor grader. In addition, the ITD Div. of Hwys rental rate for a wheel tractor is very little less than for a motor grader ($7.50/hr vs $8.00/hr) Additionally the drag box provides little or no compaction whereas the rear grader wheels can be used for compacting. The tractor drawn drag box thus is less desirable than a motor grader for this task and should be used only when a grader is unavailable & may then require delineator removal.

Compaction

Compaction can be combined with moving traffic control when applicable. Loaded dumptruck is desirable.

Can be combined with hauling (loaded truck) or foreslope reshaping (rear wheels of grader). Use of haul trucks might slow down overall operation, since they would have to drive slowly while compacting.

Compaction can be omitted with some sacrifice of stability.

Various types of compacting rollers can be used, but availability is limited.

Clean Pavement

Brooming should be done when necessary to prevent dust or mud hazard. When hazard potential is very low, cleanup may be omitted.

STUDY ID	DEVELOPMENT PHASE
Reshape Foreslope: Mat'l. Added	CONSULTATION RECORD

CONTACT (name, title, organization)	TELEPHONE (incl area code)	NOTES
John T. Burke	319-363-8281	provided information on Do-Al truck
Vice Pres - Mktg		body & other maintenance equipt.
Highway Equip. Co.		incl. Sidewinder tailgate
Receptionist	503-771-1079	provided cost & supplemental data
Wilton Indust. Products		on Wipco Sidewinder tailgate
William Froscher	208-384-3690	equipment information incl.
Road Equipt Superintend.		Rivinius & Henry Dick grader blade
ITD Div. of Hwys		attachment brochures
Stanley Carper, Special	208-384-3663	VE consultant
Assignments Engr., Idaho		
Trans. Dep't.		

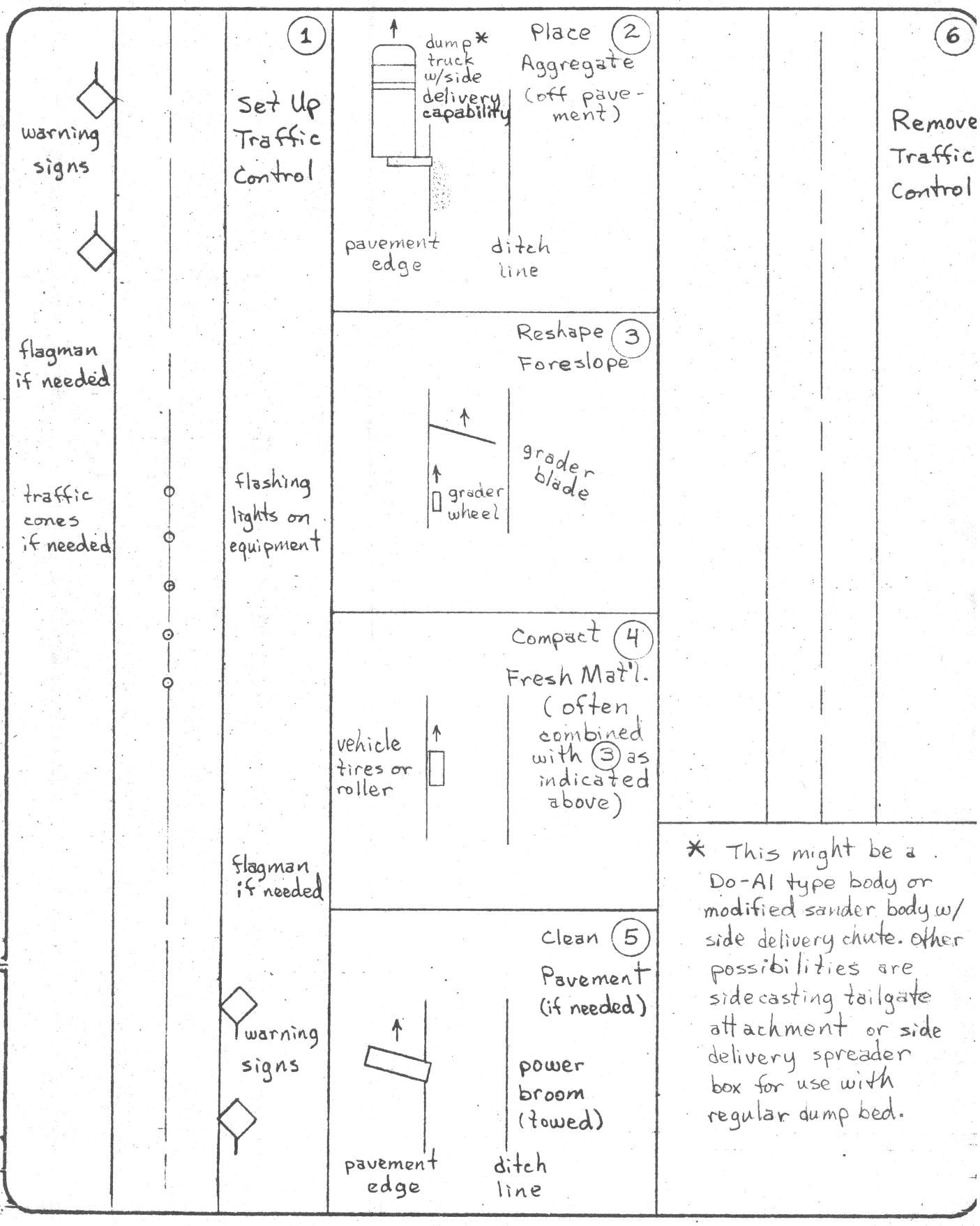
DOCUMENT ABSTRACT: List all books, specifications and drawings used when is is impractical to bind them into the workbook.

REFERENCES (title, author, data & location)	NOTES
equipment brochure, Wilton Industrial Products Portland, Oregon	Sidewinder sidecasting tailgate for ordinary dump truck
equipment brochure, Highway Equipt. Co. Cedar Rapids, Iowa	Do-Al dump body, various spreader boxes & tailgate attachments

STUDY ID
Reshape Foreslope: Mat'l. Added

DEVELOPMENT PHASE

SKETCH OF PROPOSED DESIGN



STUDY ID Reshape Foreslope: Mat'l. Added	DEVELOPMENT PHASE ESTIMATE OF PROPOSED DESIGN

ITEM	QUANTITY		LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL	
see page 13							

STUDY ID	DEVELOPMENT PHASE
Reshape Foreslope: Mat'l. Added	DISCUSSION

Discuss the technical and economic feasibility, life cycle costs, affect of proposal on environment, human factors, etc.

The equipment and procedural modifications are technically feasible.

Life cycle cost analysis would be very difficult because equip't. cost changes resulting from suggested modifications are very difficult to estimate without actual experience. It is believed the increased productivity would more than offset any increased equipment cost.

If dumping on pavement is eliminated as suggested, dust production will be reduced compared to existing practice.

Procedural changes always involve some disruption of established routine. Improved productivity resulting from the suggested changes would hopefully overcome any initial reluctance.

mat'l added

Discuss: 1. How should it be implemented? 2. What should be changed? 3. Who should do it? 4. How long should it take? 5. Any deadline requirement? 6. What other areas for V.E. were found?

1. Equipment modifications should be undertaken on a limited trial basis until satisfactory results are obtained.

2. Method of adding material should be changed so that it is deposited directly in the edge rut instead of being dumped on highway and bladed off.

3. Equipment modifications and trial usage should be done by District personnel with coordination and assistance as needed from Maintenance Section.

4. More than one season would probably be needed to find the best of the suggested options or possibly a method better than any of those suggested here.

5. No deadline is suggested.

6. No other VE areas are suggested.

Economic Comparison Between Paved and Unpaved Shoulders Based on Construction and Maintenance Costs

An economic comparison between 2 ft. wide paved and unpaved shoulder strips appears in the following table. Various forms of economic analysis have advantages in particular situations. In this case the cumulative present worth of the year-by-year construction and maintenance cost differences has been used. This approach illustrates how the initial higher cost of paved shoulders tends to be offset over a period of years as the maintenance savings build up. The approach used here would be less convenient when comparing more than two alternatives. Derivation of cost estimates is outlined at the end of the discussion.

Present Worth Comparison
2 ft wide shoulder strips

	aggregate stabilized w/ 1 1/2% salt				asphalt paved						
yr	constr	mtc	(A) total ann. cost	see note	constr	mtc	(B) total ann. cost	(A-B) ann. cost diff	pres. worth factor 6%	p w of ann. cost diff	cumu-lative pres. worth
0	1212	64	1276		4029		4029	-2753	1.0000	-2753	-2753
1		206	206	-25			-25	231	.9434	218	-2535
2		206	206	-25			-25	231	.8900	206	-2329
3		206	206	-25			-25	231	.8396	194	-2135
4		206	206	-25			-25	231	.7921	183	-1952
5		206	206	-25			-25	231	.7473	173	-1779
6		206	206	-25	299	32	306	-100	.7050	-70	-1849
7		206	206	-25			-25	231	.6651	154	-1695
8		206	206	-25			-25	231	.6274	145	-1550
9	1212	64	1276	-25			-25	1301	.5919	770	-780
10		206	206	-25			-25	231	.5584	129	-651
11		206	206	-25			-25	231	.5268	122	-529
12		206	206	-25	299	142	416	-210	.4970	-104	-633
13		206	206	-25			-25	231	.4688	108	-525
14		206	206	-25			-25	231	.4423	102	-423
15		206	206	-25			-25	231	.4173	96	-327
16		206	206	-25			-25	231	.3936	91	-236
17		206	206	-25			-25	231	.3714	86	-150
18	1864	64	1928	-25	2177	32	2184	-256	.3503	-90	-240
19		206	206	-25			-25	231	.3305	76	-164
20		206	206	-25			-25	231	.3118	72	-92
21		206	206	-25			-25	231	.2942	68	-24
22		206	206	-25			-25	231	.2775	64	40
23		206	206	-25			-25	231	.2618	60	100
24		206	206	-25	118	142	235	-29	.2470	-7	93
25		206	206	-25			-25	231	.2330	54	147
26		206	206	-25			-25	231	.2198	51	198
27	652	64	716	-25			-25	741	.2074	154	352
28		206	206	-25			-25	231	.1956	45	397
29		206	206	-25			-25	231	.1846	43	440
30		206	206	-25	118	32	125	331	.1741	57	497

Note: Saving on overall pavement maintenance due to shoulder paving. See Section Derivation of Cost Estimates.

Discussion

Results of the analysis are influenced strongly by several items. One of these is the difference in construction cost between paved and unpaved sections; another is the frequency of required maintenance. Both these and other factors such as the costs assigned to individual maintenance operations may vary considerably from State to State. As the last column in the table shows, length of the evaluation period can have a major effect on the outcome. Care must be taken to use a realistic evaluation period. Interest rate also affects the results. Raising the interest rate would delay the breakeven year.

The sample computation does not include all economic considerations relating to the question of whether shoulders should be paved. The difference in Federal-aid availablility for maintenance as opposed to construction may exert an influence relatively independent of other factors. For example, highway administrators in a large, sparsely populated State might find the local income too low to support an extensive maintenance effort. In such a case, it might be decided local resources could best be used to construct a paved shoulder highway system with the help of Federal matching funds. The lower maintenance costs associated with this type of construction would present less of a strain on the limited annual operating funds available from local sources. Officials in a more densely populated State, on the other hand, would have much greater local revenue, permitting a larger expenditure for maintenance. They might prefer to use Federal matching funds to build more miles of roads with unpaved shoulders, accepting the higher maintenance cost because their greater population density would provide the necessary annual revenue to support a more extensive maintenance program. In view of these considerations, the Federal-aid influence is potentially a strong factor in decisions involving construction vs. maintenance spending, but is not easily incorporated into the present worth type of analysis. It has been omitted from the analysis, but its potential influence should not be overlooked.

The effect of differences in accident rates on roads with paved vs. unpaved shoulders has also been omitted from the analysis. It is frequently assumed that pavement widening invariably leads to accident reduction, thus favoring paved shoulders. An Oregon study (reference 4) indicated this may not be true. Using accident statistics on straight, level sections of highway, the researchers found no significant relationship between paved shoulder width and accident frequency in most ADT ranges. In two ADT ranges, accident rates were found to increase as paved shoulder width increased. This study did not involve comparison between paved and unpaved shoulders. Only various widths of paved shoulder were considered. A more recent study (reference 5) in North Carolina concluded roads with paved shoulders generally have lower accident rates than roads with unpaved shoulders. These examples illustrate the inconsistent results which have been obtained in studies of the topic. Because of the lack of consistent, reliable data, economic analysis of paved vs. unpaved shoulders was omitted from a recent comprehensive discussion of the economic effects of safety imrpovements (reference 3). If reliable local data is available, including it in a cost analysis with construction and maintenance effects would improve the balance of the analysis.

The reduced shoulder maintenance expected when shoulders are paved would result in fewer traffic delays caused by poor edge condition or caused by the maintenance operation itself. The economic effect could be estimated based on traffic density, maintenance frequency, vehicle operating costs, and approximate travel delay associated with maintenance activities or poor edge condition. No attempt has been made to assess the effect in this study, but it should be included in any complete analysis.

If it is accepted that paved shoulders reduce shoulder maintenance and thus provide a user benefit in terms of fewer traffic delays, this factor would always favor paved shoulders. In addition, if it is assumed that paved shoulders either have no significant effect on accident rate or tend to reduce accidents, then the combined effect of these two user-related items is to favor paved shoulders. Therefore in cases where the simplified analysis (user benefits omitted) favors paved shoulders the omission of these two factors is not significant. This is the case in the example. If the width in the example were changed to 3 feet, maintenance savings would not pay for the paved shoulders. Other factors would then have to be evaluated in order to decide whether paving would be justified.

Derivation of Cost Estimates for Economic Comparison

Average 1975 Idaho Division of Highways Contract Bid Prices (In Place)

- 3/4" aggregate base, $3/ton; assume 140 pcf
- Plant mix, $7.50/ton; assume 140 pcf (asphalt bid separately)
- Prime & seal asphalt, $92/ton; assume 0.30 gal/yd^2
- Paving asphalt, approx. $85/ton; assume 6% asphalt in plant mix
- Cover coat material, Type I, $9.40/ton; assume 30 lb/yd^2

Salt Cost, 1975 Idaho Division of Highways Maintenance Report

- Salt, $14/ton statewide average; assume 1.5 lb. salt per 100 lb aggregate for stabilization of gravel shoulders. Assume $1.00 per ton of aggregate salt mixing cost.

Maintenance Costs from VE Workbook Estimates

- Pull shoulder, $32/shoulder-mile
- Additional material, $142/shoulder-mile

Material to Fill Edge Rut

- Price varies from zero for crusher rejects to same price as base aggregate. Assume averate cost $1.50/ton. Assume cross-section is 3" x 12" right triangle. 1/4 x 1 x 1/2 x 5280 = 660 ft^3/shoulder-mile. 660 x 140/2000 = 46.2 tons/shoulder-mile. 46.2 x $1.50 = $69/shoulder-mile.

Geometrics

- Assume 2 ft. wide paved shoulder strip vs. 2 ft. wide salt-stabilized shoulder, both 0.3 ft. deep with 4:1 sideslopes.

Maintenance Frequency

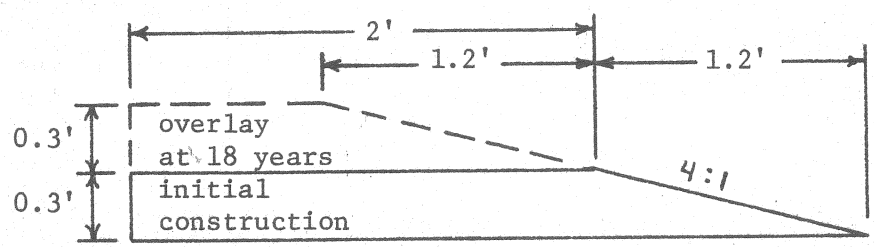
Iowa DOT participants in this study have said shoulder pulling required 1-3 times/yr or average of twice on salt-stabilized aggregate shoulders. Material added about once per year.
$32 + $32 + $142 = $206/year
In reconstruction years, assume pulling required twice:
$32 + $32 = $64/year

Idaho Division of Highway VE team members have said pulling and adding material required very seldom at edge of paved shoulder. Six year intervals are estimated here.

Chip seal estimated at 6 year intervals on paved shoulders, with 0.3 ft. overlay at 18 years.

Reconstruction of gravel shoulder assumed at 9 year intervals, with 0.3 ft. buildup at 18 year to match pavement overlay.

Construction and Seal Coat Cost, Paved Shoulder Strip



Initial Construction of Paved Shoulders

Plant mix
140(0.3 x 2.6 x 5280)/2000 = 288 tons plant mix/shoulder-mile
$7.50 x 288 = $2160/shoulder-mile
6% asphalt
288 - (288/1.06) = 16 tons paving asphalt
16 x $85 = $1360/shoulder-mile

Prime and Seal Asphalt
0.3 x 3.2 x 5280/9 + 563 gallon/shoulder mile prime
0.3 x 2 x 5280/9 + 352 gallon seal
915 gallon total/shoulder-mile
915/250 = 3.7 tons; 3.7 x $92 = $340/shoulder-mile

Cover Coat Material
30 x 2 x 5280/(9 x 2000) = 18 tons/shoulder-mile
18 x $9.40 = $169/shoulder mile

Total 2160 + 340 + 169 = $4029/shoulder-mile

Seal Coats @ 6 year, 12 year
$169 + $92 x 352/250 = $169 + $130 = $299/shoulder-mile

Overlay @ 18 year

Plant mix 140(0.3 x 1.4 x 5280)/2000 = 155 tons/shoulder-mile

$7.50 x 155 = $1162/shoulder-mile

6% asphalt

155 - (155/1.06) = 9 tons paving asphalt

9 x $85 = $765

Prime and Seal Asphalt

0.3 x 2 x 5280/9 = 352 gallon/shoulder-mile prime

0.3 x 0.8 x 5280/0 = 141 gallon/shoulder-mile seal

493 gallon/shoulder-mile total

493/250 = 2.0 tons; 20 x 92 = $184/shoulder-mile

Cover Coat Material

30 x 5280/(9 x 2000) = 7 tons/shoulder-mile; 7 x $9.4 = $66/shoulder-mile

Total 1162 + 7654 + 184 + 66 = $2177/shoulder-mile

Seal Coats @ 24 year, 30 year

$66 + $92 x 141/250 = $66 + $52 = $118/shoulder-mile

Initial Cost, Salt Stabilized Gravel Shoulder Strip

Gravel

Same dimensions as previous diagram

140(0.3 x 2.6 x 5280)/2000 = 288 tons stabilized gravel/shoulder-mile

$4.00 x 288 = $1152/shoulder-mile

Salt 1.5%

$288 - \frac{288}{1.015}$ = 4.3 tons; 4.3 x 14 = $60/shoulder-mile

Total 1152 + 60 = $1212/shoulder-mile

Reconstruction costs are assumed identical to initial costs.

0.3' buildup @ 18 year to match mainline overlay

140(0.3 x 1.4 x 5280)/2000 = 155 tons aggregate

155 x $4 = $620/shoulder-mile

Salt $155 - \frac{155}{1.015}$ = 2.3 tons; 2.3 x 14 = $32/shoulder-mile

Total 620 + 32 = $652/shoulder-mile

Total Cost @ 18 year Includes Rebuilding Original Shoulder and Adding 0.3 ft. thickness: 1212 + 652 = $1864

Saving on Pavement Maintenance Due to Shoulder Paving

A comparison of pavement maintenance cost vs. pavement width was made under ITD Research Project 80. Data reported under Nevada's Maintenance Management System were used. For the first 2 years and 4 months during which the system operated, average annual pavement maintenance costs were very close to $50 per mile less on 24 ft. wide pavement than on 20 ft. wide pavement. The $25 per shoulder-mile negative maintenance charge used in the analysis reflects this saving.

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