RAILROAD CLASSIFICATION YARD DESIGN METHODOLOGY STUDY

EAST DEERFIELD YARD: A CASE STUDY

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16. Abstract

This interim report documents the application of a railroad classification yard design methodology to Boston and Maine's East Deerfield Yard Rehabilitation. This case study effort represents Phase 2 of a larger effort to develop a yard design methodology, and to document the methodology in the form of a yard design manual.

The application of the yard design methodology to CONRAIL's Elkhart Yard is described in a separate interim report.

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PREFACE

This report documents the application of a railroad classification yard design methodology to Boston and Maine Corporation's (B&M) East Deerfield Yard Rehabilitation. The work was performed by members of the Transportation and Industrial Systems Center (TISC) of SRI International for the Department of Transportation's Transportation Systems Center (TSC), Cambridge, Massachusetts. Dr. John Hopkins, TSC, was the technical monitor of the project (under contract DOT-TSC-1337). The effort was sponsored by the Office of Freight Systems, Federal Railroad Administration, as part of a program managed by Mr. William F. Cracker, Jr.

The research was performed under the supervision of Dr. Peter J. Wong of SRI. Dr. Masami Sakasita of SRI was the project leader and was assisted by Ms. Mary Ann Hackworth.

Mr. Vinay Mudholkar of the B&M is the leader of the overall East Deerfield Yard rehabilitation project and was the coordinator of the design effort; he was assisted by Mr. David Koretz.

The authors would like to acknowledge the invaluable assistance of Mr. Barney Gallacher of the Southern Pacific Transportation Company who was a special consultant to the project.

ILLUSTRATIONS

EAST DEERFIELD YARD REHABILITATION: A CASE STUDY

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1.0 Introduction

Located at the intersection of the B&M Railroad's two major mainlines, East Deerfield Yard is the most heavily utilized freight car classification facility in New England. The east/west Fitchburg mainline connects Maine, Massachusetts, and southern New Hampshire to New York State and points west, while the north/south Connecticut River mainline links northern New Hampshire, Vermont, and Canada with Massachusetts, Connecticut, Rhode Island, New York, and points south. A medium-sized yard (31 tracks ranging from 2,500 to 4,000 ft), East Deerfield switches an average of 600 cars each day by means of flat switching and some humping over an unretarded hump. Built in 1880 and last expanded in 1918, the yard has seen no major maintenance in the past 15 years. East Deerfield also manifests a peculiar design feature: the Fitchburg mainline passes through the middle of the yard, bisecting it into the two sections now used as a westbound yard and an eastbound yard. As traffic patterns have shifted from a predominantly east-west flow, the number of cars that have to cross the mainline in the course of the classification process has grown significantly. Because frequent crossover moves would severely disrupt mainline traffic, crossing cars are moved only once a day. The problems currently experienced by the B&M are largely due to its antiquated design and imperfect condition. In particular, the problems observed at the yard are:

- Long detention time.*
- Frequent derailments.
- High level of unidentified damage to cars and lading.

It was evident to B&M management that reconfiguration and rehabilitation were equally necessary at East Deerfield to improve service reliability and the cost of efficient operation.

The East Deerfield redesign study was conducted jointly by project teams from SRI and B&M. From the early stages of the project, the study primarily consisted of four tasks:

- Mainline relocation
- Hump profile design
- Yard capacity requirement evaluation
- Yard trim-end geometry evaluation.

The relationship of these tasks is shown in Figure 1. As can be seen in the diagrams, two types of inputs were required: (1) engineering-related input defining geometric and cost constraints and (2) transportation-related input defining the train arrival patterns, departure patterns, and yard activity parameters.

Because the yard space is confined by the Connecticut and Deerfield Rivers, the available area was predetermined. The work was initiated by determining an optimal relocation configuration for the mainline. Next, a rough track geometry was laid in the given space. Then, hump profile design and capacity evaluation were conducted in parallel. The profile design work concentrated on identifying and designing economical hump retardation systems. In this task three different hump profiles were designed. The capacity evaluation study focused on determining the traffic levels to be handled at the yard. Four traffic patterns were tested to determine this traffic level. The trim-end evaluation was performed using engineering judgment, because no problems were foreseen in utilizing only one trim-end engine.

In the yard design process two computer models developed by SRI were used extensively. These programs proved invaluable throughout the course of the study.

2.0 Mainline Relocation

One of the most significant problems at East Deerfield is the aforementioned bisection of the yard by the Fitchburg mainline. To alleviate this situation, two alternatives were proposed by the B&M planning staff. Alternative I is to relocate the mainline to the northern side of the classification tracks (between those tracks and the locomotive house/car repair area). Alternative II is to relocate the mainline to the southern perimeter

*Freight Car Utilization and Railroad Reliability Case Studies--Final Report, October 1977 (AAR No.-R-283).

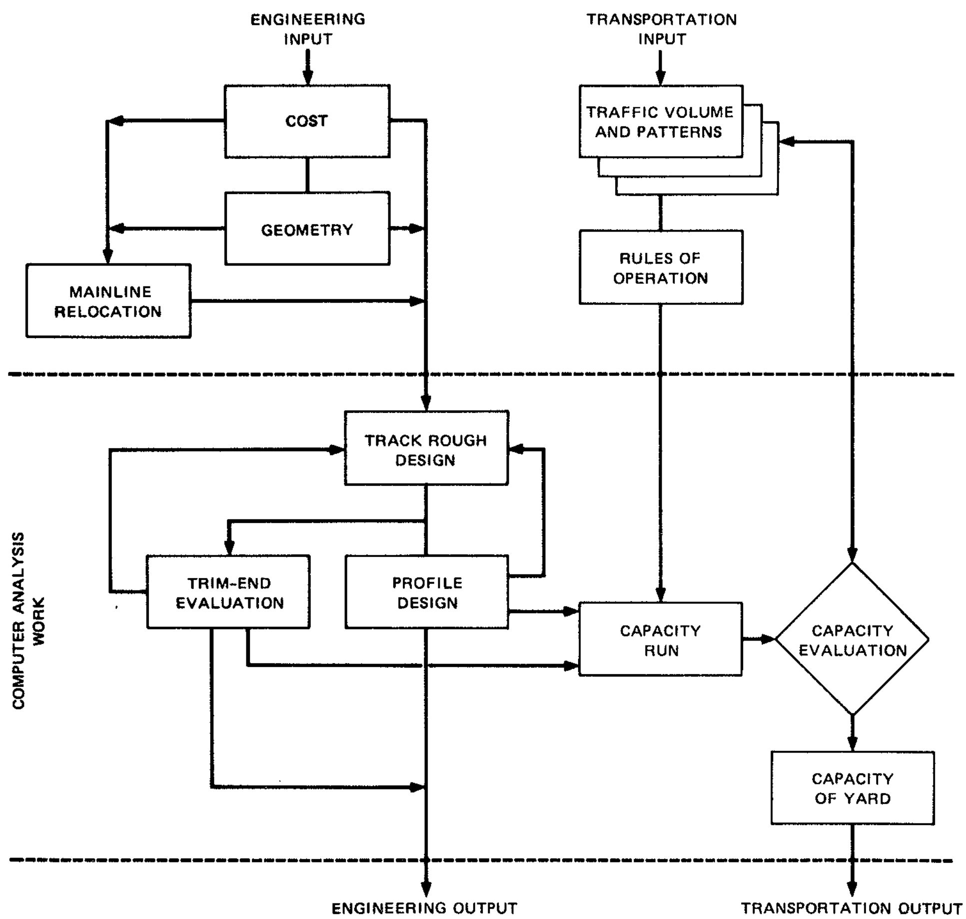


FIGURE 1   FLOW CHART OF EAST DEERFIELD YARD PROJECT

of the yard, to avoid any mainline crossing movements. In both alternatives, the proposed mainline is a single track. Schematic layouts of the alternatives are shown in Figure 2.

Alternative I eliminated crossing movements between different class/receiving/departure tracks in the yard. However, this alternative does not remove conflict between mainline traffic and such intrayard movements as those from the classification tracks to the car repair area or from the engine house to the departure tracks.

Alternative II eliminates all mainline crossing movements. However, this scheme may create some problems regarding fuel supply to locomotives on the mainline track. (Some through trains are currently fueled at East Deerfield.) If the fuel were to be supplied to locomotives on the mainline after the modification of the yard, then an extension of a pipeline from the fuel tank to the mainline would have to be constructed. Otherwise, all through trains would have to be fueled at other locations on the B&M system. RESULT ?

After considering these and other strengths and weaknesses of the two alternatives, the study team determined that Alternative II is preferable to Alternative I.

3.0 Hump Profile Design

3.1 Introduction

An analysis of the traffic volume and the existing geometry at the East Deerfield yard indicated that an economical version of the hump yard is the most suitable yard type for the new East Deerfield yard. It is generally believed that a flat yard is most suitable for a traffic level less than 500 cars/day, and a fully equipped hump yard for a traffic level over 1,500 cars/day. For a traffic level between 500 and 1,500 cars/day, an economical version of the hump yard is preferred. This is because a flat yard at this level would be too labor-intensive, and a fully equipped hump yard too expensive. Therefore, the hump profile design is a crucial element of hump yard design. This section describes the hump profile design process, which consists of selecting retarder configurations and designing a hump profile for each retarder configuration. Retardation-mechanism specifications are given in Appendix A.

3.2 Selection of Retarder Configurations

This subsection describes the retarder configuration selection process for B&M's East Deerfield yard.

The overall objective of this study was to choose a retarder configuration that would meet the following requirements:

- Minimal initial costs, especially capital cost.
- Sufficiently high hump speed to handle traffic to be classified at the East Deerfield yard.
- Permissible impact speed of cars on class tracks.

Because resources for yard rehabilitation are limited, the study team investigated the most economical retarder system possible. Thus, the team focused its attention on weight-responsive hydraulic retarders, which have been successfully installed at various Southern Pacific (SP) yards as tangent point retarders.

System retardation capability and amount of impact speed are closely related. A small system retardation capability and a "low" hump crest could result in a car stalling near the tangent point. A small system retardation capability with a "high" hump crest could result in a car traveling at a higher than permissible speed, thus causing damage to a car or cargo when it collides with a car on the same track.

To alleviate these shortcomings associated with low-powered retarders, the distance between the hump crest and the tangent point should be shortened. If this is done, the excessive velocity head to be taken out of an easy roller will be reduced. The weight-responsive hydraulic retarder system achieves a short distance between the hump crest and the tangent point by placing a retarder on the tangent point of each track. However, this system requires a significant amount of capital for the installation of retarders on the tangent point of each track.

The alternative configurations the study team considered are briefly described below. Each of these alternatives uses weight-responsive hydraulic retarders. However, the retarder control mechanism within each alternative is not necessarily identical to that used in SP's tangent point retarder system.

3.2.1 Alternative 1: All Tangent Point Retarders

In this retarder configuration, a weight-responsive hydraulic retarder is placed on the tangent point of each classification track (see Figure 3-a). The let-out speed from the retarders is set to a constant speed (approximately 4.5 mph). The distance between the hump crest and the tangent point is very short because there are no retarders in between, and the hump height is less than one-half of a "normal" hump height. This configuration has been applied to several SP yards and is said to hump approximately three cars per minute.

3.2.2 Alternative 2: Master and Tangent Point Retarders

The master and tangent point retarder configuration is a modification of Alternative 1. Total retarder length is shortened by using a master retarder on the tangent segment between the hump crest and the first switch (see Figure 3-b). Weight-responsive hydraulic retarders are used in this configuration. The distance between the hump crest and tangent point is longer than the

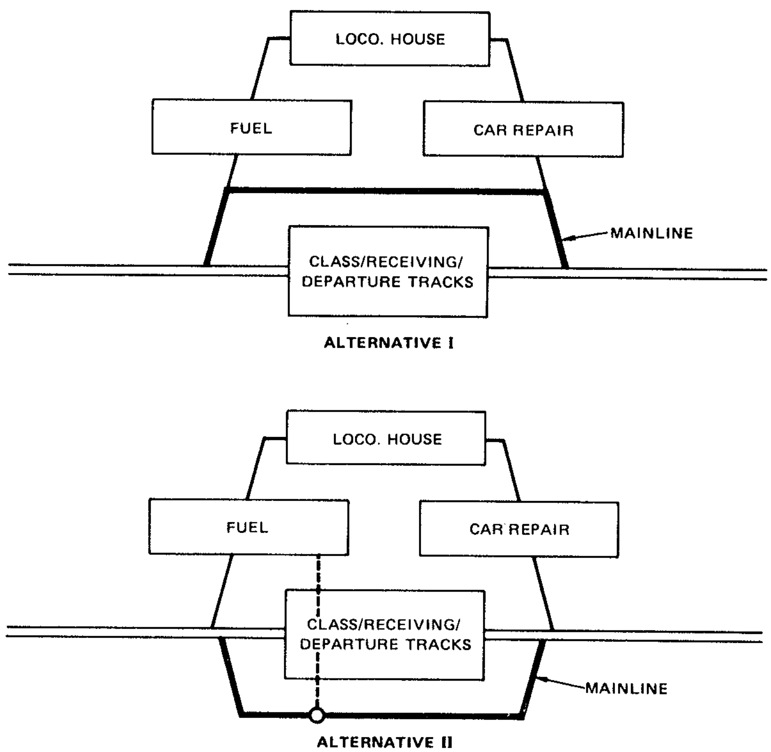


FIGURE 2 SCHEMATIC LAYOUT OF ALTERNATIVES

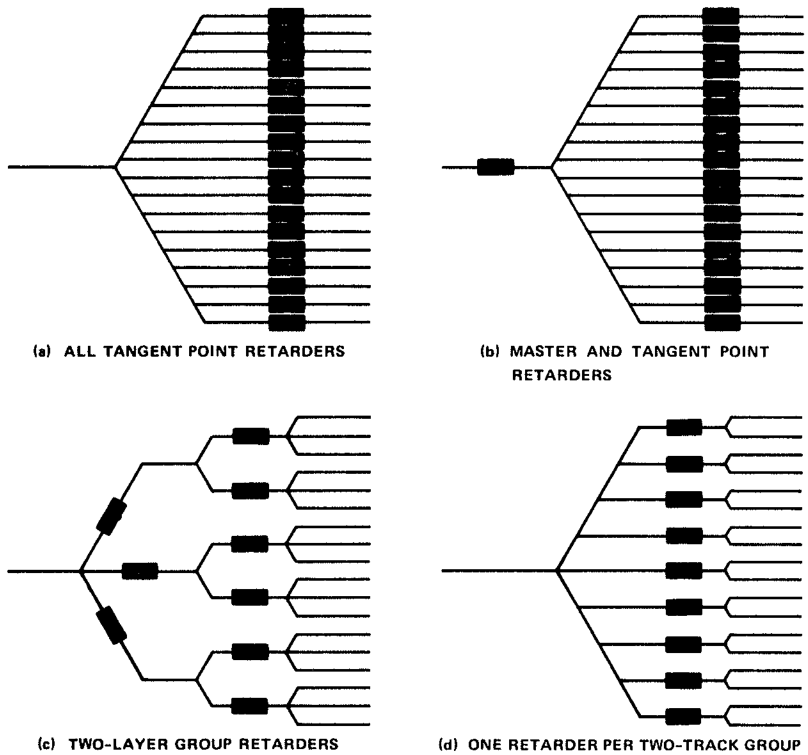
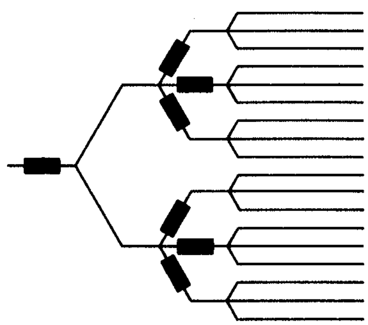
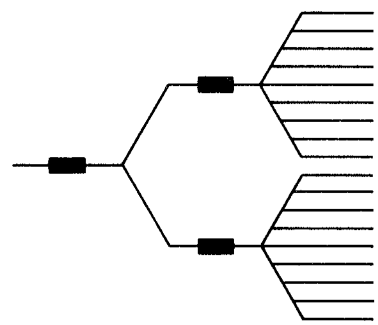


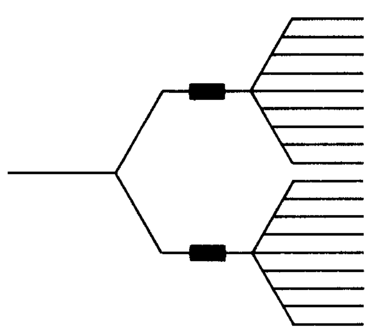
FIGURE 3 RETARDER CONFIGURATIONS



(e) MASTER AND SIX GROUP RETARDERS



(f) MASTER AND TWO GROUP RETARDERS



(g) TWO GROUP RETARDERS

FIGURE 3 RETARDER CONFIGURATIONS (Concluded)

distance described above under Alternative 1. A system using master tangent point retarders will lead to a wider impact speed range if the total length of the master retarder plus a tangent point retarder is kept to the same length as the tangent point retarder length in Alternative 1.

3.2.3 Alternative 3: Two-Layer Group Retarders

In the two-layer group retarder configuration, weight-responsive hydraulic retarders are installed between the hump crest and the last switch to the classification tracks (see Figure 3-c). In this scheme--a further compromised configuration of Alternative 2--the last control point is placed before the last switch to the classification track. The distance between the hump crest and the tangent point will be considerably longer than the distance described under Alternative 1. Consequently, the hump crest will be higher than that of Alternative 1, and the impact speed of cars will vary widely.

3.2.4 Alternative 4: One Retarder per Two-Track Group

In this economical version of Alternative 1, there is one weight-responsive hydraulic retarder for every two tracks (see Figure 3-d). The performance of this system is somewhat inferior to Alternative 1. However, when there is one weight-responsive hydraulic retarder per two-track group, only about one-half of the retarder length required for Alternative 1 will be needed.

3.2.5 Alternative 5: Master and Six Group Retarders

This configuration has one master retarder and six group retarders (see Figure 3-e). All the retarders are weight-responsive hydraulic retarders. The hump height is approximately 10 ft, measured from the tangent point level, and the distance between the hump crest and the tangent point of the outermost track is approximately 800 ft. This configuration is an economical alternative. However, the impact speed of cars may vary widely.

3.2.6 Alternative 6: Master and Two Group Retarders

This configuration consists of a master retarder and two group retarders (see Figure 3-f). Both master and group retarders are weight-responsive hydraulic retarders. Because this configuration has only three retarders, the total retarder length will be much shorter than that of the other configurations. However, the retarder control logic in this configuration will have to be more sophisticated than those used in the other alternatives. The range of impact speed will be wide.

3.2.7 Alternative 7: Two Group Retarders

This configuration consists of two group retarders as shown in Figure 3-g. The retarders are weight-responsive hydraulic retarders. Though this configuration may require longer total retarder length than Alternative 6, the retarder control logic is considered to be much simpler than Alternative 6. The range of impact speed will be wide.

3.2.8 Other Alternatives

Other speed control configurations considered include: (1) Dowty retarders--the performance characteristics and maintenance requirements of Dowty systems are not fully known, except through information supplied by the manufacturer, because the systems have not been installed in the northern United States; (2) Dowty retarder/weight-responsive hydraulic retarder hybrid configuration--the study team determined that it would not be desirable to maintain two different retarders built by two different firms because of the problems that could occur in cases of system malfunction; and (3) Fully equipped master and group retarder configuration--the possibility of using this retarder configuration was abandoned in the early stages of the study because of its high cost. *

On the basis of the cost and performance factors described above, the study team designed a hump profile for the master and six group retarder (Alternative 5), master and two group retarder (Alternative 6), and two group retarder (Alternative 7) configurations using weight-responsive hydraulic retarders. *

3.3 Hump Profile Design

This section describes the three final hump design alternatives for the proposed East Deerfield yard. The retarder configurations selected as the final alternatives are the master and six group retarder configuration (Alternative 5), the master and two group retarder configuration (Alternative 6), and the two-group retarder configuration (Alternative 7). All the configurations use weight-responsive hydraulic retarders.

The hump design objective was to satisfy the following conditions:

- The speed of the hard roller at the tangent point is approximately 4 mph or higher.
- The easy roller's speed at the tangent point is approximately 6 mph or lower.
- There should be no catch-ups before the clearance point of each track.

The major assumptions used in the design process are:

- The hard roller has a rolling resistance of 18 lb/ton between the hump crest and the entrance to the group retarders, and 12 lb/ton thereafter.

- The easy roller has a rolling resistance of 2 lb/ton at all points along the track.
- The velocity head loss due to each switch is .06 ft when the car travels along the curved track. The velocity head loss is assumed to be zero if a car travels on the straight track. The value .06 is constant for all turnout numbers. The velocity head loss is .03 ft for equilateral turnouts.
- The velocity head loss due to a curved section of track is .045 per degree of deflection angle.
- The minimum vertical curve length is 30 times the absolute difference of the two grades expressed in percent. No switch points or retarder segments should be located in a vertical curve section.
- The average car length is 55 ft and the average car weight is 64 tons.
- The extra weight of the car due to wheel rotation is 3.061 tons, which translates to a 5% lower value for gravitational acceleration.
- The wind resistance is zero.

The three alternative designs are briefly described below.

3.3.1 Master and Six Group Retarders (Alternative 5)

A rough sketch of the master and six-group retarder configuration is given in Figure 4. This scheme has a master retarder 34 ft in length and six group retarders that vary from 42 to 70 ft in length. The short master retarder is located close to the hump crest; the beginning point of the master retarder is 70 ft downstream from the hump crest. The beginning points of the group retarders are located 390 to 530 ft downstream from the hump crest. The tangent point/clearance location also varies from track to track. The longest distance from the hump crest to the tangent point is 904 ft on the outermost track. The shortest distance is 573 ft on the innermost track.

The hump system performance characteristics of the master and six group retarder configuration is presented in Table 1. The table shows that the configuration meets the design criteria. However, this scheme has some drawbacks. The first problem is that the master retarder is located very close to the hump crest. Therefore, the speed variation of cars is not large. Consequently, it requires an accurate speed detection system. The next problem is that the elevations of tracks at similar distances from the hump crest are not the same. This means that the switch crew will have to climb up and down the tracks near the hump end in crossing the classification yard. The computer plots of speed and headway along Track No. 1 are presented in Figures 5 and 6.

3.3.2 Master and Two Group Retarders (Alternative 6)

This scheme has a master retarder 39 ft long and two group retarders that are both 60 ft long (see Figure 7). The configuration of the geometry is similar to the conventional master and two group retarder scheme. This configuration differs from the conventional system by using less expensive, weight-responsive hydraulic retarders. The hump crest is 9.8 ft above the tangent point. The distance between the hump crest and the tangent point of the outermost track (or tracks 1 and 18) is 877 ft.

The analysis results of this scheme using the PROFILE model are presented in Table 2. In this alternative only Track No. 1 was analyzed because this track clearly presents the worst case situation. The table shows that the system performance satisfies the objectives for Track No. 1 which is the worst case among the tracks.

This scheme has a longer distance between the group retarder and the tangent point than the master and six group retarder configuration does. Therefore this configuration requires more accurate speed retardation logic to obtain the same level of speed controllability as the master and six group retarder configuration.

The computer plots of speed and headway along Track No. 1 are presented in Figures 8 and 9.

3.3.3 Two Group Retarders (Alternative 7)

The track geometry of this alternative is very similar to that of the master and two group design, except that the group retarder does not have a master retarder (see Figure 10). To compensate for this weakness, the configuration has longer group retarders than the master and two group retarder design. This scheme also uses weight-responsive hydraulic retarders.

The results of using the PROFILE model to analyze this scheme are presented in Table 3. Only Track No. 1--the worst case among the tracks--was analyzed.

Because this scheme has only one control point along the track between the hump crest and the tangent point, it may require a sophisticated logic to maintain accurate speed control. However, the simplicity in the design configuration should be counted as a strong point. The computer plots of speed and headway along Track No. 1 are presented in Figures 11 and 12.

3.4 Conclusions

In summary, the hump profiles for the three retarder configurations were designed. It appears that all three configurations satisfy the minimum requirements set by the study team. Consequently, the choice between the three configurations can be made on the basis of cost (i.e., the configuration with the least initial installation cost plus projected maintenance costs).

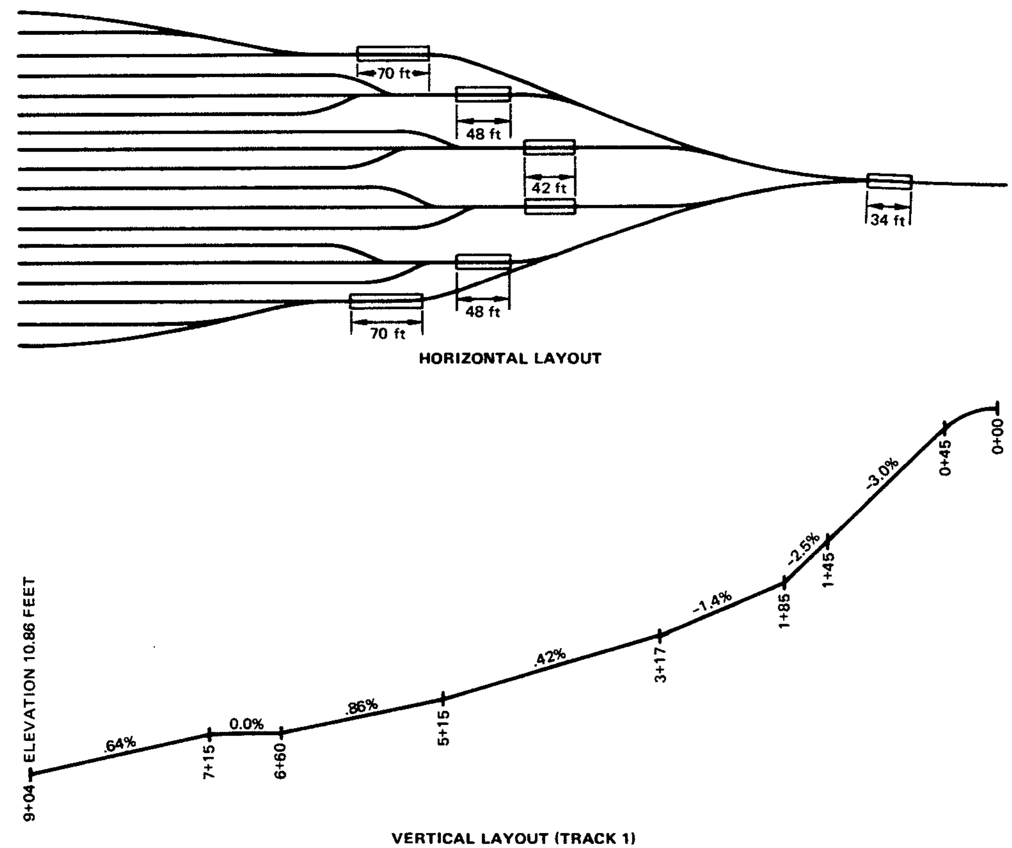


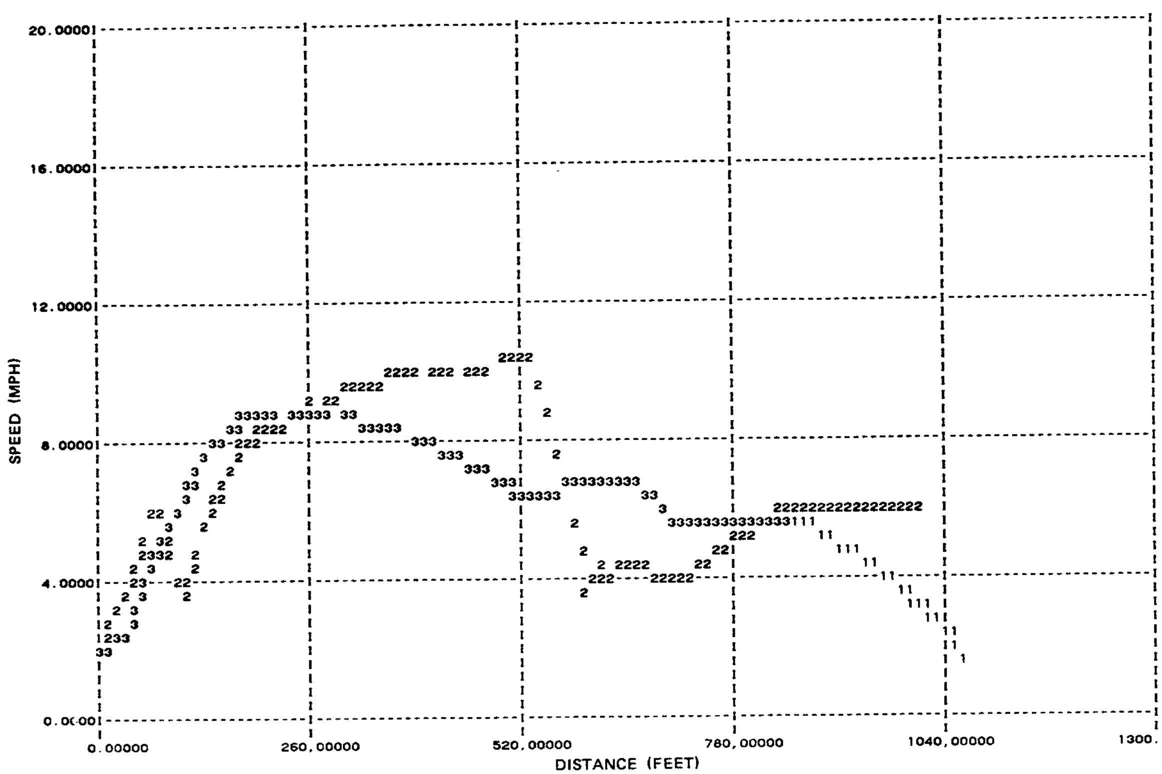
FIGURE 4 HORIZONTAL AND VERTICAL LAYOUTS OF MASTER AND SIX GROUP RETARDER CONFIGURATION

Table 1

PERFORMANCE CHARACTERISTICS OF THE MASTER AND SIX GROUP RETARDER CONFIGURATION

Track No.	Distance from Hump Crest to T.P.* (ft)	Hard Roller Speed at T.P. (mph)	Hard Roller Stalls at T.P. (ft)	Easy Roller Speed at T.P. (mph)	Catch-up Location (ft)	Master Retarder		Group Retarder	
						Retarder Length (ft)	Retardation Amount (ft)	Length (ft)	Retardation Amount (ft)
1	904	5.0	1,081	6.0	1,010	34.0	1.92	70	3.81
2	904	4.9	1,069	5.9	1,010	34.0	1.92	70	3.81
3	806	5.1	985	4.7	920	34.0	1.92	70	3.81
4	739	5.0	913	6.1	819	34.0	1.92	48	2.79
5	739	5.0	917	6.1	822	34.0	1.92	48	2.79
6	709	5.0	882	5.7	795	34.0	1.92	48	2.79
7	600	6.1	864	5.5	807	34.0	1.92	42	2.39
8	593	6.1	852	5.3	793	34.0	1.92	42	2.39
9	573	6.2	845	5.2	789	34.0	1.92	42	2.39

*T.P. = tangent point.



NOTE - PLOTTED NUMBERS ARE CAR NUMBERS

FIGURE 5 COMPUTER PLOTS OF SPEED ALONG TRACK NO. 1 (FOR MASTER AND SIX GROUP RETARDERS)

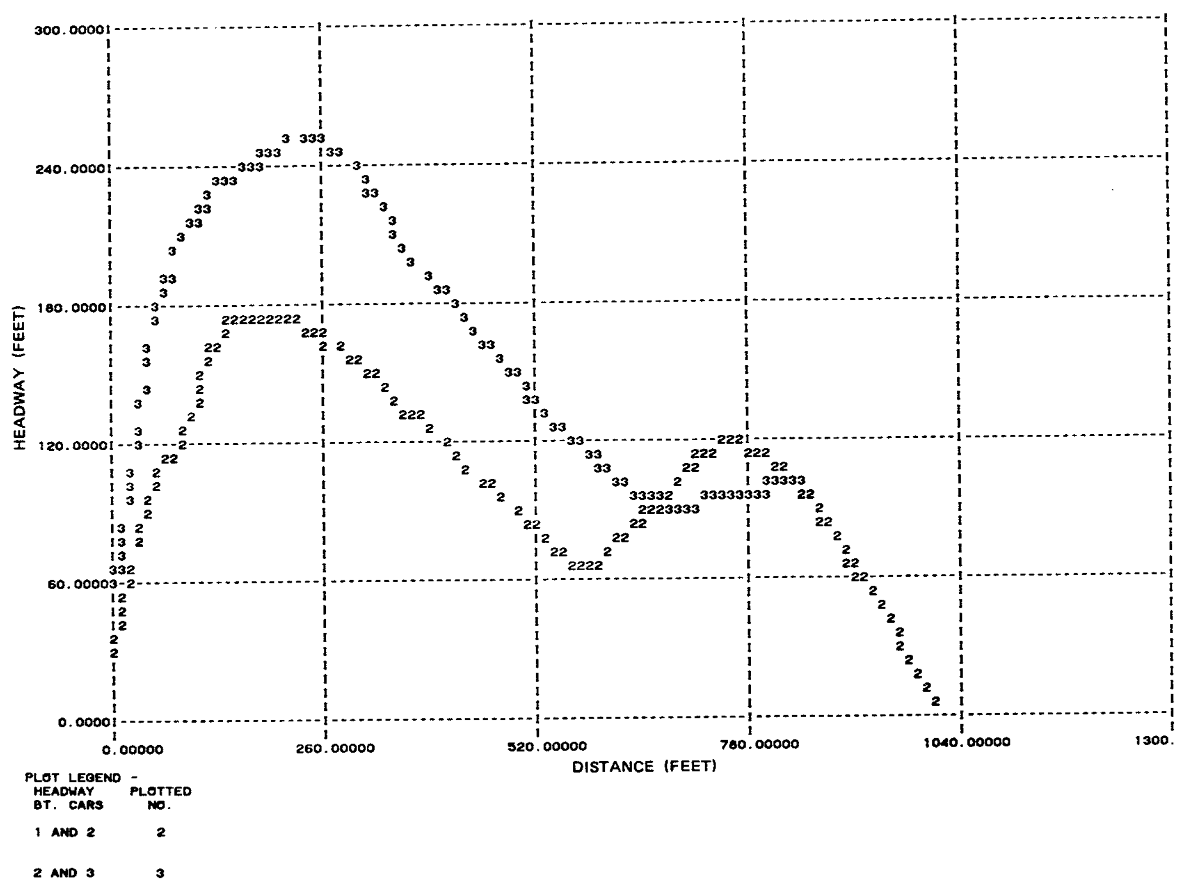
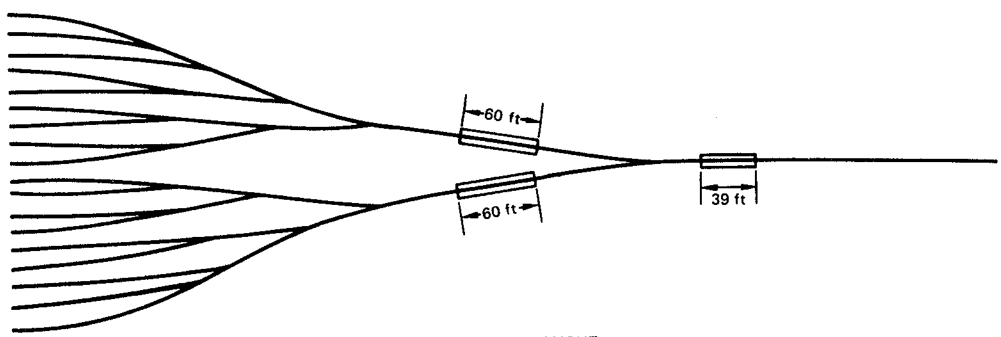
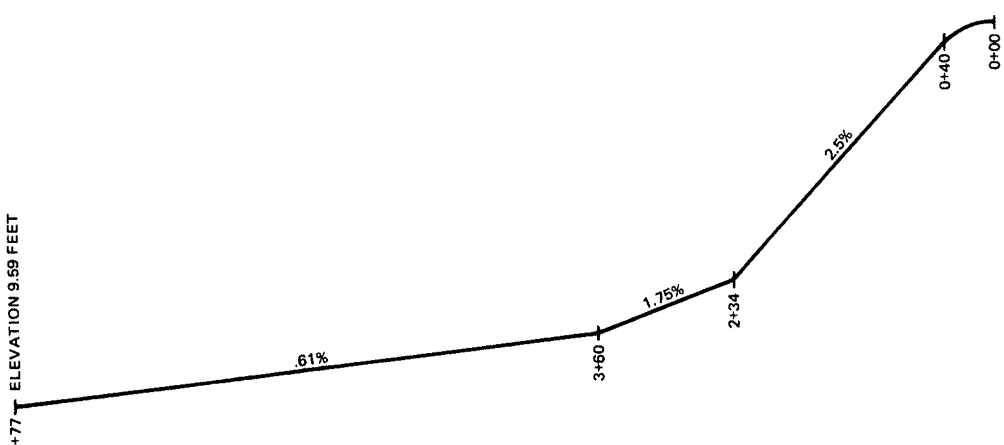


FIGURE 6 COMPUTER PLOTS OF HEADWAY ALONG TRACK NO. 1 (FOR MASTER AND SIX GROUP RETARDERS)



HORIZONTAL LAYOUT



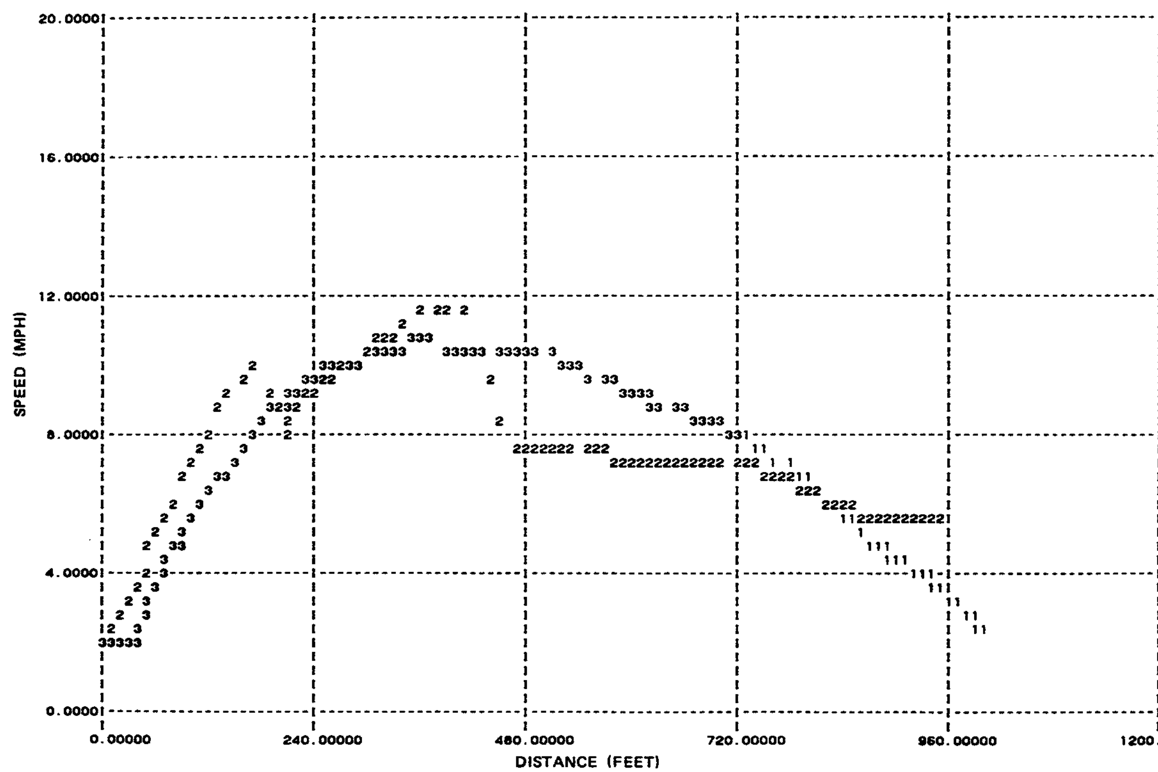
VERTICAL LAYOUT (TRACK 1)

FIGURE 7 HORIZONTAL AND VERTICAL LAYOUTS OF MASTER AND TWO GROUP RETARDER CONFIGURATION

Table 2

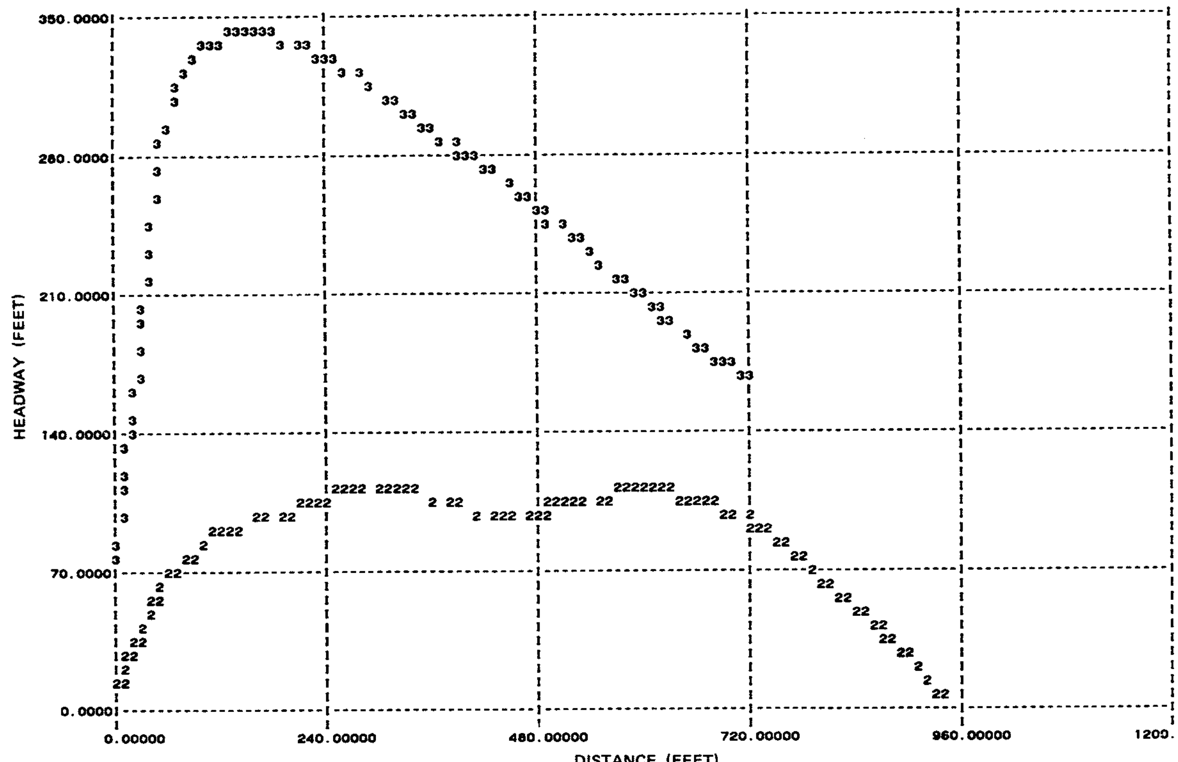
PERFORMANCE CHARACTERISTICS OF THE MASTER AND TWO GROUP RETARDER CONFIGURATION
(Track 1)

Hump speed	3 cars/min
Hard roller stalling point	1,037 ft from the hump crest
Tangent point distance	877 ft from the hump crest
Catch-up point	947 ft from the hump crest
Hard roller speed at T.P.	4.8 mph
Easy roller speed at T.P.	5.6 mph
Retardation amount (master)	2.20 ft
Retardation amount (group)	3.13 ft
Retarder length (master)	39 ft
Retarder length (group)	60 ft



NOTE - PLOTTED NUMBERS ARE CAR NUMBERS

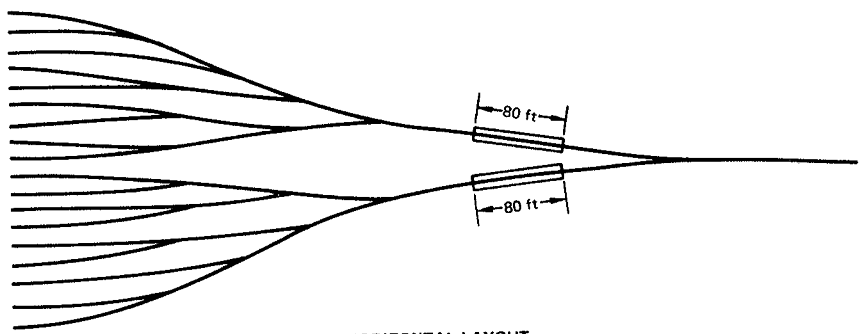
FIGURE 8 COMPUTER PLOTS OF SPEED ALONG TRACK NO. 1 (FOR MASTER AND TWO GROUP RETARDERS)



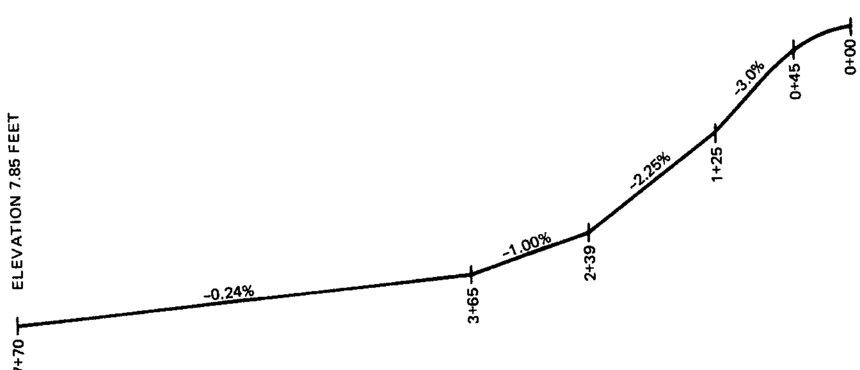
PLOT LEGEND -

HEADWAY BT. CARS	PLOTTED NO.
1 AND 2	2
2 AND 3	3

FIGURE 9 COMPUTER PLOTS OF HEADWAY ALONG TRACK NO. 1 (FOR MASTER AND TWO GROUP RETARDERS)



HORIZONTAL LAYOUT



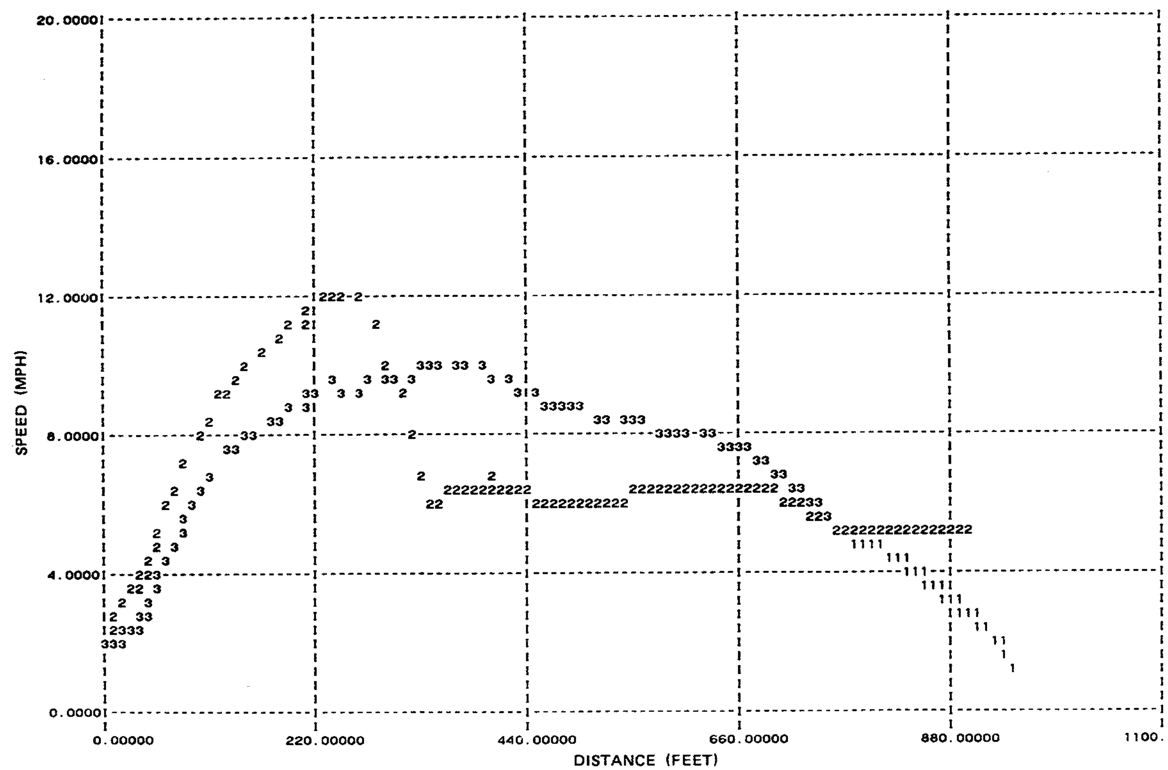
VERTICAL LAYOUT (TRACK 1)

FIGURE 10 HORIZONTAL AND VERTICAL LAYOUTS OF THE TWO GROUP RETARDER CONFIGURATION

Table 3

PERFORMANCE CHARACTERISTICS OF THE TWO GROUP RETARDER CONFIGURATION
(Track 1)

Hump Speed	3 cars/min
Hard roller stalling point	955 ft from hump crest
Tangent point distance	770 ft from hump crest
Catch-up point	891 ft from hump crest
Hard roller speed at T.P.	5.1 mph
Easy roller speed at T.P.	5.2 mph
Retardation amount	4.61 ft
Retarder length	80 ft



NOTE - PLOTTED NUMBERS ARE CAR NUMBERS

FIGURE 11 COMPUTER PLOTS OF SPEED ALONG TRACK NO. 1 (FOR TWO GROUP RETARDERS)

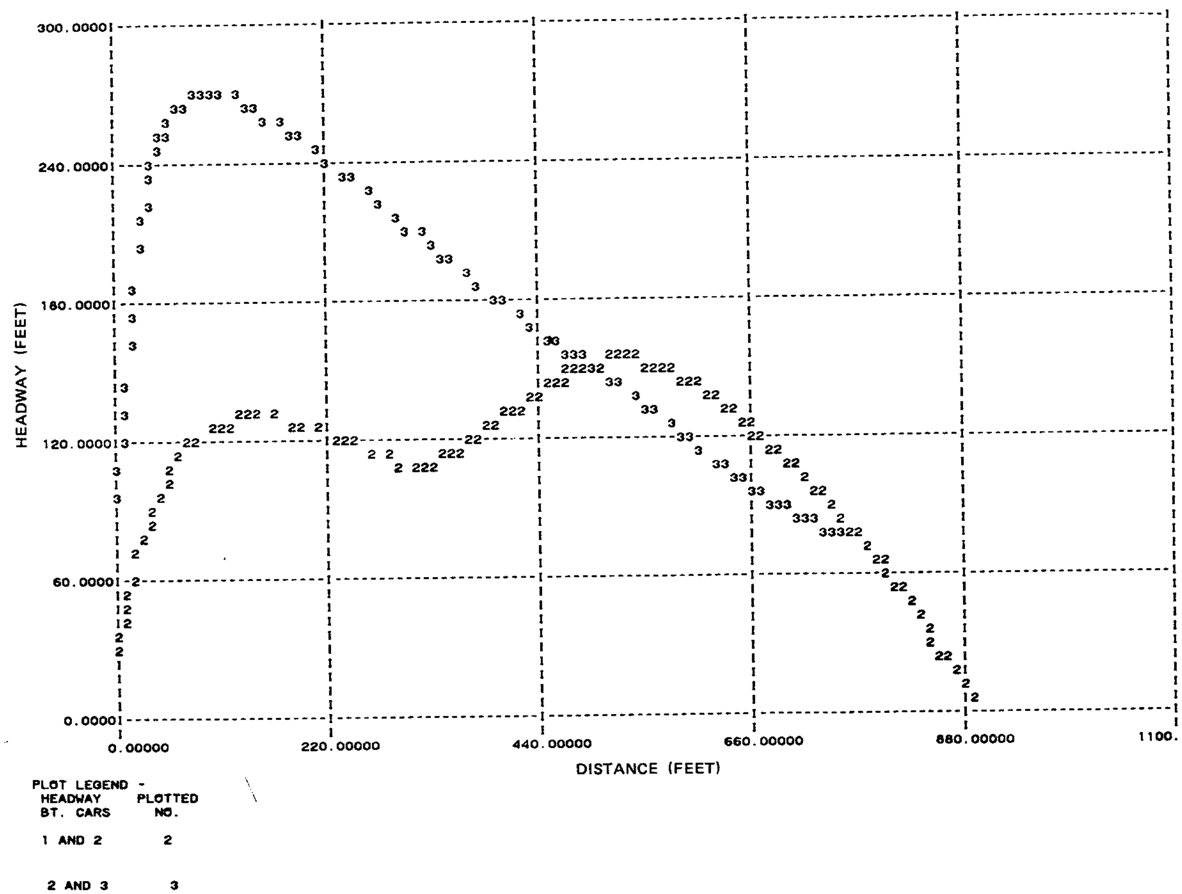


FIGURE 12 COMPUTER PLOTS OF HEADWAY ALONG TRACK NO. 1 (FOR TWO GROUP RETARDERS)

4.0 Capacity Evaluation of Proposed East Deerfield Yard

4.1 Introduction

This section describes the capacity evaluation work conducted for the East Deerfield yard. The purpose of the analysis was to roughly estimate the level of traffic volume that can be handled at the East Deerfield yard under the proposed design and operating conditions.

The computer simulation model CAPACITY, developed by SRI, was extensively used in the analysis. The CAPACITY model is a deterministic accounting model that represents the block movements in the yard following a given set of rules. The model is used as a tool in the yard design process. The yard design process is a trial-and-error process in which the yard designer evaluates his trial designs using this model. In the East Deerfield yard design, only one trial design was evaluated. However, four different traffic levels were tested to determine the level of traffic to be handled by the yard.

The following four scenarios were simulated:

- Scenario I--An average day in East Deerfield Yard, with the addition of traffic resulting from a suspension of switching operations at Springfield Yard: 628 cars/day.
- Scenario II--A heavy day in East Deerfield Yard, with the addition of traffic resulting from a suspension of switching operations at Springfield Yard: 779 cars/day.
- Scenario III--Same input as Scenario II, with traffic increased 6.5%: 828 cars/day.
- Scenario IV--Effects of abnormally heavy traffic. Additional capital investments, as well as a more intensive switching operation, were assumed. Basic traffic was roughly equivalent to that of Scenario II, with abnormally heavy traffic added, but a revamped schedule was developed to utilize East Deerfield as the hub of the four-spoke system: 1,111 cars/day.

This section consists of four major parts. The first part (Subsection 4.2) roughly describes the geometric configuration and operational plan of the proposed yard. The second part (Subsection 4.3) describes the traffic scenarios tested using the simulation model CAPACITY. The third part (Subsection 4.4) describes the assumptions used for CAPACITY model simulation. The fourth part (Subsection 4.5) describes the analysis of outputs from the CAPACITY program. The output summaries are given in Appendices B and C. Appendix B shows the details of hump and trim engine activities, and Appendix C shows the summary statistics of simulation outputs.

4.2 Description of the Proposed East Deerfield Yard

4.2.1 Proposed Yard Configuration

Figure 13 shows a schematic layout of the proposed yard configuration. There is one receiving/departure yard consisting of 8 tracks with a total physical capacity of almost 600 cars (2 tracks hold 94 cars, and the others average 65 cars). There are 18 classification tracks (averaging 68 cars in length) served by a single hump. In addition, there are car-cleaning tracks, a car repair area, and locomotive fueling and repair areas.

4.2.2 Proposed Operating Plan

Several sets of operational parameters to handle the various classifications looked promising. One operating plan for the proposed East Deerfield yard was chosen to be simulated by the CAPACITY model.

4.2.2.1 Hump Engine Utilization

The hump engine is generally used to perform all humping and reswitching functions, if available, including pulling cars from the classification yard back over the hump and rehumping. One hump engine was used for Scenarios I, II and III. Scenario IV required 2 engines on the hump.

4.2.2.2 Trim Engine Utilization

One trim engine was used at the East Deerfield yard for Scenarios I, II, and III. A second trim engine was used in Scenario IV, which also assumed additional capital investment at the trim end. The trim engine can double over class tracks when feasible in performing the task of pulling cars from the classification tracks to the receiving/departure yard. The trim engine does the following work:

Couples (trims) and pulls cars from the classification tracks to the departure tracks.

Couples (trims) and pulls blocks from the classification tracks to the receiving tracks for reswitching by the hump engine (when the hump engine is unavailable or when the cut is too heavy for the hump switcher to pull back up the hump grade).

Pulls blocks from the classification to departure tracks for holding.

Couples (trims) local trains that are to depart directly from the classification yard.

Sets out tracks of cars for local (Greenfield to East Deerfield) customers.

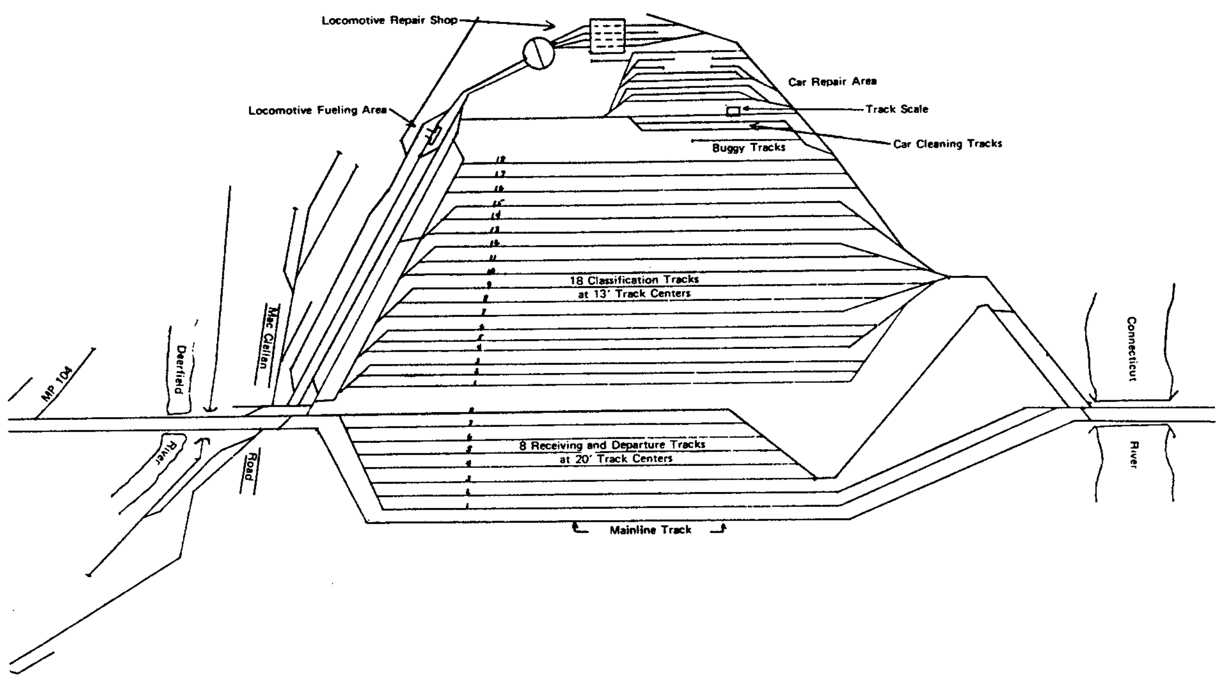


FIGURE 13 PROPOSED SCHEMATIC LAYOUT OF EAST DEERFIELD YARD

4.2.2.3 Classification Track Assignment

Cars are initially classified and humped into the following classification tracks:

Track	Classifications
1	Boston, Yard 21, W. Cambridge, Gardner, Gardner PW, Fitchburg, Ayer, Worcester, Worcester PW (Fitchburg mainline classifications).
2	CP.
3	Nashua, Manchester, Concord (New Hampshire North).
4	Lowell, Lawrence, Dover (West Routes).
5	CV.
6	Chelsea, Lynn Salem (East Routes).
7	Rigby.
8	Springfield CR.
9	CR-Rotterdam Junction.
10	D&H.
11	CN.
12	Holyoke, Springfield B&M, E6, E2, E3, So. Deerfield, Northampton, Mt. Tom, Easthampton, Athol, Orange, Erving, Chicopee, Millers Falls, Bernardston, VTR, Mechanicville town. (AM locals.)
13	Brattleboro CV, Brattleboro B&M, E7 (Dennis-Jamison, Suburban Propane, Agway, Book Press, Case Brothers, Westminster, Bellows Falls, Hinsdale, Ashuelot, Winchester, Keene), Claremont (C&C), White River Junction, Littleton, Whitefield, Groveton, Berlin. (Midnight Locals.)
14-17	Reswitch tracks.
18	B&M cleaners, cripplers, weighers, miscellaneous local blocks.

When further classification is not required, cars are trimmed and pulled from their respective classification tracks by the trim engine at the appropriate scheduled cut-off time and set out and inspected in the receiving/departure yard. Early pulls of full tracks are made by the trim and stored in the departure yard.

When further classification is necessary, groups of blocks can be either pulled from the classification tracks back over the hump by the hump engine or pulled to a receiving track by the trim engine for reswitching. Several times each day, up to 16 blocks were reswitched using Tracks 14-17 to make up several trains at one time. Two of these trains depart directly from the classification yard, thus requiring only coupling by the trim engine. The following block groupings required reswitching:

- Fitchburg mainlines (Track 1).
- New Hampshire North (Track 3).
- West Routes (Track 4).
- East Routes (Track 6).
- AM locals (Track 12).
- Midnight locals (Track 13).
- Cleaners, cripples, weighers, and miscellaneous local blocks (Track 18).

4.3 Traffic Scenarios Tested

Four scenarios were tested by the CAPACITY model to stress the yard. To increase traffic to East Deerfield, trains normally handled at other B&M yards were input to CAPACITY with East Deerfield trains. The first scenario consists of an average volume day (628 cars/day) of East Deerfield traffic to which Springfield yard's traffic is diverted to East Deerfield. The second and third scenarios are heavy volume days (779 and 828 cars/day) in which the Springfield traffic is diverted to East Deerfield. The fourth scenario is a projected day of traffic by B&M (1,111 cars/day) for which new inbound and outbound train schedules were developed to simulate East Deerfield yard as the hub of the B&M system.

Detailed listings of arrival and departure train schedules used in the four scenarios are given in Tables 4 and 5, respectively.

4.4 Assumptions Used for CAPACITY Model Simulation

Two types of assumptions are involved in CAPACITY model application. One is the type of assumptions inherent in the CAPACITY model, and the other is the type of assumptions specifically adopted in each application. The following are inherent in the CAPACITY model.

- A standard cut-off time is applied to all departing trains.
- There are an unlimited number of inspection crews.
- The durations of hump closure vary according to the amount of work required for each reswitching by the hump engine and the duration of crew breaks.
- No humping is performed while a hump engine is performing work in the bowl.
- Humping and trimming can be performed simultaneously.
- The hump engine has enough power to pull cars back over the hump for reswitching.
- Pieces of work are not interrupted for scheduled crew breaks. For example, the crew working the hump will finish humping a train and then take the required crew break in its entirety.
- All engine movement is uninterrupted by external activities, i.e., movements to the engine house, yardings of trains, buggy movements, engine turnaround, and so on.

Table 4

ARRIVAL TRAIN SCHEDULES FOR SCENARIOS I-IV

Train	Arrival Time	Number of Cars		
		Scenario I	Scenario II	Scenario III
LM1	0020	47	52	55
CP904	0130	34	36	38
YE7	0235	65	80	85
SE5	0430	75	91	97
RB30	0525	55	60	64
AP3	0615	33	33	35
WE2	0700	55	60	64
CV447	1900	35*	38*	40*
CV390	2112	43	45	48
NY10	2130	70	83	88
SP2	1400	58†	35	37
SE1	1759		57	61
CP917	2300	58†	35	37
Second CV390	0615		22	24
FEX	1500		22	23
Second AP3	1635		30	32
Total Inbound Cars		628	779	828

Train	Arrival Time	Number of Cars in Scenario IV
BOED	0030	60
MEEDB	0100	71
CP904	0130	36
RIED	0200	41
SAED	0430	91
RJRIB	0600	92
WHED	0700	60
RJRJA	0900	32
MEEDA	1100	67
SPED	1230	58
SP2	1400	35
FEX	1500	22
RJRIA	1600	90
MAED	1730	82
CV447	1900	38
RIRJB	1900	32
RJED	2000	56
CV390	2200	73
CP917	2300	75
Total Inbound Cars		1,111

*Trains E4 and CV447 are simulated together because they would be doubled over on a receiving track.

†Includes cars from train SE1.

Table 5

DEPARTURE TRAIN SCHEDULES FOR SCENARIOS I-IV

Scenario I		Scenario II		Scenario III		Scenario IV	
Train	Schedule Depart Time	Train	Schedule Depart Time	Train	Schedule Depart Time	Train	Schedule Depart Time
CP917	0130	CP917	0200	CP917	0115	CP917	0115
AP3	0300	AP3	0300	AP3	0300	EDWH	0400
EW1	0400	EW1	0400	EW1	0400	EDMEA	0500
RB30	0558	RB30	0730	RB30	0730	RJRIB	0700
ES2	0912	ES2	1000	ES2	1000	RIRJA	0930
E6*	1000	E6*	1000	E6*	1000	CV447	1000
E2*	1000	E2*	1000	E2*	1000	EPSP	1000
BM7	1300	BM7	1300	BM7	1300	E6*	1000
LM1	1900	LM1	1900	LM1	1900	E2*	1000
CV447	2000	CV447	2000	CV447	2000	EDMEB	1400
EY8	2100	EY8	2100	EY8	2100	DBOST	1515
ES6	2130	ES6	2130	ES6	2130	RJRIA	1700
						RIRJB	2000
						EDBO	2000
						EDMA	2130
						EDSA	2200
						EDRJ	2330
						EDRI	2345

*Train departs from classification yard.

The CAPACITY model is still in its development stage. Some of the assumptions listed above will change by the time this model becomes available to the general users.

Other assumptions used by the B&M as inputs to CAPACITY are as follows:

- The receiving/departure yard consists of eight tracks.
- The classification yard consists of 18 tracks of which Tracks 13-17 are used for reswitching.
- Front-end inspections are 5 min per train plus 1 min per car.
- One hump engine works per shift for Scenarios I, II, and III.
- Two hump engines work per shift for Scenario IV.
- The humping rate is 2.7 cars per min.
- Reswitch movements are made by hump and trim engines.
- One trim engine works per shift in Scenarios I, II, and III.
- Two trim engines work per shift in Scenario IV.
- Early pulls are made by the trim engine.
- Trains made up from multiple tracks leave from the receiving/departure yard.
- Trimming is simulated at 0.5 min per car.
- Outbound inspections are 5 min per train plus 0.5 min per car.
- A cut-off time period of 30 min is applied to departing trains. That is, trains can begin being made up 30 min prior to their scheduled departure time. Making this constant small enabled better simulation of reswitches and the like.
- Eight crew-break time periods were selected to approximate actual breaks. In the first three scenarios, the breaks for each shift consisted of 30 min for crew change, 30 min for lunch, and a 15-min coffee break. In Scenarios II and III, late-night work kept second-shift personnel busy until the end of their shift. Thus, only 5 min was lost as third-shift crews came out with fresh engines to relieve the homeward-bound men. In Scenario IV, the breaks were much shorter, to simulate the effect of overlapping shifts.
- The following travel times were determined through analysis of the proposed yard layout
  - Twenty minutes for the hump engine to go down into the receiving yard, pick up a cut of cars, and return to the hump.
  - Twenty-two minutes for the trim-end engine to travel from the departure yard to the classification yard, pick up a cut of cars (not counting trimming time) and bring it to the departure yard.

- Nine minutes for the trim-end engine to travel from one classification track to another (assuming worst case).
- In Scenario IV, the second hump engine was assumed to be only 5 min behind the end of the first engine's cut.
- In Scenario IV, the interference of the two trim-end engines was assumed to cause a 50% delay in any trim-end travel time.

4.5 Analysis of CAPACITY Outputs

CAPACITY was used in an iterative process. Each scenario was run, modified, and rerun until a steady state was achieved in which no bottlenecks were observed on the hump, in the classification yard, or in the back end of the yard, and cars were making the desired connections.

Output from CAPACITY runs provided:

- Receiving-yard occupancy diagram and track requirements.
- Arriving-train histories and hump utilization table.
- Classification yard buildup histories.
- Departure train makeup scenarios including all pulls from the classification yard.
- Departure yard occupancy diagram and track requirements.

Estimation of the East Deerfield yard capacity under the four scenarios was conducted by examining:

- Receiving/departure track requirements.
- Hump and trim engine utilization and number of cars handled by the trim engine.
- Class track requirements.
- Departure train delays.
- Average car detention time in the yard.

4.5.1 Receiving/Departure Track Requirements

The number and length of tracks required in the receiving/departure yard for each scenario were determined by combining the receiving and departure yard occupancy diagrams and track length requirements. The durations of inbound and outbound train occupancies on a receiving and departure track were plotted over a 24-hr period. The number of tracks required to accommodate the traffic for a given scenario is at least the greatest number of trains that occupy receiving/departure tracks simultaneously, and additional tracks required (1) for trains that are longer than the normal track length, and (2) when block swapping occurs. Figures 14 to 17 show, for each scenario, the simulated receiving/departure yard occupancy over 24 hr. Trains requiring track lengths greater than 80 cars were assumed to occupy two tracks.

There appears to be adequate receiving/departure track capacity in the first three scenarios, especially on the average day simulated in Scenario I. Even as the yard reaches capacity on the trim-end constraint, in Scenarios II and III, there is no unresolvable congestion in the receiving/departure yard, as shown in Table 6.

The effect on track requirements of arrival/departure time variation was analyzed. This was accomplished by extending the track occupancy of each train by one hour either way and counting the maximum number of tracks occupied during any amount of time over the 24-hr period.

The results of this analysis are given in Table 7.

In Table 7 it should be noted that on the average day (Scenario I), the receiving/departure yard could begin to congest. This condition is only indicated for a short period of time (15 min) and could be easily avoided by minor rescheduling of trim-end activities. Similar occurrences on the heavy days of Scenarios II and III are slightly more frequent but can also be avoided by the yardmaster. It is apparent that additional tracks are required to accommodate the more frequent and longer trains of Scenario IV.

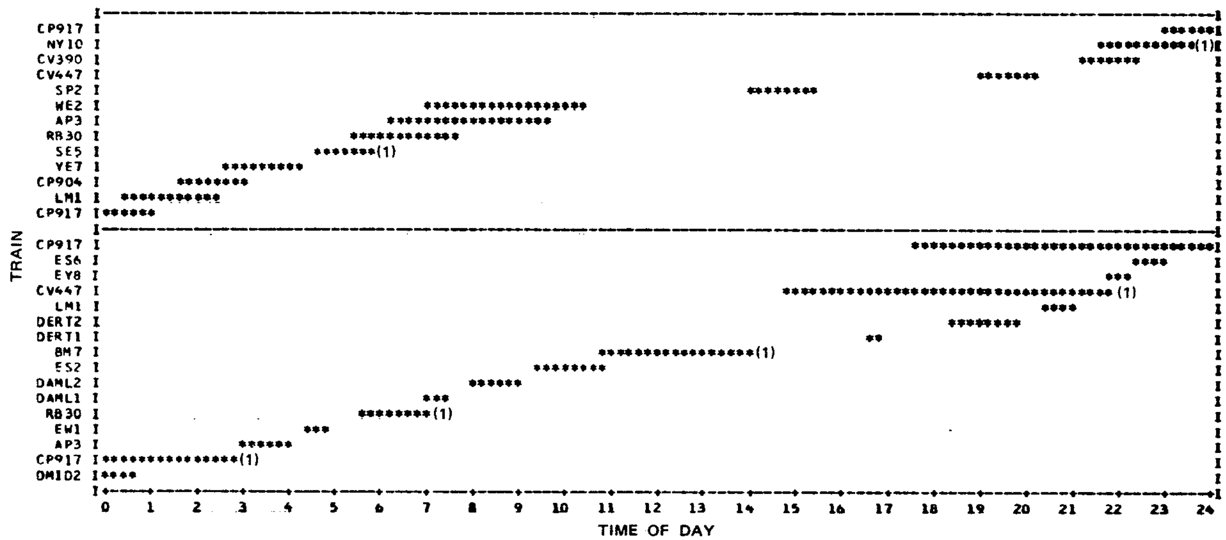
4.5.2 Hump and Trim Engine Utilization and Number of Cars Handled by the Trim Engine

CAPACITY reports the movement of engines at front and back ends of the yard, i.e., between the receiving yard and the hump and between the departure yard and the classification yard. Various types of facility (or crew) utilization rates (or time) were computed using the CAPACITY output. The measures used for the analysis are:

- <u>Hump Utilization</u>--Actual time that cars are moving over the hump, divided by 24 hr.
- <u>Hump Engine Utilization</u>--Time that hump engine is moving or doing work, divided by 24 hr.
- <u>Hump Crew Utilization</u>--Time that hump engine is moving or doing work, divided by time crew is working (24 hr minus shift changes, lunch hours, etc.).
- <u>Trim Engine Utilization</u>--Time that trim engine is moving or doing work, divided by 24 hr.
- <u>Trim Crew Utilization</u>--Time that trim engine is moving or doing work, divided by time crew is working (24 hr minus shift changes, lunch hours, etc.).

A significant amount of time is spent by the hump and trim engines performing reswitching work. The hump and trim engines performed the following reswitches during each scenario. (See Table 8.)

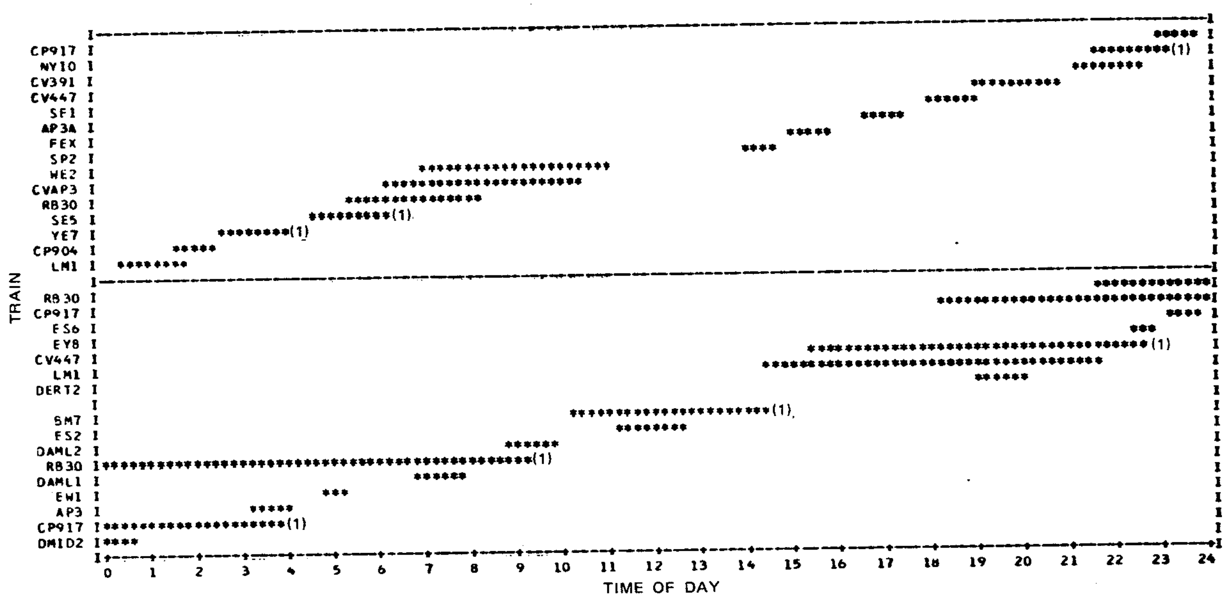
The hump downtime per reswitch was manually included in the hump crew and hump engine utilization calculations. The engine and crew utilization



(1) Train has greater than 80 cars, thus requiring 2 tracks.

NOTE: The following trains were reswitch trains temporarily stored on receiving/departure tracks prior to humping: DERT2, DERT1, DAML2, DAML1, and DMID2.

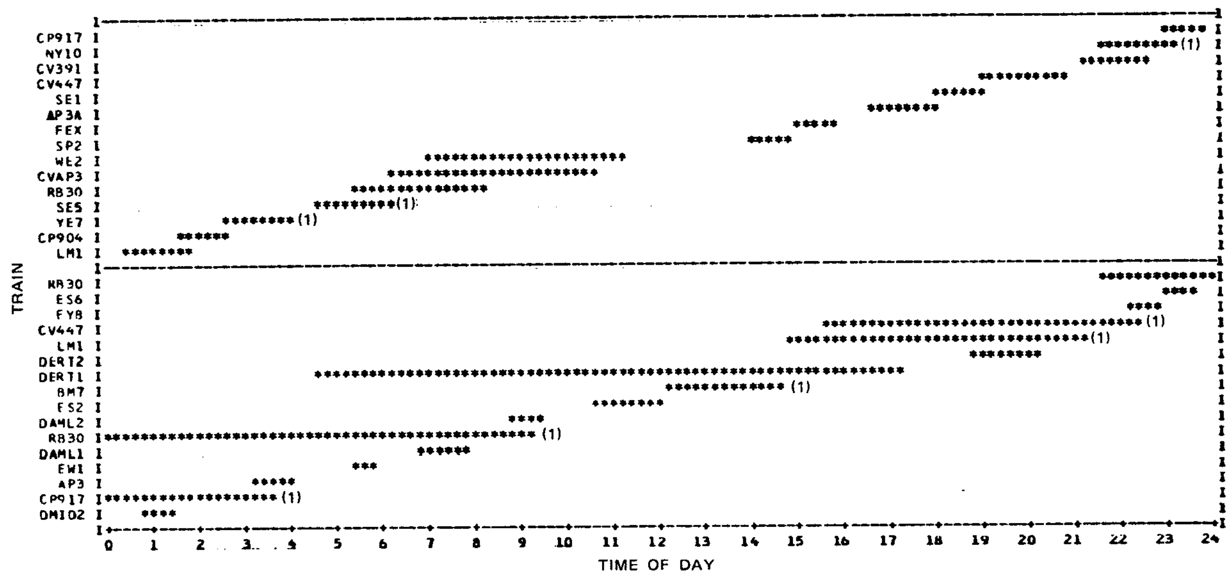
FIGURE 14 RECEIVING/DEPARTURE YARD OCCUPANCY FOR SCENARIO I



(1) Train has greater than 80 cars, thus requiring 2 tracks.

NOTE: The following trains were reswitch trains temporarily stored on receiving/departure tracks prior to humping: DERT2, DAML2, DAML1, and DMID2.

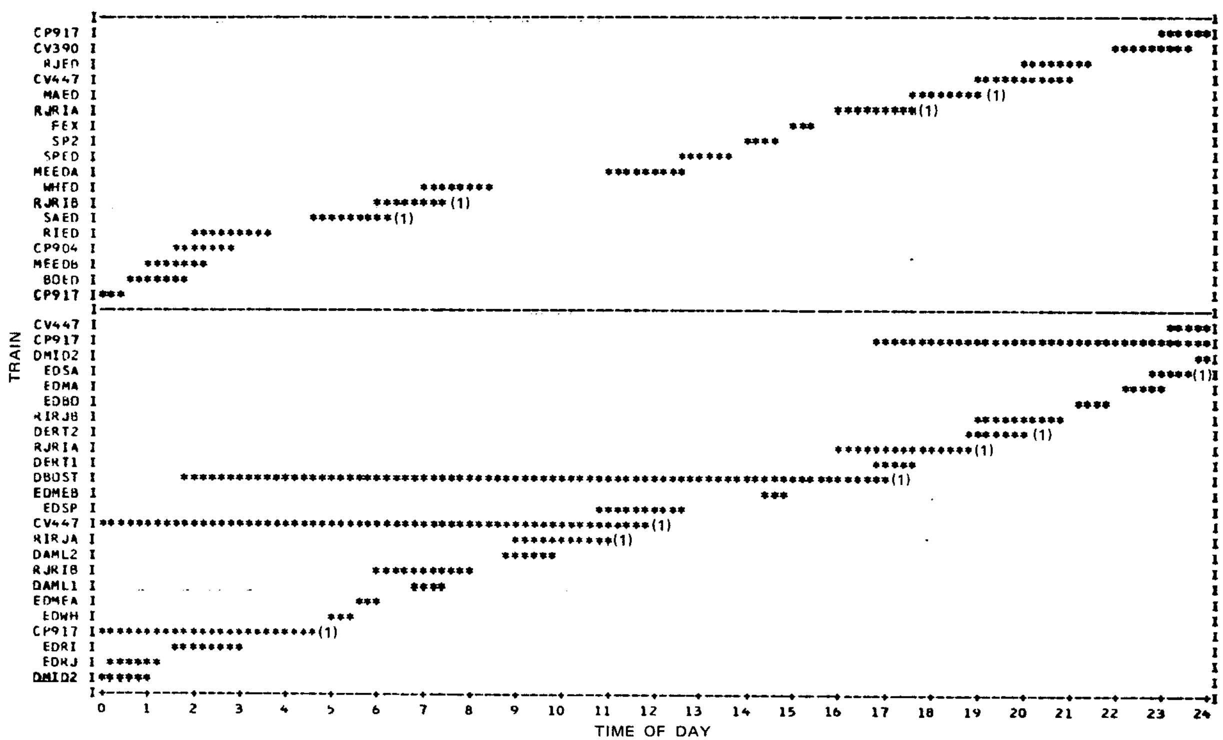
FIGURE 15 RECEIVING/DEPARTURE YARD OCCUPANCY FOR SCENARIO II



(1) Train has greater than 80 cars, thus requiring 2 tracks.

NOTE: The following trains were reswitch trains temporarily stored on receiving/departure tracks prior to humping: DERT2, DERT1, DAML2, DAML1, and DMID2.

FIGURE 16 RECEIVING/DEPARTURE YARD OCCUPANCY FOR SCENARIO III



(1) Train has greater than 80 cars, thus requiring 2 tracks.

NOTE: The following trains were reswitch trains temporarily stored on receiving/departure tracks prior to humping: DMID2, DERT2, DERT1, DAML2, DBOST, DAML2, DAML1, and DMID2.

FIGURE 17 RECEIVING/DEPARTURE YARD OCCUPANCY FOR SCENARIO IV

Table 6

RECEIVING/DEPARTURE TRACK REQUIREMENTS

Scenario	Maximum No. of Trains	Maximum No. of Tracks Required	Maximum No. of Cars in the Receiving/Departure Yard
I	5	7	325
II	6	8	400
III	5	7	345
IV	6	10	455

Table 7

SENSITIVITY ANALYSIS ON RECEIVING/DEPARTURE TRACK REQUIREMENTS

Scenario	Maximum No. of Trains	Maximum No. of Tracks Required	Maximum No. of Cars in the Receiving/Departure Yard
I	8	10	488
II	9	11	549
III	8	11	589
IV	8	13	606

Table 8

RESWITCHING ACTIVITIES DURING SCENARIOS I-IV

Classification Track	Classifications	Total Daily Reswitching Time	
		Scenario I	Scenario II
12*	AM locals	2 hr, 40 min	3 hr, 12 min
18	Cleaners, local, cripples (total for 3 times daily)	2 hr, 22 min	2 hr, 28 min
1,3,6*	ES6/EY8	4 hr, 04 min	4 hr, 45 min
13*	Midnight locals	2 hr, 35 min	3 hr, 04 min
4	West routes	37 min	46 min

Classification Track	Classifications	Total Daily Reswitching Time	
		Scenario III	Scenario IV
12*	AM locals	3 hr, 15 min	3 hr, 20 min
18	Cleaners, local, cripples (total for 3 times daily)	2 hr, 32 min	2 hr, 28 min
1†	Fitchburg mainline classifications		2 hr, 23 min
1,3,6*	ES6/EY8 (EDSA/EDMA)	4 hr, 49 min	5 hr, 55 min
13*	Midnight locals	3 hr, 05 min	3 hr, 27 min
4‡	West routes	46 min	1 hr, 38 min

*Indicates two-stage reswitching.

†In Scenario IV, the combined cars of Track 1 (and its two early pulls) were reswitched, with EDBO cars (Boston and Yd21) going to Tracks 3 and 6 (now empty) and EDSA/EDMA cars going onto the appropriate reswitch tracks, to be combined with the rest of the upcoming first reswitch at EDSA/EDMA, in Tracks 14-17.

‡Total for twice daily in Scenario IV.

details can be found in Appendices B and C. Statistics for Scenario IV are for two switch engines at each end of the yard. Overtime was required in each scenario. Resultant crew and engine utilization statistics for Scenarios I-IV are given in Table 9 and Figure 18.

The hump utilization statistics are low and reveal no problems on the hump. It was important, however, that Scenarios I-IV allowed enough time for the hump engine to perform the required reswitching work.

It was assumed that the maximum utilization that can be expected of a switch engine during a 24-hr period is about 80%. Statistics for Scenarios I and II, an average day and a heavy day, fall below 80% utilization of the trim and hump engines. Scenario III, however, approaches maximum utilization of the hump engine and the trim engine.

Another measure of trim engine efficiency is the number of cars handled per engine. It was assumed that the maximum number of cars that one trim engine can handle is about 500 cars per shift. The results of the four scenarios are summarized in Table 10.

The number of cars handled per trim engine per shift does not exceed 500 in any of the four scenarios. The maximum handling of cars by the trim engines occur during the second shift, except in Scenario III where it occurs in the first shift. Scenario III heavily works the trim engine, moving 71 to 92% of the number of cars a trim engine is capable of handling during a shift.

4.5.3 Classification Track Requirements

The proposed 18 classification tracks constraint was tested. The proposed capacities of the classification tracks vary, averaging 68 cars in length. When specified classification track lengths are exceeded, the model reports the number of extra tracks of the same length required to store the block of cars. During the iterative process, optional early pulls were simulated until most of the specified track limits were maintained.

Early pulls from the classification yard to the receiving/departure yard were made as follows.

Scenario I			Scenario II		
Trk	Time	Cars	Trk	Time	Cars
7	0454	60	9	0929	50
9	1005	60	10	1338	70*
11	1406	57	11	1435	60
2	1656	53	2	1730	47

Scenario III			Scenario IV		
Trk	Time	Cars	Trk	Time	Cars
1	0358	47	1	0056	45
9	1115	77*	1	0409	56
10	1351	75*	2	1609	32
11	1451	60	11	2221	52
2	2314	71*			

Only Scenario I has excess Rigbys on Track 7. In later runs the Rigbys on arriving Train NY10 were simulated as a bypass block, as currently practiced. Early pulls for CRs and D&Hs (Tracks 9 and 10) became unnecessary with the more frequent movements of Scenario IV. In Scenario IV, CRs, D&Hs, and Rigbys departed three times per day, thus keeping the classification yard fluid. The classification yard remained fluid in all the scenarios as long as there was adequate space in the receiving/departure yard to pull full tracks. If there is a problem with trim engine availability or tracks out of service, the track space in the classification yard can become a critical bottleneck at East Deerfield, especially in Scenario III. Scenario IV depends on additional receiving/departure tracks and switch engines to keep the classification yard fluid as discussed earlier in this section.

4.5.4 Departure Train Delays

Train delays are reported in the CAPACITY train makeup scenarios. Train delays were evaluated for reasonableness and effect on the overall operation of the yard. Various factors can contribute to train delays, such as:

- Time between start couple time and scheduled departure time insufficient to make up long trains or trains requiring several pulls.
- Trim engine unavailability for train makeup.
- Delay in reswitching operations.
- Inefficient scheduling of train makeup or humping.
- Unavailable road power for train to depart (not simulated).

Table 11 summarizes the departure of all the trains during the 24-hr period for each scenario. In Scenario I, the average day, trains departed at times that seem reasonably accurate and practical. The simulation of Scenarios II and III resulted in the majority of trains being delayed 30 to 60 min. This train lateness is not out of line with what would be expected to occur during an unusually heavy day.

4.5.5 Average Detention Time

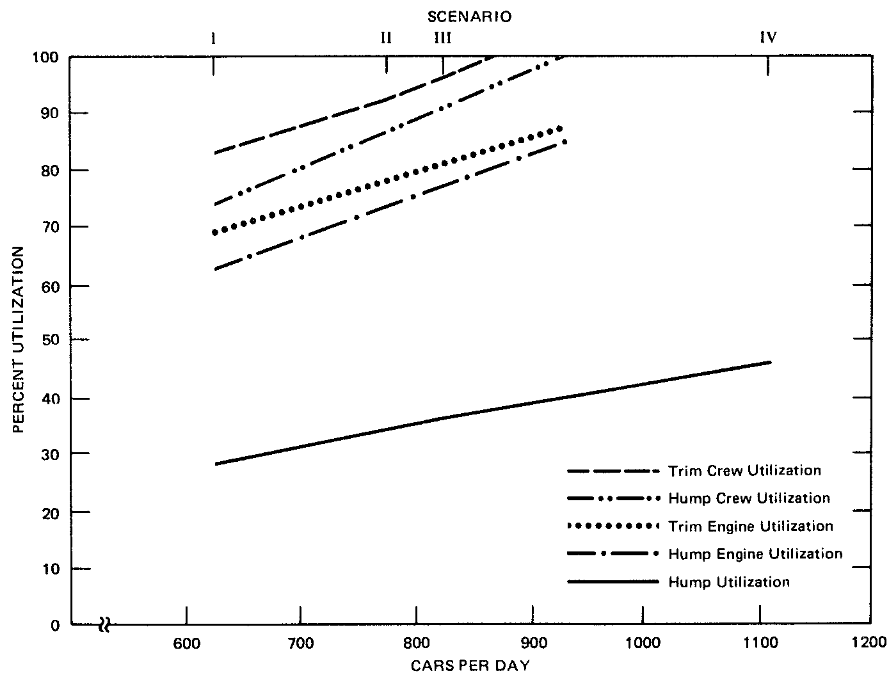
Average detention time is an excellent indicator of a yard's efficiency, but is heavily

*Excess cars were allowed to overflow onto neighboring tracks.

Table 9

UTILIZATION OF SWITCHING CREWS AND ENGINES

	Scenarios			
	I	II	III	IV
Percent hump utilization	27.9	34.2	36.6	45.9
Percent hump engine utilization	62.6	72.7	76.8	46.6
Percent hump crew utilization	74.2	86.2	91.0	55.2
Percent trim engine utilization	69.9	77.4	81.0	64.9
Percent trim crew utilization	82.9	91.8	96.0	77.0
Overtime required (hours)	0.5	1.6	1.8	0.5



NOTE: The hump and trim crew and engine utilizations are not shown for Scenario IV because two engines and crews were utilized.

FIGURE 18 RESOURCE UTILIZATION

Table 10

NUMBER OF CARS HANDLED* BY TRIM ENGINE

Shift	Scenario I	Scenario II	Scenario III	Scenario IV	
				Engine 1	Engine 2
0700-1500	251	367	459	119	217
1500-2300	394	498	364	288	327
2300-0700	266	239	353	244	285
Total	911	1,104	1,176	651	829

*The number of cars handled includes each time cars are pulled to the hump for reswitching, the cars that are coupled to leave from the classification yard, and all the pulls to the departure yard.

Table 11

DEPARTING TRAINS IN SCENARIOS I-IV

Train	Scenario I		Scenario II		Scenario III	
	Time	Cars	Time	Cars	Time	Cars
CP917	0251	89	0342	107	0332	112
AP3	0358	16	0359	18	0403	25
EW1	0449	37	0510	44	0552	47
RB30	0658	82	0909	101	0917	111
ES2	1053	66	1233	79	1156	86
E6	1147	8	1231	10	1323	11
E2	1201	6	1246	7	1338	8
BM7	1355	75	1421	89	1438	98
LM1	2102	60	2131	80	2116	80
CV447	2149	83	2231	107	2220	112
EY8	2209	40	2253	53	2242	56
ES6	2257	45	2346	58	2338	62

Train	Scenario IV	
	Time	Cars
EDRJ	0116	50
EDRI	0304	77
CP917	0433	115
EDWH	0522	44
EDMEA	0557	24
RJRIB	0803	72
RIRJA	1057	93
CV447	1148	121
EDSP	1233	73
E6	1133	8
E2	1152	5
EDMEB	1447	40
RJRIA	1842	84
RIRJB	2045	54
EDBO	2153	61
EDMA	2255	78
EDSA	2335	87

dependent on the operational strategy utilized. For example, as will be shown below, moving classifications out of the yard more than once a day does much to reduce average detention time. An accurate calculation of the average time cars spend in the East Deerfield yard during a 24-hr period was derived from CAPACITY reports. In Table 12 the yard-wide car detention times are summarized for all four scenarios, as well as detention figures for the last three runs, which exclude cars that bypassed the hump.

In the first three scenarios, most classifications move once each day. Therefore, the expected value of detention time in the classification yard alone is 12 hr per car, although planned connections decrease that somewhat in actuality. In Scenario IV, when many blocks move twice or even three times, we see a marked drop in detention time. Therefore, there is a benefit to be gained for almost all cars through yard consolidation, provided the work can be handled in just one place.

The current average detention time per car at East Deerfield yard is approximately 31 hr. The average detention figures from the East Deerfield CAPACITY runs indicate that the new plan would significantly improve the yard operations. Figure 19 shows a constant level of efficiency even as the yard approaches capacity. However, the addition of any more traffic would cause the average detention time to rise sharply.

4.6 Conclusions

The general operating feasibility of each scenario was determined, taking into account track, engine, and crew requirements.

Because track space is the most critically restrained resource at East Deerfield, adequate physical capacity at all times is a necessity. Cars in classification tracks can be pulled to the receiving/departure yard, but from the receiving/departure yard there is no place to go. As receiving/departure tracks become full, power availability, unexpected traffic levels, and tracks out of service become an increasing concern.

After physical space, engines and crews are a yard's most constrained resources. In the East Deerfield study, they proved to be the most limiting factor of the proposed yard's capacity. While most utilization figures are important, crew utilization is most crucial.

On a day-to-day basis, the yard should handle its traffic with ample fluidity.

Scenario I depicts what should be the day-to-day operation of East Deerfield Yard, with the closing of Springfield Yard. At some 628 cars/day, the CAPACITY results show the yard to be fluid and efficient. There is ample time to do all the work required each day; meeting schedules and deadlines seems to pose few problems. Track capacities are seldom reached, and crew and switch engine utilization statistics are well within reason.

Scenario II indicates that with careful yardmastering, constant work, and no unforeseen problems, the addition of 150 cars/day will not choke the yard. the receiving/departure yard can become congested for brief periods. Trains are delayed around 30 to 60 min. The hump-and-trim crew and engine utilizations are high but no greater than what could be expected during an unusually heavy volume day. Some overtime is required to perform the work.

Although the yard remains fluid in Scenario III, the yard capacity is approached. Beyond the level of 800 to 830 cars, the yard becomes congested and begins to fall behind.

Scenario IV demonstrates that East Deerfield could handle an abnormally heavy amount of traffic with the addition of two or three more receiving/departure tracks and one or two more classification tracks. In addition, a second trim-end pullout lead is required, and four engines per shift are necessary. Without all of these additional investments, the scenario could not operate.

The yard's capacity has been determined on the basis of certain block mixes of incoming cars. With different block mixes or a different arrival schedule, yard capacity could be slightly higher or lower. Humping rate can probably go higher, because the hump profile is designed for a higher humping rate (3 cars/min) than the value (2.75 cars/min) used in the CAPACITY simulation. Detention time may actually be slightly higher depending on availability of inspectors, locomotives, and the like. External activities, like movements to the engine house, yardings of trains, track occupancy by trains for fueling, caboose switches,

Table 12

AVERAGE DETENTION TIME
(Hours)

	All Cars	Humped Cars Only
Scenario I	17.03	17.03
Scenario II	17.25	17.53
Scenario III	17.29	17.57
Scenario IV	13.31	14.71

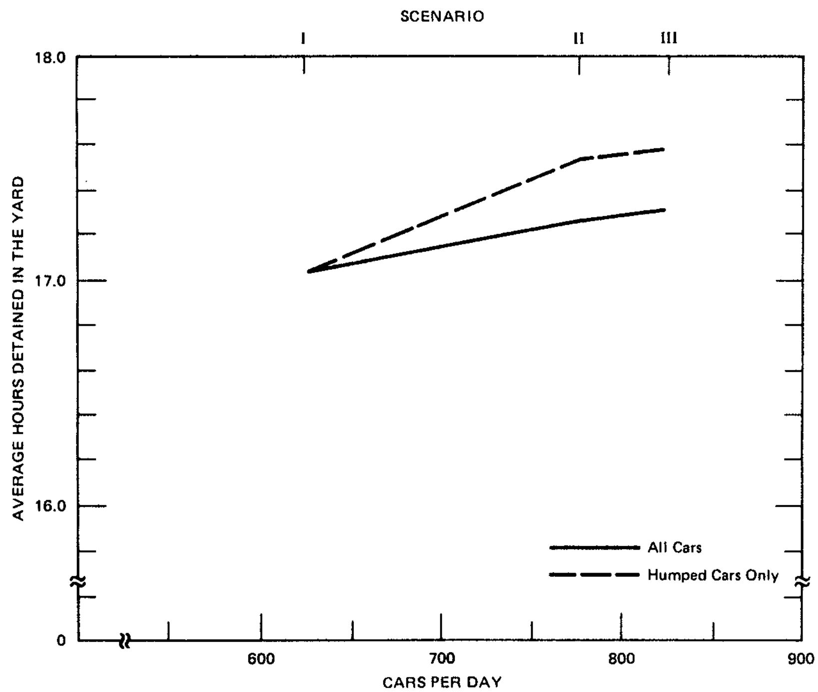


FIGURE 19 AVERAGE DETENTION TIME UTILIZING ONE HUMP AND TRIM ENGINE

and engine turnaround interfere with the work of the switch engines, and can cause delays. These delays are not present in CAPACITY. Primarily at the trim end, they reduce the practical capacity of the new yard by a small amount.

Appendix A

SPECIFICATIONS FOR CAR RETARDERS, CONTROLS, AND SWITCH MACHINES FOR BOSTON AND MAINE CORPORATION, E. DEERFIELD, MASSACHUSETTS

Office of Vice President--Engineering
Boston and Maine Corporation
Iron Horse Park
N. Billerica, MA 01862

SPECIFICATIONS

The equipment to be furnished shall consist of that required for an 18-track gravity classification yard with a hump retardation system, 18 inert skate retarders (one on each class track), and 17 switch machines together with control panel, power source, and control apparatus.

Performance Requirements

The retardation system shall meet the performance levels stated below:

A. The humping speed shall be 3 cars/min or higher; cars are assumed to be 55 ft long.

B. The rate of misswitching shall not exceed 1/1,000 for total cars humped.

C. Cars shall not stall before the tangent point of each class track.

D. At least 90% of the cars shall couple on the class tracks with the speed less than 6 mph.

E. The maximum speed on the switch and curve segments shall be less than 16 mph.

Alternative Retarder Configurations

The retarder configuration shall be any one of the four alternative configurations described below. However, any proposed configuration must meet the performance requirements listed above.

Alternative 1 consists of retardation mechanism that can meet the performance requirements listed above. The bidder proposing this alternative is free to choose the retarder, the configuration, and the hump profile design.

Alternative 2 consists of one hydraulic weight responsive primary retarder (ahead of first switch), and six secondary retarders (each ahead of three class tracks group). A rough geometric design of this system is supplied to bidders.

Alternative 3 consists of one hydraulic weight responsive primary retarder (ahead of first switch), and two secondary retarders (each ahead of nine class tracks group). A rough geometric design of this system is supplied to bidders.

Alternative 4 consists of two retarders (each ahead of nine class tracks group). A rough geometric design of this system is supplied to bidders.

Retarders

Clasp-Type Retarders

In the event that conventional clasp-type retarders are used, the retarders shall be hydraulically operated weight responsive, and shall meet the following requirements:

A. Can take velocity heads out of 160-ton, 4-axle, 36" wheel car.

B. Maximum working hydraulic pressure shall not exceed 2,500 psi.

C. The dimensions and clearances of retarders shall be such that when installed, all normal standard gauge railroad cars and diesel locomotives may be operated through the retarders without contact when retarders are in "open" position.

D. Retarders shall be shipped fully assembled insofar as possible, ready for installation. Buyer will install retarders and will furnish and install all necessary timber supports, guard rails, and compromise joints.

   If the supplier cannot furnish the running rail and abrasion rail and also cannot ship units assembled, he should state so.

E. Bidder may bid the retarders on any of the following plans and will state which plan is the basis of his bid:

   a) Abrasion surfaces to be replaceable steel shoes, furnished by supplier indicating unit price.

   b) Abrasion surfaces to be new 115-lb RE rail, furnished by supplier.

c) Abrasion surfaces to be new 115-lb RE rail, furnished by railroad with freight allowed to supplier's fabrication plant.

d) Same as Plan C except that buyer, at buyer's expense, will flash butt-weld the abrasion rail into any desired length up to 70 ft each so as to form one continuous abrasion surface through each retarder without the necessity of end flares between the individual retarder units of each track.

If bidder proposes to furnish running rails with the retarder, he should so state. If furnished, rails should be new 115-lb RE section.

F. Retarders of Alternative 2 shall be capable of taking the following velocity heads (level track rating):

Retarder Number	Velocity Head	Contemplated Total Length
Primary	1.92 ft	34 ft
Secondary-1	3.81 ft	70 ft
-2	2.79 ft	48 ft
-3	2.39 ft	42 ft
-4	2.39 ft	42 ft
-5	2.79 ft	48 ft
-6	3.81 ft	70 ft

G. Retarders of Alternative 3 shall be capable of taking the following velocity heads (level track rating):

Retarder Number	Velocity Head	Contemplated Total Length
Primary	2.20 ft	39 ft
Secondary-1	3.13 ft	60 ft
-2	3.13 ft	60 ft

H. Retarders of Alternative 4 shall be capable of taking the following velocity heads (level track rating):

Retarder Number	Velocity Head	Contemplated Total Length
Primary-1	4.61 ft	80 ft
-2	4.61 ft	80 ft

Nonclasp-Type Retarders

In the event that nonclasp-type retarders are used, the retarders should meet the following specifications.

A. The dimensions of retarders shall be such that when installed, all normal standard gauge railroad cars and diesel locomotives may be operated through the retarders without any damages.

B. Retarders shall be shipped fully assembled insofar as possible, ready for installation. Buyer will install retarders and will furnish and install all necessary timber supports, guard rails, and compromise joints.

Pumps, Valves, and Lines

This section applies to hydraulically operated weight-responsive retarders.

A. Bidder will furnish all required motors, pumps, accumulators, valves, and connections. Valves shall be provided at each retarder so individual retarders may be made inoperative with the remaining retarders in service.

B. Two electric motors and two hydraulic pumps shall be furnished with one pump leading and the second pump to cut in automatically when pressure requires. Pumps to be arranged so that the loading-trailing arrangement can be alternated. If supplier proposes an air-assisted hydraulic system, supplier shall furnish the necessary air compressors.

C. Electric motors for pumps shall be 3-phase, 220/440-volt, 60-cycle with 120-volt control.

D. Pump control wiring must comply with Commonwealth of Massachusetts Electrical Safety Orders and any local codes that may apply.

E. Buyer will furnish and install necessary electric cable, conduit, and hydraulic piping from pump house to retarders and return. Bidder shall furnish connections at each end of hydraulic lines together with all required valves.

F. Buyer will furnish and install pump house, including foundation. Bidder shall furnish cases for any required hydraulic control stations. Foundation will be supplied by buyer.

G. Buyer will furnish all required hydraulic oil to supplier's specifications.

Quantity and specifications of hydraulic oil required shall be stipulated in quotation.

Controls

Controls will be provided to function automatically to satisfy the specified performance requirements. Paragraphs A through E of this section apply to systems using hydraulic weight-responsive retarder systems. Paragraphs F through H apply to all the alternatives.

A. Controls will be factory-wired and furnished fully assembled, enclosed in weather-tight instrument cases. Buyer will furnish foundations for the instrument cases.

B. Controls will be arranged so that when control panel at the crest is placed in "hump" position, pumps will start. Impulse will be provided so that indication light will show at crest when working pressure has been reached. When control lever at crest is placed in "trim" position, retarders will open and stay open so cars may be pulled out of bowl. Pumps will shut off when control is placed in "off" position.

C. Release speed controls will be arranged so that they may be altered by a signal maintainer by changing printed circuit cards or by other convenient means.

D. Bidder shall furnish all necessary control apparatus, including control panel at crest. Buyer will install wire and cables between control panel and pump house and between pump house and retarders. Buyer will install retarders.

E. Control panel will include a F-N-S lever. With the lever set in "F," the retarders will automatically release cars at 1 mph faster than "N." With the lever set in "S," the retarders will automatically release cars at 1 mph slower than "N." Control panel shall also include toggle switches to permit placing each retarder independently into Manual Open, Manual Closed and Automatic.

F. Bidder to provide automatic switching. Automatic switching to include four car memory and to be such that it will be necessary to push only one button for each car or cut of cars to be switched.

G. Bidder to provide lock-up circuit on the 17 power switches so that switch cannot be thrown between trucks or when following car is closely approaching. Buyer will furnish necessary track circuit or presence detectors for lock-up circuits. If the bidder cannot provide lock-up circuits he should so state.

H. Bidder to furnish, without extra charge, the service of a qualified factory engineer for advice in installing and testing the equipment.

Switch Machine Specifications

Bidder shall furnish 17 noninterlocked power switch machines to be adjustable so as to provide 4-3/4 inch throw at the No. 1 rod. Machines are to be equipped with connecting rod. Weight of rail will be 115-lb RE.

Machines may be powered by either air, electric, or hydraulic power.

Machines must be such that they can be remotely operated from the crest, hand-operated at the location of the turnout (or as an alternate, be equipped with a button on the switch machine so they can be power-operated at the location of the turnout) and be trailable by engines or cars without damage.

Switch machines are to be so equipped that if points do not complete the throw because of an obstruction in the points, they will return to the original position.

Bidder shall specify whether machines are to be equipped with a target that properly indicates the position of the switch or, as an alternate, equipped with indicator lights at the turnout.

Maximum throwing time shall be 1 second.

Buyer is to install switch machines.

Inert Skate Retarders

Eighteen inert skate retarders shall be furnished for Tracks Nos. 1-18. Each skate retarder shall be capable of removing 1.75 ft of velocity head (level-track rating) from a 160-ton 4-axle car with 36" wheels. Buyer will furnish necessary timber supports, 115 RE running rail, and guard rail.

Hump Signals

Bidder shall furnish four hump signals, including mast. Buyer will provide foundations. Signal masts, heads, and cases shall be made of aluminum.

General

Bidder shall furnish full description and diagram with bid, showing thereon general arrangement and layout of equipment to be furnished by supplier, together with an approximate bill of material (hydraulic piping, and the like) to be furnished by buyer. Bidder shall furnish, with bid, make and catalog number of all major electrical components, such as motors, starters, and the like. Bidder shall separately quote the price of inert skate retarders.

Equipment shall be guaranteed to meet the specifications and to operate satisfactorily for a period of 12 months after initial testing and adjustments.

If bidder desires to submit quotation on equipment alternative to the above that would accomplish the desired results, he may so bid, provided he clearly outlines any and all deviations from these Specifications.

Upon delivery of any equipment or system or performance of engineering, invoices will be accepted and payment made in an amount not to exceed 80% of the amount of the invoice. When the system is placed in revenue service, 50% of the money withheld will be released. The balance of the money withheld will be paid upon satisfactory performance in accordance with all pertinent criteria and specifications together with completion of contract, provided no claims exist.

Buyer reserves the right to accept a bid or portions of bids or to reject any or all bids.

Appendix B

DETAILS OF HUMP AND TRIM ENGINES ACTIVITIES

Table B-1

HUMP ENGINE ACTIVITIES
(Scenario I)

	Min	Time	Task
1st Shift	24	0710-0734	AM locals, 1st reswitch
	40	0734-0814	RB30
	44	0814-0858	Switching out local cars, cleaners, etc.
	34	0858-0932	AM locals, 2nd reswitch
	32	0932-1004	AP3
	40	1019-1059	WE2
	32	1240-1312	Cleaned and repaired cars
	33	1312-1345	Switching out local cars, cleaners, etc.
Total	279		
2nd Shift	41	1520-1601	Springfield pickup SP2
	46	1640-1726	ES6/EY8, 1st reswitch
	46	1925-2011	ES6/EY8, 2nd reswitch
	38	2011-2049	CV447 and E4
	51	2135-2226	Midnight locals, 1st reswitch
	36	2226-2302	CV390
Total	258		
3rd Shift	46	2332-0018	NY10
	46	0018-0104	Midnight locals, 2nd reswitch
	41	0104-0145	CP917
	33	0145-0218	Switching out local cars, cleaners, etc.
	37	0218-0255	LM1
	33	0255-0328	CP904
	44	0413-0457	YE7
	37	0457-0534	Reswitch of West Routes
	48	0550-0638	SE5
Total	365		
Grand Total	902	62.6% hump engine utilization 74.2% hump crew utilization	

Table B-2

TRIM ENGINE ACTIVITIES
(Scenario I)

	Min	Time	Task
1st Shift	64	0730-0834	AM locals, 2nd pullout
	77	0842-0959	ES2
	52	0959-1051	Early pull, ConRails
	26	1106-1132	Couple E6 and E2 for Class Yd. departure
	30	1243-1313	BM7
	51	1400-1451	Early pull, CNs
Total	300		
2nd Shift	65	1530-1635	ES6/EY8, 1st pullout
	49	1650-1739	Early pull, CPs
	87	1739-1906	ES6/EY8, 2nd pullout
	52	1936-2028	LM1
	35	2028-2103	CV447
	42	2103-2145	EY8
	45	2145-2230	ES6
Total	375		
3rd Shift	72	2320-0032	Midnight locals, 2nd pullout
	62	0100-0202	CP917
	30	0230-0300	AP3
	41	0345-0426	EW1
	52	0448-0540	Early pull, Rigbys
	33	0540-0613	RB30
	42	0613-0655	AM locals, 1st pullout
Total	332		
Grand Total	1,007	69.9% trim engine utilization 82.9% trim crew utilization	

Table B-3

HUMP ENGINE ACTIVITIES
(Scenario II)

	Min	Time	Task
1st Shift	38	0730-0808	AM locals, 1st reswitch
	42	0808-0850	RB30
	38	0850-0928	Switching out local cars, etc.
	38	0928-1006	AM locals, 2nd reswitch
	40	1021-1101	CV390 and AP3
	42	1101-1143	WE2
	34	1240-1314	Cleaned and repaired cars
	40	1314-1354	Switching out local cars, etc.
Total	312		
2nd Shift	33	1514-1547	Springfield "pickup" SP2
	28	1547-1615	FEX
	51	1635-1726	ES6/EY8, 1st reswitch
	31	1726-1757	AP3
	41	1901-1942	SE1
	56	1952-2048	ES6/EY8, 2nd reswitch
	39	2048-2127	CV447 and E4
	56	2135-2231	Midnight locals, 1st reswitch
	37	2231-2308	CV390
Total	372		
3rd Shift	37	2313-2350	NY10
	33	2350-0023	CP917
	45	0023-0108	Midnight locals, 2nd reswitch
	36	0108-0144	Switching out local cars, etc.
	39	0144-0223	LM1
	33	0223-0256	CP904
	50	0400-0450	YE7
	46	0450-0536	Reswitch of West Routes
	54	0606-0700	SE5
Total	373		
Grand Total	1,057	72.7% hump engine utilization 86.2% hump crew utilization	

Table B-4

TRIM ENGINE ACTIVITIES
(Scenario II)

	Min	Time	Task
1st Shift	54	0720-0814	RB30
	69	0814-0923	AM locals, 2nd pullout
	47	0923-1010	Early pull, CRs
	84	1025-1149	ES2
	31	1149-1250	Couple E6 and E2 for Class. Yd. departure
	42	1250-1332	BM7
	57	1332-1429	Early pull, D&Hs
	52	1429-1521	Early pull, CNs
Total	436		
2nd Shift	78	1551-1709	ES6/EY8, 1st pullout
	44	1724-1810	Early pull, CPs
	100	1810-2020	ES6/EY8, 2nd pullout
	27	2020-2047	LM1
	46	2047-2133	CV447
	49	2133-2222	EY8
	51	2222-2313	ES6
Total	395		
3rd Shift	88	2318-0036	locals, 2nd pullout
	74	0130-0244	CP917
	31	0244-0315	AP3
	44	0400-0444	EW1
	47	0600-0647	AM locals, 1st pullout
Total	284		
Grand Total	1,115	77.4% trim engine utilization 91.8% trim crew utilization	

Table B-5

HUMP ENGINE ACTIVITIES
(Scenario III)

	Min	Time	Task
1st Shift	39	0738-0817	AM locals, 1st reswitch
	44	0817-0901	RB30
	39	0901-0940	AM locals, 2nd reswitch
	38	0955-1033	Switching out local cars, etc.
	42	1033-1115	CV390 and AP3
	44	1115-1159	WE2
	36	1240-1316	Cleaned and repaired cars
	41	1316-1357	Switching out local cars, etc.
Total	323		
2nd Shift	34	1510-1544	Springfield "pickup" SP2
	29	1548-1617	FEX
	64	1655-1759	ES6/EY8, 1st reswitch
	32	1759-1831	AP3
	43	1905-1948	SE1
	64	1948-2052	ES6/EY8, 2nd reswitch
	40	2052-2132	CV447
	57	2135-2232	Midnight locals, 1st reswitch
	38	2232-2310	CV390
Total	401		
3rd Shift	37	2315-2352	NY10
	34	2352-0026	CP917
	37	0026-0103	Switching out local cars, etc.
	47	0103-0150	Midnight locals, 2nd reswitch
	40	0150-0230	LM1
	34	0230-0304	CP904
	51	0405-0456	YE7
	46	0456-0542	Reswitch of West Routes
	56	0612-0708	SE5
Total	382		
Grand Total	1,106	76.8% hump engine utilization 91.0% hump crew utilization	

Table B-6

TRIM ENGINE ACTIVITIES
(Scenario III)

	Min	Time	Task
1st Shift	57	0720-0817	RB30
	70	0817-0927	AM locals, 2nd pull out
	87	0942-1109	ES2
	61	1109-1210	Early pull, CRs
	32	1240-1312	Couple E6 and E2 for Class Yd. departure
	33	1312-1345	BM7
	60	1345-1445	Early pull, D&Hs
	52	1445-1537	Early pull, CNs
Total	452		
2nd Shift	58	1607-1705	ES6/EY8, 1st pull out
	103	1754-2007	ES6/EY8, 2nd pull out
	25	2007-2032	LM1
	48	2032-2120	CV447
	50	2120-2210	EY8
	53	2210-2303	ES6
Total	337		
3rd Shift	58	2308-0006	Early pull, CPs
	81	0006-0127	Midnight locals, 2nd pull out
	65	0127-0232	CP917
	35	0232-0307	AP3
	46	0352-0438	Early Pull, track 1
	46	0438-0524	EW1
	45	0600-0647	AM locals, 1st pull out
Total	376		
Grand Total	1,165	81.0% trim engine utilization 96.0% trim crew utilization	

Table B-7

HUMP ENGINE ACTIVITIES
(Scenario IV)

	Min	Time	Task
Hump Engine #1			
1st Shift	29	0700-0729	AM locals, 1st reswitch
	38	0741-0819	Switching out local cars, etc.
	34	0920-0954	AM locals, 2nd reswitch
	34	1245-1319	Cleaned and repaired cars
	40	1344-1424	Switching out local cars, etc.
Total	175		
2nd Shift	28	1512-1540	FEX
	50	1643-1733	EDSA/EDMA, 1st reswitch
	50	1845-1935	MAED
	81	1940-2101	ESDA/EDMA, 2nd reswitch
	41	2110-2151	RJED
Total	250		
3rd Shift	51	2240-2331	PM reswitch of West Routes
	48	0005-0053	CP917
	36	0108-0144	Switching out local cars, etc.
	46	0201-0247	MEEDB
	35	0320-0355	RIED
	47	0440-0527	AM reswitch of West Routes
	54	0551-0645	SAED
Total	317		
Grand Total	742	51.5% utilization--hump engine #1 61.5% utilization--hump crew #1	
Hump Engine #2			
1st Shift	42	0714-0756	RJRIB
	42	0804-0846	WHED
	45	1215-1300	MEEDA
	41	1318-1359	SPED
	33	1425-1458	Springfield "pickup" SP2
Total	203		
2nd Shift	88	1525-1653	Reswitch Track 1
	44	1718-1802	RJRIA
	39	2046-2125	CV447
	58	2136-2234	Midnight locals, 1st reswitch
Total	229		
3rd Shift	47	2316-0003	CV390
	45	0038-0123	Midnight locals, 2nd reswitch
	42	0129-0211	BOED
	33	0232-0305	CP904
Total	167		
Grand Total	599	41.6% utilization--hump engine #2 49.3% utilization--hump crew #2	

46.6% hump-engine utilization--hump engines #1 & #2

55.2% hump-crew utilization--hump crews #1 & #2

Table B-8

TRIM ENGINE ACTIVITIES
(Scenario IV)

	Min	Time	Task
Trim Engine #1			
1st Shift	85	0810-0935	AM locals, 2nd pullout
	68	0935-1043	CV447
	40	1043-1123	Couple E6 and E2 for Class Yd. departure
Total	193		
2nd Shift	75	1534-1648	EDSA/EDMA, 1st pullout
	63	1653-1756	RJRIA
	44	1930-2014	RIRJB
	64	2014-2118	EDBO
	77	2130-2247	EDSA
Total	323		
3rd Shift	104	2252-0036	Midnight locals, 2nd pullout
	105	0036-0221	EDRI
	61	0400-0501	2nd early pull of Track 1
	52	0600-0652	AM locals, 1st pullout
Total	322		
Grand Total	838	59.6% utilization--trim engine #1 70.6% utilization--trim crew #1	
Trim Engine #2			
1st Shift	64	0900-1004	RIRJA
	103	1009-1152	EDSP
	53	1330-1423	EDMEB
	55	1445-1540	Reswitch of Track 1, including early pull cars
Total	275		
2nd Shift	49	1600-1649	Early pull, CPs
	149	1735-2034	EDSA/EDMA, 2nd pullout
	72	2100-2212	EDMA
	59	2212-2311	Early pull, CNs
Total	329		
3rd Shift	91	2316-0047	EDRJ
	56	0047-0143	1st early pull of Track 1
	108	0143-0331	CP917
	55	0401-0456	EDWH
	45	0456-0541	EDMEA
	53	0630-0723	RJRIB
Total	408		
Grand Total	1,012	70.3% utilization--trim engine #2 83.3% utilization--trim crew #2	
		64.9% trim engine utilization--trim engines #1 and #2 77.0% trim crew utilization--trim crews #1 and #2	

Appendix C

STATISTICAL SUMMARIES OF SCENARIOS I-IV

Summary of Capacity Model Run, Scenario I; Average Day, East Deerfield Plus Springfield

This simulation was for an average day in East Deerfield Yard, with the addition of traffic resulting from a suspension of switching operations at Springfield Yard.

The operational scheme approximated the Freight Timetable (#22) of Spring 1979. Reswitches were done for West Routes, the group of morning locals, the group of postmidnight "locals," and the combined traffic of ES6 and EY8. The assignment of work to the proper engines was done as accurately as possible, with the exception of local traffic delivery. Assumptions and results are listed below.

Physical Assumptions

18 classification tracks
2.7 cars/minute humping rate
1 hump engine
1 trim-end engine.

Results

Average detention time in yard	17.03 hr	
Cars into yard (per day)	628	
Cars over hump (per day)	1,095	
Hump utilization	27.9%	6.7 HOURS
Hump engine utilization	62.6%	15 HOURS
Hump crew utilization	74.2%	17.8 HOURS
Trim engine utilization	69.9%	
Trim crew utilization	82.9%	
Projected incidental overtime	0.5 crew hr/day	

Eight Receiving/Departure tracks were sufficient.
No critical buildup in the Receiving/Departure Yard.

These figures do not allow time for delivery of local traffic, but there appears to be open time for this work, except for the Turners Falls run three times a week, which would require overtime work.

Summary of Capacity Model Run, Scenario II; Heavy Day, East Deerfield Plus Springfield

This simulation was for an unusually heavy day in East Deerfield Yard, with the addition of traffic resulting from a suspension of switching operations at Springfield Yard.

The operational scheme approximated the Freight Timetable (#22) of Spring 1979. In addition, late trains AP3 and CV390 of the preceding day were introduced, as well as a freight extra from Fitchburg. Arriving trains were given 10-20% more traffic than on an average day. In this and following runs, Rigbys on NY10 bypassed the hump. All other operational considerations were the same as in Scenario I. Assumptions and results are listed below.

Physical Assumptions

18 classification tracks
2.7 cars/minute humping rate
1 hump engine
1 trim-end engine.

Results

Average detention time in yard	17.25 hr
Cars into yard (per day)	779
Cars over hump (per day)	1,369
Hump utilization	34.2%
Hump engine utilization	72.7%
Hump crew utilization	86.2%

Trim engine utilization 77.4%
Trim crew utilization 91.8%

Projected incidental overtime 1.6 crew hr/day

Eight Receiving/Departure tracks were sufficient.
Possible buildup in Receiving/Departure yard during second shift.

These figures do not allow time for delivery of local traffic, but there appears to be open time for this work, except for the Turners Falls run three times a week, which would require overtime work.

Summary of Capacity Model Run, Scenario III; Heavy Day + 6.5%, East Deerfield Plus Springfield

This simulation was similar to that in Scenario II, but 49 additional cars each day were included to push the simulated yard to maximum capacity. As seen below, practical capacity was reached on the trim end. All operational considerations were the same as in Scenario II. Assumptions and results are listed below.

Physical Assumptions

18 classification tracks
2.7 cars/minute humping rate
1 hump engine
1 trim-end engine.

Results

Average detention time in yard	17.29 hr
Cars into yard (per day)	828
Cars over hump (per day)	1,414
Hump utilization	36.6%
Hump engine utilization	76.8%
Hump crew utilization	91.0%
Trim engine utilization	81.0%
Trim crew utilization	96.0%
Projected incidental overtime	1.8 crew hr/day

Eight Receiving/Departure tracks were sufficient.
Possible buildup in Receiving/Departure Yard during second shift.

These figures do not allow time for delivery of local traffic, but there appears to be some open time for this work, except for the Turners Falls run three times a week, which would require overtime work.

Summary of Capacity Model Run, Scenario IV; Abnormally Heavy Traffic Added to East Deerfield Traffic

This simulation was run to demonstrate the effects of abnormally heavy traffic. Additional switch engines and crews were assumed, as well as a more expansive switching operation. Traffic was roughly equivalent to the level of Scenario II, with abnormally heavy work added. The schedule was revamped to move D&Hs, CRs, and Rigbys three times a day, and other east-west trains were scheduled with an East Deerfield-based round trip. North-south traffic remained the same. Major assumptions were made as to the ability of each end of the yard to support two engines.

Physical Assumptions

18 classification tracks
2.7 cars/minute humping rate
2 hump engines
2 trim-end engines.

Results

Average detention time in yard	13.31 hr
Cars into yard (per day)	1,111
Cars over hump (per day)	1,791
Hump utilization	45.9%
Hump engine utilization	46.6%
Hump crew utilization	55.2%
Trim engine utilization	64.9%
Trim crew utilization	77.0%
Projected incidental overtime	0.5 crew hr/day

Eight Receiving Departure tracks were insufficient. Critical buildup occurred several times during the day--at least 10 tracks are needed in the Receiving/Departure Yard, probably more.

These figures do not allow time for delivery of local traffic, but there appears to be ample time for this work.