COMPARISON OF MASS DIAGRAM AND LINEAR PROGRAMMING METHODS OF MASS ALLOCATION IN FOREST ROAD DESIGN

by

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ABSTRACT

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Accessibility of the forest is a basic requirement for a commercially managed forest. Logging in British Columbia often is carried out in remote areas where log transportation is primarily by truck hauling on forest roads.

Forest road construction and particularly earth moving are significant elements in the total cost of forest products. Proper choice of road design elements will determine the optimum economy of any forest road. The derivation of road design elements is shown in detail as an introduction to the earth allocation problem.

Minimization of costs of main forest access roads is studied in this thesis and alternate methods of mass allocation are presented. A semi-graphical method of mass allocation (mass diagram) is compared with a method employing the electronic computer and the tools of operations research (linear programming).

The theory of linear programming (LP) is shown as the optimization technique used for minimizing the earth moving costs. The LP assumptions and limitations are discussed.

The two methods were tested on the forest main haul road C in the University of British Columbia Research Forest. Calculations of volume distribution and the required intermediate calculations are carried out with an electronic computer for comparison with traditional methods.

The mass diagram method might be used for a long time due to its simplicity, whilst LP provides a more precise solution.

The costs of earthmoving and planning are $84.00 or 0.6% of the total earthwork and planning costs less by using LP rather than the mass diagram in the example calculated.

The use of dynamic programming (DP) to determine the optimum road lay-out is suggested as a topic for further research, a preliminary step for optimization in mass allocation.

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I. INTRODUCTION

The costs of road construction, road maintenance and hauling account for up to 75% of the total costs of logging. The major cost of forest road construction is associated with earthwork. However, minimizing volume of excavation does not imply automatically minimized earth moving cost. Two roads of any length with the same volume of earthwork will have different cost depending on the sum of transportation distances.

Earthwork is composed of two optimization problems, which should be integrated. Firstly, excavation must be minimized, which is obtained by optimum road lay-out. Secondly, there is the problem of optimum earth allocation between stations. Fill, cut, waste or borrow must be optimized based on earth moving cost.

Optimizing each problem separately often results in a sub-optimization of the whole system. It is difficult to look at entire systems without the aid of mathematical models. Based on traditional methods, a new approach of volume allocation is presented according to the criteria of minimizing earth allocation cost using LP, and a comparison is made with the most commonly used mass diagram method.

The introduction of the mass diagram by Goering was a great improvement in traditional station-to-station earth volume allocation. The mass diagram is a semi-graphical method of earth allocation and determines direction of haul and the amount of volume hauled. Inaccuracies may occur due to the natural lack of precision of graphical solutions.

Boughton (1966) proposed first to minimize the earth allocation volume using the LP technique. However, in his approach regions of excess cut or regions of extra fill were not subdivided, but were treated as contiguous units. This approach results in neglecting the earth moving cost.

This thesis tries to improve on the accuracy of Boughton's solution by considering the haul and the net volume at each station. The earth allocation costs are calculated using excavation cost plus the transportation cost between particular cut and fill stations. In this way, the results of the LP method and the mass diagram could be compared.

II. GEOMETRIC ROAD DESIGN ELEMENTS

Road design elements are the geometric factors to be considered when designing a forest haul road. The design elements here considered are:

- horizontal alignment
- vertical alignment
- cross sections.

The determination of the optimal combination of values for these design elements, for any particular haul road, requires a thorough understanding of the purpose of the road, the physical and mechanical characteristics of the vehicles that will use it, and the properties of the soil through which the road will be built. The remainder of this chapter deals with the relative importance of the design elements listed above and their derivation for a main road in the University of British Columbia Research Forest.

FOREST MAIN HAUL ROADS

A forest main haul road often is a permanent all-weather road for the execution of forest management. It must provide for a safe and economic traffic flow over its entire length.

LAND SERVICE

A forest main haul road, as a means of access to forest land, is of main importance as it is the backbone to the network consisting of lower standard forest roads. In its design prime consideration is given to fast transportation by vehicles between points, such as landings, dumps, and mills.

The significant service functions of a main haul road is to provide easy access for equipment and personnel to perform functions related to management, silviculture, and protection of the forest tract.

ECONOMIC OBJECTIVE

The economic objective in haul road design implies a minimum total cost for road construction, for maintenance of the road and the vehicles using it, and for the transportation of goods and services. The measure of economic transportation of logs is based on speed and load (weight or volume). Hauling costs are expressed in dollars per unit weight or volume.

Finding the minimum total cost of road construction, maintenance for road and vehicles, and hauling cost is not dealt with in detail in this thesis. This thesis approaches the problem of minimizing earthwork cost only.

ENGINEERING CHARACTERISTICS OF MAIN FOREST HAUL ROADS

Traffic Flow and Density

Traffic on main haul roads consists mainly of heavy duty equipment such as logging trucks, maintenance and service vehicles. The traffic flow, because of generally low volume, is rarely interrupted. Company owned roads, operated on a private or semi-private basis, are closed to public during working hours.

In regard to the direction of traffic flow on a forest road, there is a one way flow for loaded trucks to the dumps and return trips of empty trucks to the landings.

The average daily traffic depends on the size of a particular logging enterprise and varies considerably. There is much less traffic on a forest road than on a public road of comparable design. A traffic density on forest main haul roads of 100 to 1000 vehicles per day is not uncommon. This corresponds to 25 to 250 loads leaving an operation per day.

Speed

Speed is denoted for road design purposes as design speed. Design speed has been defined by the American Association of State Highway Officials as the maximum safe speed that can be maintained over a section of road when conditions are so favourable that the design features of the road govern.

The U. S. Forest Service bases all economic calculations on design speeds of 45 mph and 50 mph for loaded and empty trucks respectively (Logging Handbook, 1960). Speeds up to only 40 mph are considered in the Forest Engineering Handbook (U. S. Department of the Interior, 1964). Adamovich and Webster (1968) assumed a design speed of 35 mph for main haul roads in the University of British Columbia Research Forest.

Weight of Vehicles

The maximum gross vehicle weight (GVW) of loaded logging trucks is limited by the truck capacity and bearing capacity of the road. Maximum off highway GVW is 250,000 pounds composed of a truck tare weight of 70,000 pounds and a load of 20,000 fbm or 180,000 pounds on a basis of 9 pounds per fbm.

The advantage of high loading capacities is that more volume is hauled per round trip and fewer trucks are required for transportation of the same volume. However, increased GVW increases road construction and maintenance cost. Optimum vehicle weight should be considered as the one resulting in minimum total cost of transport, road and vehicle cost. Research would be required to investigate the interdependencies.

OPTIMUM ROAD STANDARDS

To select the optimum standard of a road, the minimum total yearly cost is considered which is the sum of amortization cost and the interest on the investment, maintenance and hauling costs.

Forest road history in Europe, especially in Bavaria, Germany, shows that many private forest roads changed their status to public forest roads. Some of them finally were developed into public highways. The same trend can be seen now in British Columbia, were some private, company owned roads have changed to semi-private roads with limited public access. Thus, if in doubt about choosing between two standards for a future main haul road, which could develop into a public road, the higher standard should be selected, if the government would pay the increased cost.

Selection of Design Elements

The selection of the design elements depends on the goal and characteristics of a particular road. Those for forest main haul roads have been defined in the previous chapter. Based on these assumptions the required minimum physical standards can be defined for the horizontal and vertical alignment of the road and also for its cross section.

Horizontal Alignment

Horizontal alignment is the horizontal deflection of the tangents between the starting point and the end point via intermediate control points. Horizontal curves are smooth transitions from one tangent to the next one.

The number of curves per unit length of the road, as well as the radii of the curves significantly influence the travel speed, which in turn, influences the round trip time and operation cost (Logging Road Handbook, 1963). Horizontal alignment is a function of topography, soil, vehicle design and speed. The curves are usually circular curves and are specified either by their radii or their degree of curvature.

Superelevation in Curves

Superelevation is defined in two ways and used interchangeably in this text. Superelevation is the ratio of the vertical distance between the heights of inner and outer edges of road surfaces and the horizontal projection of the road width, or the angle between a horizontal plane and the road surface in degrees.

Superelevation is generally justified in order to keep the design speed in curves at the same level as on adjacent tangents. This results in uniform speed, and therefore economic timber transportation. However, superelevation is a definite hazard to slow moving vehicles, and, when icy conditions prevail.

According to the Manual of Geometric Design Standards for Canadian Roads and Streets (1967) and Edwards and Townsend (1961) a maximum superelevation of 0.08 may be applied. For design speeds below 35 mph in forest road design, superelevation can be neglected if the road surface conditions permit.

Side Friction Factor

The side friction factor is a measure of the tendency of a vehicle not to move perpendicular to its direction of travel when acted upon by centrifugal forces.

The side friction factor is governed by the speed of the vehicle, its tires, and the characteristics of the road surface (Meyer, 1967). The higher the side friction factor, the greater the degree of curvature allowable without decreasing the design speed even without superelevation. This means, that the road centerline may follow ridges, and gullies much closer.

Minimum Radius Due to Design Speed - Background Theory

The theory of superelevation must be defined in order to determine the maximum allowable degree of curvature for a given design speed.

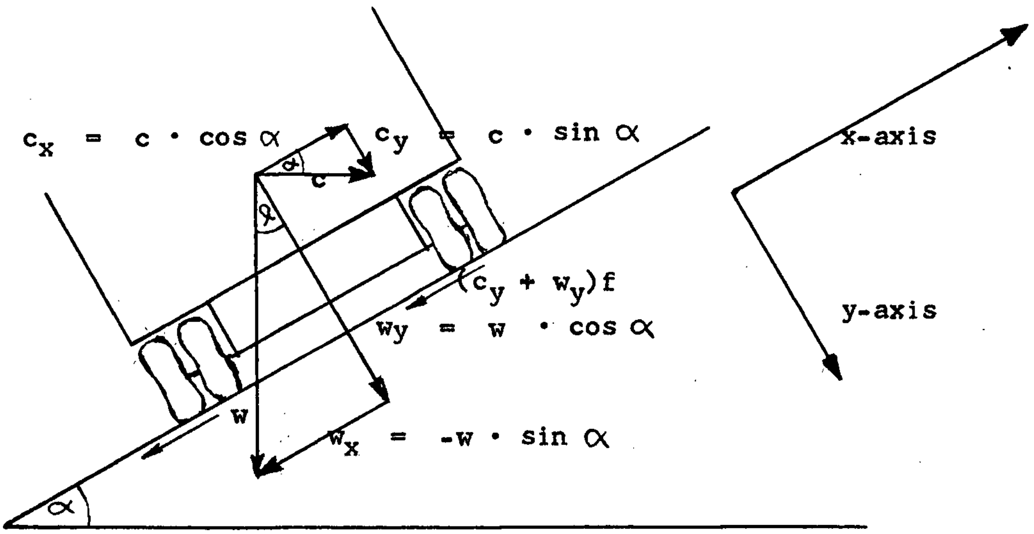

Figure 1. Free-body diagram of a truck on a superelevated road

Figure 1 shows a free-body diagram of a truck on a superelevated section of road. The following is a derivation of the side friction factor as a function of superelevation and vehicle weight.

The forces w_x (weight component parallel to road surface) and c_x (centrifugal force component parallel to road surface) are critical for slipping sideways. From a vector analysis of Figure 1, it can be seen that:

$$\sin \alpha = \frac{w_x}{w} \quad \text{or} \quad w_x = \sin \alpha \cdot w \quad \text{and}$$

$$\cos \alpha = \frac{c_x}{c} \quad \text{or} \quad c_x = \cos \alpha \cdot c$$

where

w = GVW in pounds

w_x = weight component parallel to road surface in pounds

w_y = weight component perpendicular to road surface in pounds

α = angle in degrees between actual road surface and horizontal plane (superelevation)

c_x = centrifugal force parallel to road surface in pounds

c_y = centrifugal force perpendicular to road surface in pounds

c = centrifugal force; $c = \frac{wv^2}{GR}$

where v = speed in feet per second

G = gravity, 32.23 feet per second squared

R = radius of curve in feet

Travelling at equilibrium speed means equilibrium between the forces w_x and c_x and $\Sigma P_x = \Sigma P_y = 0$. Under these conditions no slipping occurs even on surfaces without friction. The permissible superelevation as a function of design speed and curve radius can be derived as follows (Meyer, 1967):

$$w_x = c_x$$

$$\sin\alpha \cdot w = \cos\alpha \cdot c \quad \text{but} \quad c = \frac{wv^2}{GR} \quad \text{so that}$$

$$\sin\alpha \cdot w = \cos\alpha \cdot \frac{wv^2}{GR} \quad \text{where} \quad \cos\alpha = 0.996 \quad \text{for}$$

maximum superelevation, and becomes $\cos\alpha \cong 1$

$$\sin\alpha = \frac{v^2}{GR} \quad \text{(Meyer, 1967)}$$

where

v = velocity in feet per second

G = gravity, 32.23 feet per second squared

R = radius of curve in feet

α = superelevation in degrees

This indicates, that the amount of superelevation is independent of vehicle weight in the case of equilibrium of the forces w_x and c_x.

When the forces parallel to the road surface are not in equilibrium, then the vehicle has a tendency to move laterally. This tendency is expressed as the ratio of the sum of the forces parallel to the road surface and the forces perpendicular to it. It is measured by the side friction factor and is defined as follows:

$$(w \cdot \cos\alpha \cdot f_s) + w \cdot \sin\alpha = c \cdot \cos\alpha + (c \cdot \sin\alpha \cdot f_s)$$

Solving the equation for f_s leads to

$$f_s = \frac{c_x - w_x}{c_y + w_x} = \frac{c \cdot \cos\alpha - w \cdot \sin\alpha}{-c \cdot \sin\alpha + w \cdot \cos\alpha}$$

Assume that $\alpha = 0^o$ then

$$\sin 0^o = 0$$

$$\cos 0^o = 1$$

$$\max \alpha = 0.08 = 8\% = 4.6^o$$

Yields the result

$$f_s = \frac{c}{w}$$

where

f_s = side friction factor

all other symbols as above

Calculation of the Side Friction Factor for Forest Roads

Based on data and experience, the design manual (1967) gives a side friction factor of $f_s = 0.165$ for a design speed of 35 mph on blacktop.

Based on forest road conditions and the formula developed above, the side friction factor becomes:

$$f_s = \frac{c}{w} = \frac{\frac{wv^2}{GR}}{w} = \frac{v^2}{G \cdot R_{min}} = \frac{(1.467 \cdot 35)^2}{32.23 \cdot R_{min}}$$

$$f_s = \frac{81.796}{R_{min}}$$

where

R_{min} = minimum radius of curve in feet which must be determined

all other symbols as above

The side friction factor on forest roads can be assumed to be 60% of the coefficient of friction in line of travel. On dry firm gravel, usually on main haul roads, the coefficient of friction equals $f = 0.8$ (Adamovich, 1970).

Thus, the side friction factor is

$$f_s = 0.6 \cdot f$$

$$f_s = 0.6 \cdot 0.8$$

$$f_s = 0.48$$

Maximum Degree of Curvature

Knowing the values of design speed, superelevation and side friction factor, the degree of maximum curvature can be calculated according to the following formula, based on previous equilibrium equations:

$$D = \frac{85{,}944\ (e + f_s)}{v^2} \qquad \text{(Design Manual, 1967)}$$

where

D = maximum degree of curvature = $5730 \div R$

e = superelevation in tangent value

f_s = side friction factor

v = design speed in mph = speed in ft/sec $\div$ 1.467

Using the maximum values for the formula provides the maximum degree of curvature.

$$D_{max} = \frac{85{,}944\ (0.48)}{35 \cdot 35} = \frac{41{,}253.12}{1225}$$

$$D_{max} = 33.7^{o} \cong 34^{o}$$

The maximum degree of curvature corresponds to a minimum radius of

$$R = \frac{5730}{D} = \frac{5730}{33.7}$$

$$R = 170 \text{ feet}$$

The maximum allowable degree of curvature on forest roads is more than twice the one allowed for highways of the same design speed. This is due to the differences of the friction factors as a function of road surfaces.

Curve Widening

Curve widening is an important factor, because it influences the volume of earthwork to a great extent. When a vehicle negotiates a curve, the rear axles travel on a curve of a smaller radius than the front axles. The difference of the radii depends on the degree of curvature and vehicle design. Diagrammatically this may be represented as shown in Figure 2.

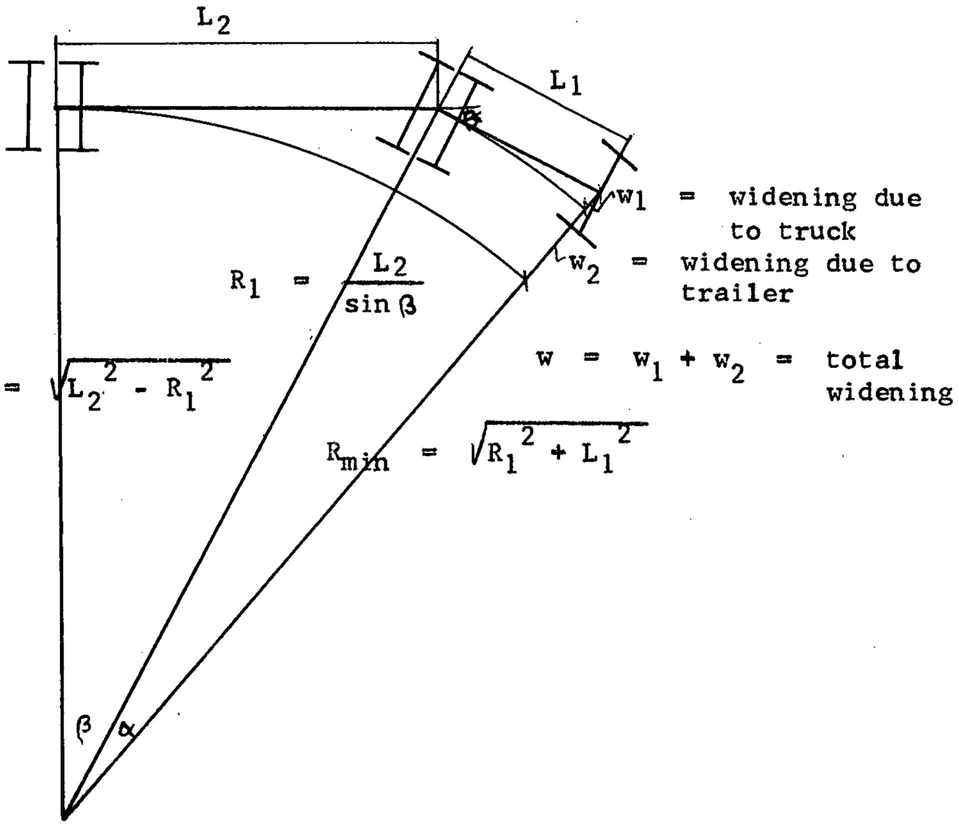

Figure 2. Curve widening due to tractor and trailer

Considering the tractor only, one obtains the following results:

$\sin \alpha = \frac{w_1}{\frac{L1}{2}}$ and $\sin \alpha = \frac{L1}{R_{min}}$ yield

$\frac{w_1}{\frac{L1}{2}} = \frac{L1}{R_{min}}$ or $L_1 \cdot \frac{L1}{2} = w_1 \cdot R_{min}$ and solved for w_1

$w_1 = \frac{L1}{2R_{min}}$ (due to tractor only)

Considering the trailer only, the curve widening is derived as follows:

$$\sin \beta = \frac{w_2}{\frac{L_2}{2}} \quad \text{and} \quad \sin \beta = \frac{L_2}{R_1} \quad \text{yield}$$

$$\frac{w_2}{\frac{L_2}{2}} = \frac{L_2}{R_1} \quad \text{and} \quad w_2 \cdot R_1 = L_2 \cdot \frac{L_2}{2} \quad \text{result in a widening}$$

$$w_2 = \frac{L_2^{\,2}}{2R_1} \quad \text{(due to trailer only)}$$

Combining these two results we obtain the following total widening due to tractor and trailer:

$$w = w_1 + w_2$$

$$w = \frac{L_1^{\,2}}{2R_{min}} + \frac{L_2^{\,2}}{2R_1} \quad \text{(due to tractor and trailer)}$$

$$\text{but} \quad R_1 = \sqrt{R_{min}^{\,2} - L_1^{\,2}} \quad \text{and } w \text{ becomes}$$

$$w = \frac{L_1^{\,2}}{2R_{min}} + \frac{L_2^{\,2}}{2\sqrt{R_{min}^{\,2} - L_1^{\,2}}}$$

where

w = curve widening in feet

L_1 = wheel base of tractor in feet

L_2 = wheel base of trailer only in feet

R_{min} = minimum radius of curve in feet

R_1 = radius of curve followed by the rear truck axles

The wheel bases of coastal logging trucks with extended reach are L_1 = 17.5 feet and L_2 = 47.0 feet for tractor and trailer respectively.

$$w = \frac{(17.5)^2}{2R_{min}} + \frac{(47.0)^2}{2R_1} \quad \text{and}$$

$$w_{max} = \frac{306.25}{2(170)} + \frac{2209}{2\sqrt{(170)^2 - (17.5)^2}}$$

$$= \frac{306.25}{340.00} + \frac{2209.0}{338.2} = 0.9 + 6.5$$

$$w_{max} = 7.4 \text{ feet}$$

The widening remains a function of the curve radius. Several empirical formulae heve been developed for easy calculation of curve widenings.

$$w = \frac{D^o}{10} \quad \text{(Adamovich, 1970)}$$

$$w = \frac{400}{R} \quad \text{(U. S. Forest Service, Oregon)}$$

$$w = R - n\sqrt{R^2 - L^2} + \frac{v}{R}$$

The first two formulae are valid for forest roads, the third is used in highway design, taking the numbers of lanes (n) and the design speed (v) into account.

Vertical Alignment

A forest road usually connects points that differ in elevation. Also, in connecting these points it must pass through areas of broken topography and is often constrained to pass through certain specific points such as valleys and saddles known as control points. The resulting fluctuation in grades thus required, and the vertical curves for smooth transition between different grades, are known as the vertical alignment of the road. Proper vertical alignment takes in consideration problems of sight distance, stopping distance, vehicle capacity and surface erosion.

Grades

The proper choice of maximum grades is very important as they affect significantly costs of earthwork, road maintenance and hauling. Steep maximum grades decrease earthwork as the road centerline follows the topography very close but increases road maintenance and operation costs. Grades are expressed in per cent and are the ratio (tangent) of the vertical distance and horizontal projection of the actual road length multiplied by 100. Increased grades permit attainment of points at different elevations in a shorter distance, which in some cases avoids switchbacks. However, truck speeds will be reduced and maintenance cost of road and vehicles will be increased.

Due to the characteristics of the one way traffic flow of loaded and empty trucks on forest roads, a distinction is made between a favourable and an adverse grade. A favourable grade denotes a grade downhill, and an adverse grade a grade uphill, for a loaded truck.

Maximum Adverse Grade

Maximum adverse grade is reached, when the tractive effort is equal to the sum of road resistances without acceleration or decceleration and is limited by the friction factor for traction, that is when the wheels would slip.

Fast transportation is possible at grades, which allow the engine to turn at full horsepower rating. Waelti (1960) suggested a maximum adverse grade of 6% under general coastal conditions and a design speed of 35 mph for coastal logging trucks. Adamovich (1968) proposed the same value for the specific conditions of the University of British Columbia Research Forest. Maximum grades are calculated with the formula

$$p_{max} = \frac{TE - w_t R_R - R_C - R_A}{20 w_t}$$

where

p_{max} = maximum adverse grade in per cent

TE = tractive effort in pounds

w_t = GVW in tons

R_R = rolling resistance in pounds per ton

R_C = curve resistance in pounds

R_A = air resistance in pounds

The tractive effort is a function of the torque, the transmission and differential gear ratio and the efficiency of the engine. Thus, the tractive effort will be different for each gear. The tractive effort is calculated as follows for direct speed:

$$TE = \frac{375 \cdot BHP \cdot n}{s} \quad \text{and} \quad TE = w_t R_R + 20 p w_t$$ (Adamovich, 1970)

where

TE = tractive effort in pounds

BHP = break horse power

n = efficiency of truck engine

w_t = GVW in tons

R_R = rolling resistance in pounds per ton

p = adverse grade in per cent

The speed in the formula above is based on the rimpull of the engine, which is assumed to be 10,000 pounds for a standard logging truck used in the University of British Columbia Research Forest on an adverse grade. 10,000 pounds rimpull correspond to the second gear and a speed of 12 mph. Thus, the maximum adverse grade for a logging truck is calculated for the conditions mentioned as follows:

$$\frac{375 \cdot 325 \cdot 0.8}{12} = 45 \text{ tons} \cdot 60 \frac{\text{pounds}}{\text{ton}} + 45 \text{ tons} \cdot 20p$$

and solved for p yields

$$p = \frac{375 \cdot 325 \cdot 0.8}{12 \cdot 20 \cdot 45} - \frac{45 \cdot 60}{20 \cdot 45} = 9 - 3$$

$$p_{max} = 6\%$$

Velocity Grade

A velocity grade is a steeper than the maximum adverse grade for which the initial momentum of the vehicle at the beginning of the velocity grade is used to overcome the extra grade resistance. The initial momentum on a true velocity grade is sufficient to overcome it without shifting gears.

The maximum allowable velocity grade is calculated according to the following formula:

$$p_o = p_r + \frac{s_1^2 - s_2^2}{d_v}$$

where

p_o = velocity grade in per cent

p_r = maximum adverse grade in per cent

s_1 = speed at beginning of the velocity grade in mph

s_2 = speed at the end of the velocity grade in mph

d_v = horizontal distance of velocity grade in feet

Use of velocity grades makes it possible to overcome rapid change in elevation over a short distance while still holding good alignment. This results in savings on construction cost and travel time, although increases maintenance costs.

Maximum Favourable Grade

Any favourable grade is governed by the safe stopping distance. The stopping distance is the shortest distance in which a vehicle can come from its travel speed to a complete stop. Stopping distance is a function of reaction time of the driver, vehicle speed and coefficient of friction of the road surface. The stopping distance is calculated from the following formulae:

$$D = D_1 + D_2$$

$$D_1 = t \cdot s \cdot 1.467$$

$$D_2 = \frac{s^2}{30(f - \frac{p}{100})}$$

where

D = stopping distance in feet

D_1 = reaction distance in feet

D_2 = breaking distance in feet

t = reaction time in seconds

s = speed in mph

f = coefficient of friction

p = maximum favourable grade

$$D = t \cdot s \cdot 1.467 + \frac{s^2}{30(f - \frac{p}{100})}$$

$$\frac{30(D - (t \cdot s \cdot 1.467))}{s^2} = \frac{1}{f - 0.01p}$$ and solved for p

$$p = (f - \frac{s^2}{30(D - (t \cdot s \cdot 1.467))}) \cdot 100$$

$$p = 100(f - \frac{s^2}{30D - 44.0 \cdot t \cdot s})$$

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where

f = 0.35 for wet gravel

s = 35 mph design speed

D = 250 feet

t = 1.5 seconds

$$p = 100(0.35 - \frac{1225}{7500 - 2310})$$

p = 11%

Waelti (1960) proposed 8% maximum favourable grade for coastal conditions. For the conditions in the University of British Columbia Research Forest Adamovich and Webster (1968) utilized 10% as a maximum favourable grade.

Minimum Grade

A road is as good as its drainage, because water reduces the bearing capacity of the subgrade. Thus, poorly drained roads are expensive in maintenance and have a short lifespan. No road should be designed with zero per cent grade. In terms of hauling cost, the U. S. Forest Service found a maximum travel speed at 1.5% favourable grade. In terms of road maintenance the maximum grade occurs when silt is just eroded. Silt is a very fine and important binding material and is eroded at grades greater than 1% if not in mixture with other particle sizes.

Vertical Curves

When the algebraic difference of the following grade and the approaching grade is positive, then the vertical curve is denoted as a sag curve; if the difference is negative, it is denoted as a crest curve.

The length of crest curves is a function of the adjacent grades and the sight distance for safe stopping.

$$L_{min} = \frac{A \cdot S^2}{200\,(\sqrt{h_1} + \sqrt{h_2})^2} \qquad \text{(Meyer, 1967)}$$

where

L_{min} = minimum length of vertical curve in feet

A = algebraic difference of adjacent grades, following grade minus approaching grade

S = sight distance in feet

h_1 = height of truck driver's eye; h_1 = 7 feet

h_2 = height of obstruction on the road; h_2 = 0.3 feet

The formula for the length of crest curves is:

$$L_{min} = \frac{A \cdot S^2}{200\,(2.65 + 0.17)^2}$$

The formula might be simplified more by assuming that the sight distance equals the stopping distance.

$$B = \frac{s^2}{30f} \quad \text{(Manual of Geometric Design Standards, 1967)}$$

$$R = s \cdot t \cdot 1.467$$

$$S = B + R$$

where

B = braking distance in feet

R = reaction distance in feet

s = speed in mph; design speed = 35 mph

f = coefficient of friction; f = 0.35

t = reaction time in seconds; t = 1.5 seconds

S = stopping distance in feet

The stopping distance for first class forest road conditions is:

$$S = \frac{35 \cdot 35}{30 \cdot 0.35} + 35 \cdot 1.5 \cdot 1.467$$

$$S = 193 \text{ feet}$$

Substitution in the foregoing formula leads to:

$$L_{min} = \frac{A(193)^2}{1590} \quad \text{and} \quad L_{min} = \frac{A \cdot 37,249}{1,590}$$

$$\underline{L_{min} = 23.4\ A}$$

This result implies that the length of a crest curve for coastal conditions is 23.4 feet per 1% difference of adjacent grades. This finding agrees with the most commonly used practice that the grade change per 100 feet should not be more than 6%.

The above formula is applied only as a guideline; the engineer may decide to deviate from it due to the terrain but never at the expense of safety.

Cross Sections

The shape of the cross section determines to a great extent the earthwork required. The road width and the side slope ratios are of main importance. The road width is the width of the running surface, the shoulders and the ditch. Figure 2 illustrates the terminology of cross sections.

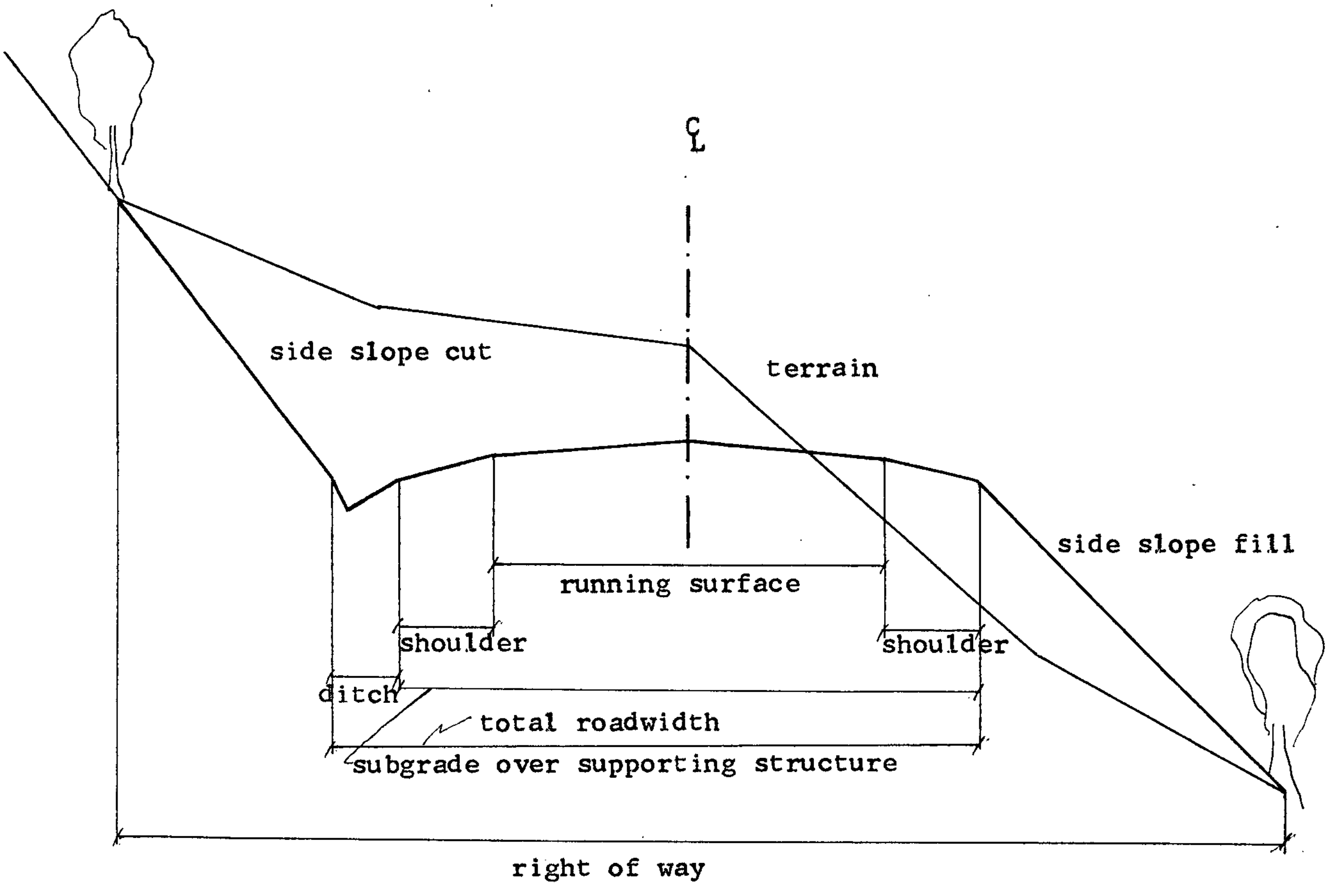


Figure 3. Terminology on Cross Section

Road Width

The road width is a function of safety, drainage, speed, and type and number of vehicles travelling on a forest road. The road width must be at least equal to the vehicle width. A lateral band at either side of the running surface for lateral support of the vehicles reduces maintenance cost for both road and vehicles, and increases traffic safety.

Dense traffic may necessitate a multilane road. In forestry the decision on the number of lanes is based on the volume hauled. Unfortunately, no accurate criteria has been developed todate. The British Columbia Forest Service (Waelti, personal communication) is studying the spacing of turnouts for a given speed and given number of vehicles to find an answer which would optimize earthwork and truck speed.

Terrain and soil must also be considered for choosing a particular road width, since these two factors affect earthwork to a large extent.

Ditches

The ditch accumulates the water flowing from the side slopes towards the road and the water from the road surface. A ditch must be on any cut along a main haul road to ensure adequate water run off to avoid decreased bearing capacity of the subgrade and reduce frost heaves.

Calculating the ditch width involves many uncertain variables such as area of watershed, grade changes, culvert spacing, rainfall, and roughness coefficients of the ditch. Due to the number and uncertainty of these variables, an empirical solution of the ditch dimensions is justified.

There are two types of ditch dimensions proven adequate for the research forest according to the soil characteristics. In rock, the ditch width is 2 feet, in common material 3 feet. The ditch depth in both materials is 1 foot. A wide ditch results in a greater road width and increased excavation and consequently increased earth moving. The ditch depth is not related to volume calculations, because it is excavated by a grader or blasted and affects the road construction cost only to a minor extent. Deep ditches would be expensive to construct and maintain.

Side Slopes

The side slopes are the slopes of the cuts and / or fills joining the road surface. Side slopes are denoted as the ratio of the horizontal distance to one unit of vertical distance or the cotangent of the slope angle.

The objective is to construct side slopes as steep as possible without inducing the danger of slides and without impairing the sight distance in order to reduce earthwork. The maximum allowable side slope is a function of soil composition and density. Fill and cut have different side slope ratios due to different compaction. Modern equipment working on new fills compacts common material to a higher density than *in situ.*

Soil Properties as They Affect Side Slopes

The best angle of a side slope for a given location can only be determined through a detailed analysis of the soil. The following considerations are based on undisturbed and untreated soil.

Side slopes depend on the shear strength that the soil can withstand. Shear strength is composed of friction, which is the resistance due to interlocking of particles, and cohesion, which represents the forces which hold the particles together. Cohesive forces are of chemical and electrical nature.

The resultant of these forces is the angle of the slopes as established naturally. This angle is called the angle of repose. The shear strength is expressed by Coulomb's Law (Capper and Cassie, 1963).

$$s = c + t \cdot \tan \alpha$$

where

α = angle of internal friction, in degrees, approximately equal to the angle of repose c = cohesion in pounds per square inch

t = normal stress in pound per square inch

s = soil shear strength in pound per square inch

Solving the equation for the angle of repose:

$$\tan \alpha = \frac{s - c}{t}$$

Angles of repose for rock and loess are close to 90° due to very high cohesion. Weathering reduces cohesion to such an extent, that a side slope must be applied for safety of the traffic. For fine material with low cohesion and almost no friction, such as wet clay, angles of repose are as low as 10°, which corresponds to a side slope ratio of 5 : 1. Cut and fill slopes in average common material and rock are usually based on past experience. This is the approach used by Adamovich and Webster (1968) in the proposal for slope ratios in the University of British Columbia Research Forest (Figure 4).

The shape of natural slopes is always slightly concave. The engineer at the actual construction site must take advantage of this fact by excavating more material than required close to the road and less at the far end of the side slopes. This strategy has a cost reducing effect due to a reduction in earth moving without impairing safety. However, this strategy does not hold for all soils and must be tested under each new set of conditions.

Main Haul Road in UBC Research Forest

Typical Cross Section in Common Material

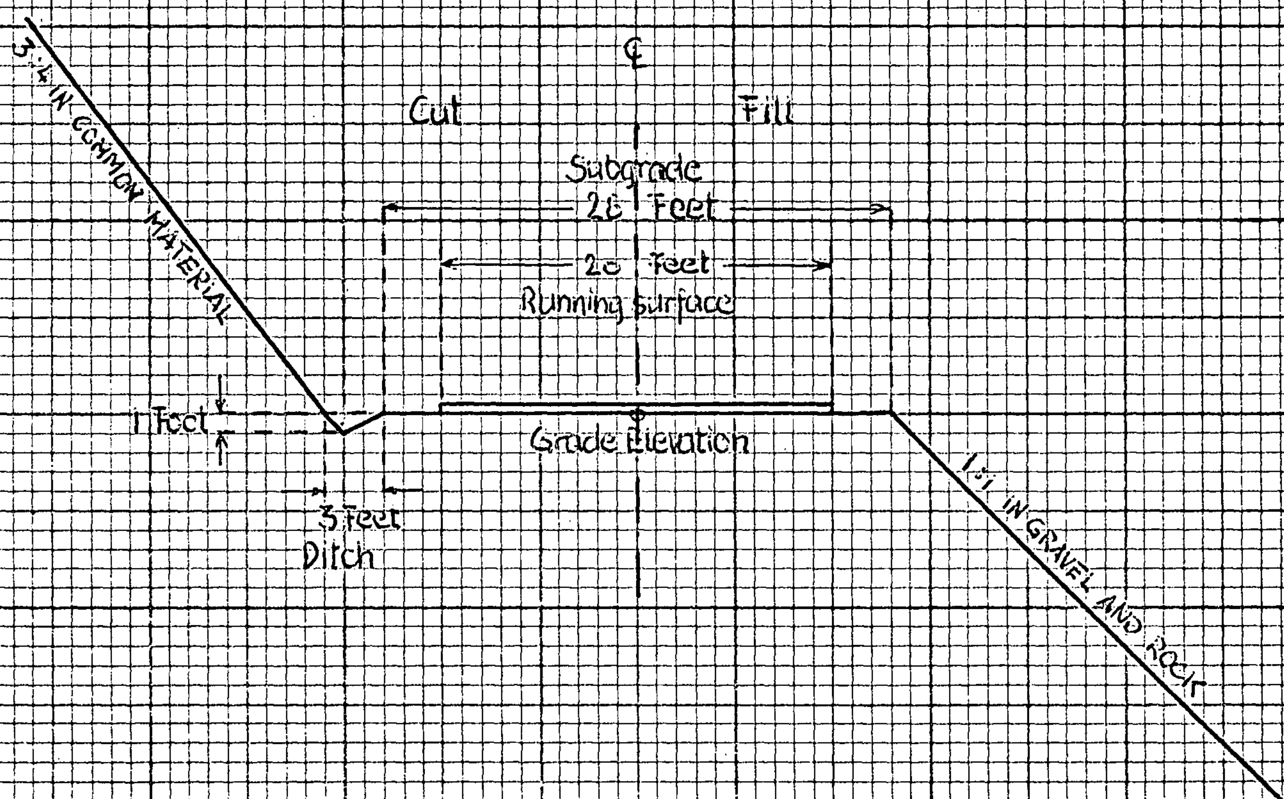


Figure 5. Typical Cross Section

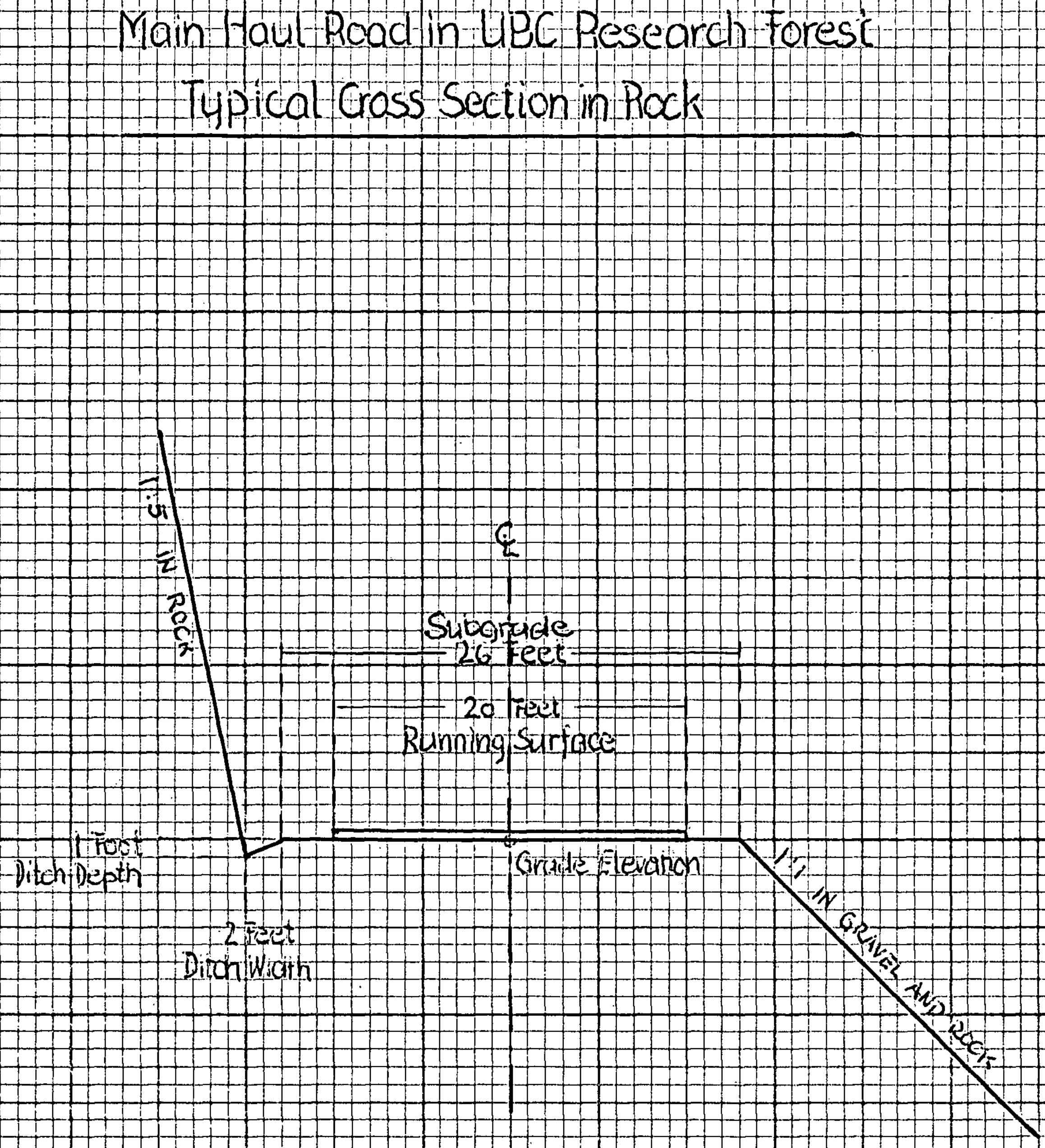


Figure 5. Typical Cross Section

III. LOCATION METHODS

Location methods are techniques by which the forest engineer determines the line of a future road. The most common location methods in forestry are the highway engineer's method, and its modification for logging engineers, the contour offset method and the direct location method (Pearce, 1964). The selection of one of these methods depends on the proposed standard of the road, the topography, the supervision during construction and experience of the location engineer.

The first step of every location method is the reconnaissance of the area. Then, the decision is made as to the class of the survey to be conducted. A higher class will be chosen in cases of high standard roads, difficult terrain, good engineering supervision during construction and with less experienced personnel. Except for the direct location method, a preliminary line (P-line) is run and staked, after which the elevation of the stakes is measured. The topography is taken at all stations on difficult terrain or at every station in the case of high class surveys.

The P-line, the elevation of stations and the topography provide the necessary information for establishing a contour strip map for the location survey line. Based on the criteria of minimizing earthwork, trial profiles are proposed. Areas are calculated and volumes based on the end area formula. Using a tabulated form for volume distribution, the station-to-station values of excavated material to be used on the site, excess cut, need in fills, waste and borrow are decided on. Once the volume distribution satisfies the required standards, the location survey line is fixed and is ready for laying out in the field. Staking of the location survey line, the side slopes, and sometimes the right of way, terminates the planning stage of the road.

IV. EARTH ALLOCATION METHODS

For comparing alternate route possibilities, the so called "design mass graph" can be used, which has been developed by the British Columbia Forest Service. The volume estimate is based on previous construction and experience.

The most primitive method of earth allocation is done by determining volumes and balance points based on the profile only. However, this method is inaccurate and used only for preliminary cost estimates.

The station-to-station method is a numerical method which allows a quick volume and cost analysis using desk calculators. The balance points between cuts and fills are determined, and the haul distances checked. Calculation of the freehaul and overhaul allows compilation of distances for the construction equipment to be used, and therefore the costs. In the table below the headings for volume and distance calculations are shown (Figure 5)

						Volume yd^3				Total volume				used	ex-	need	overhaul		l'haul	
	Area		$\frac{A_1+A_2}{2}$		Dist	rock		common		rock		common		on	cess	in	waste	bor-	dist	qu-
Sta	c	f	c	f	yd	c	f	c	f	c	f	c	f	site	cut	fill		row		ant

Figure 5. Headings for the volume and distance calculations of the station-to-station method

This method has the great advantage of giving quickly the size of the earthwork, but is inaccurate and arithmetical errors can easily occur: checking is necessary. The station-to-station method can easily be computerized which eliminates the arithmetical errors. Part of the British Columbia Forest Service program, based on this theory, calculates volumes (Appendix 2). These volumes were later used as an input for the LP program (Appendix 3).

MASS DIAGRAM

The mass diagram is a continuous graphical representation of net cumulative volumes of cuts and fills on a road construction. It shows the volume balance points, the amount of haul and its direction. This permits the effects of changing volume allocation in terms of volumes and cost to be studied. A horizontal line intersecting the mass diagram is a balance line, where the sum of cuts and fills are equal. The length of the balance line shows the haul distance, which is usually delimited by freehaul and maximum economic overhaul distance. The haul is determined graphically and is the area between the mass diagram and any balance line. Calculation of the average haul and the cost of earth moving in station yards, allows computation of the earth moving cost. Finally, the direction of haul is determined on the mass diagram (see Appendix 4), based on the efficiency of the equipment used for construction.

EARTH ALLOCATION BY LINEAR PROGRAMMING

Construction of a road involves relocation of earth due to the difference of the shape of the terrain and the road cross sections, and location of the road, which is constrained by the alignment. Earth will either be removed from high sections (cuts) and deposited in low sections (fills) or wasted. This process can be formulated as an allocation problem of allocating excess material to fills. The optimization technique most commonly used for solving allocation problems is LP.

Linear Programming

LP finds the optimum of a decision problem, which is described by linear functions of variables (Dantzig, 1963; Simonnard, 1966). In mathematical notation, the definition of a linear program is written as follows (Smythe, 1966; Hillier-Lieberman, 1968):

$$\max z = c_1 x_1 + c_2 x_2 + \dots + c_n x_n$$

$$\text{subject to} \quad a_{11}x_1 + a_{12}x_2 + \dots + a_{1n}x_n \sim b_1$$

$$a_{21}x_1 + a_{22}x_2 + \dots + a_{2n}x_n \sim b_2$$

$$\vdots$$

$$a_{m1}x_1 + a_{m2}x_2 + \dots + a_{mn}x_n \sim b_m$$

where

z = objective function; it is the overall measure of effectiveness

x = decision variable or level of activity

n = number of competing activities

c_j = cost of one unit of activity j

a_{ij} = amount of resource i consumed per unit activity j

b_i = amount of resource i available

m = number of constraints of the system; this number will will be at least equal to the number of scarce resources

$\sim$ = $\geq$, = , $\leq$

Assumptions of Linear Programming

Five basic assumptions must be satisfied in order to use LP successfully as a valid optimization technique (Dantzig,1963).

- non negativity: a particular activity cannot be negative, it must be at least zero

- additivity: in order to exclude interactions between activities, which are explicitely not permitted in LP, the activities must be additive with respect to the objective function and resource use

- divisibility: fractions of the decision variables must be permissible; if not, there exist different optimization algorithms for integer and mixed LP

- deterministic: the cost coefficients (c_i), the amount of resource consumed (a_{ij}), and available resource (b_i) for activities must be known constants

- proportionality: the input and the output of an activity are proportional to the level of that particular activity. More explicitely, the output of a system is linearly and directly proportional to the input. This assumption requires that the objective function and every constraint must be linear.

Characteristics of Linear Programming

The assumptions listed above put heavy restrictions on the use of LP. However, altered LP techniques, and different optimization techniques permit the deletion of some of these restrictive assumptions. Despite these limitations, LP features, as an optimization technique, a number of unique advantages.

The power of LP results from its ability to solve large problems. Computer programs have been developed that can solve LP problems with up to 4095 constraints and the number of variables are only limited by the total memory space of the computer system. The LP model is in the form of simultaneous equations, which, after some modifications, are solved by simple techniques.

Linear Model of Mass Allocation Problem

Letting x_{ij} denote the volume allocated from cut station i to fill station j, c^d_{ij} the cost of moving one cu yd from cut station i to fill station j considering the haul distance, c_b the cost of borrowing one cu yd at a borrow pit, b_j the volume borrowed in cu yds, c_w the cost of wasting one cu yd, w_i the volume wasted, then the linear function becomes:

$$\min \sum_j \sum_i c^d_{ij} \, x_{ij} + \sum_j c_b b_j + \sum_i c_w w_i$$

where

i = cut station, excess material

j = fill station, material required

c^d_{ij} = cost of earth moving per cu yd over the distance d from cut station i to fill station j

x_{ij} = volume of material transported from cut i to fill j

c_b = cost of borrow per cu yd

b_j = volume borrowed for fill j

c_w = cost of wasting one cu yd at cut i

w_i = volume wasted at cut i

Note that the second and the third terms of the objective function do not include distance, because the borrow pit is assumed to lie within freehaul distance. The material wasted will be at the place where it occurs. Thus, there is no transportation of material involved.

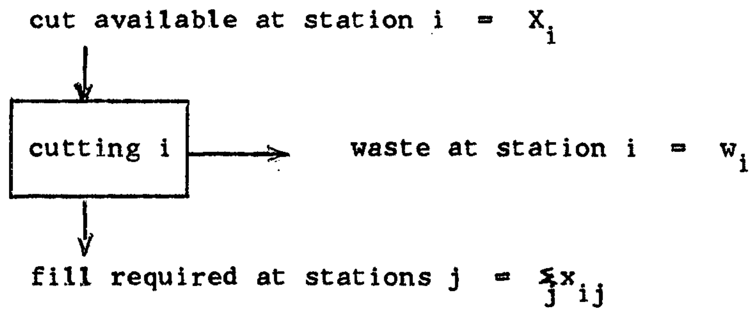
Constraints

The sum of the material available from cuts and borrows equals the sum of material required in fills and wasted. These equations are denoted as the material balance equations.

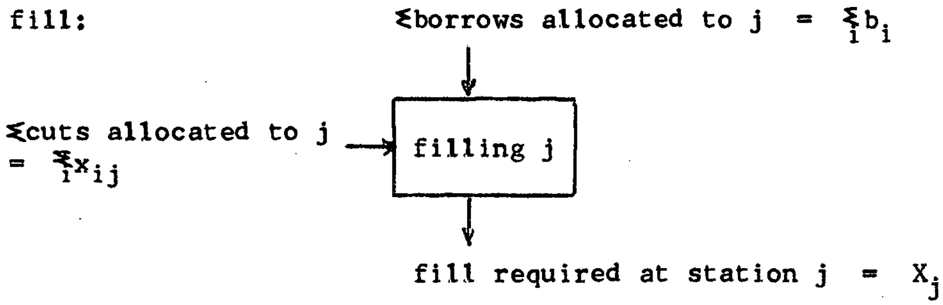
$$\Sigma\text{cuts} + \Sigma\text{borrows} = \Sigma\text{fills} + \Sigma\text{waste}$$

These material balance equations are the constraints. There are two different cases with regards to volume distribution at a station: fill or cut. The following figures show a graphical representation of these two cases:

cut:



fill:



Obviously, there is no borrow at any cut station. Thus, the general material balance equation becomes:

$$\sum \text{cuts} - 0 = \sum \text{fills} + \sum \text{waste}$$

$$\sum \text{cuts} - \sum \text{fills} - \sum \text{waste} = 0$$

This constraint in mathematical notation is:

$$X_i - \sum_{j \in R} x_{ij} - w_i = 0$$

where

X_i = volume of cut available at station i

x_{ij} = cut volume from station i transported to fill station j

$j \in R$ = denotes those fill stations, j, that are within maximum economic overhaul distance of station i

w_i = volume wasted at station i

In the case, where fill is required, there will be no waste. This factor is set to zero in the general material balance equation:

$$\Sigma \text{cuts} + \Sigma \text{borrows} = \Sigma \text{fills} + 0$$

$$\Sigma \text{fills} - \Sigma \text{cuts} - \Sigma \text{borrows} = 0$$

This equation in mathematical notation as a constraint for LP becomes

$$X_j - \sum_{i \in R} x_{ij} - \sum_i b_i = 0$$

where

b_i = volume borrowed at station i within freehaul distance

x_{ij} = cut volume transported from station i to station j

$i \in R$ = denotes those cut stations, i, that are within maximum economic overhaul distance of station j

X_j = volume of fill required at station j

Reason for Using Linear Programming

The formulation of the objective function and the constraints demonstrated a linear relationship. All decision variables were of a deterministic and fractional nature, which allows the use of a straight forward optimization technique looking for the optimum. At this stage, it was decided to check the feasibility of utilizing LP.

Investigation showed, that all the five basic assumptions of LP were satisfied. Furthermore, the problem could be run on the University of British Columbia computer facilities under the MPS system. This ensured a fast and accurate solution.

Based on these considerations, LP was used as the optimization technique for finding the optimal solution.

V. DESCRIPTION OF THE STUDY OBJECT

The road project used for illustration purposes of the theory developed in this thesis, is road C in the University of British Columbia Research Forest.

The proposed road C is a forest main haul road and will connect the main gates of the Univeristy of British Columbia Research Forest with the camp at Loon Lake. The road location is shown in Appendix 5. The road location follows the propositions of the masterplan. Road C will be one of the three main roads for fast access to the centers of the forest and to the two main camps.

The material through which the road passes, is basically hornblende granite diorite rock. All this rock must be blasted. This layer is covered by dense poorly weathered till. The till is unsorted with a silty-sand matrix, containing gravel and boulders up to two feet in diameter. The till is generally impermeable. This layer may be removed with a bulldozer without additional equipment. The general aspect of the country is moderately rolling with mountainous areas in the north.

The cross sections are either full cuts or full fills, or sidewise cross sectioning both in common material and rock.

The total length of the proposed road will be 10,250 feet or 1.94 miles. The mass diagram is calculated up to and including station 50+70.

The maximum grade is 10% and between the vertical points of intersection 32+80 and 46+75. The minimum grade is -1.6% and between the vertical points of intersection 8+50 and 17+80. There are ten curves with degrees of curvature between 8° and 36°. A shrinkage of 33 percent of the undisturbed common material is included for the mass calculations. Swell of rocky material for fill is not considered. It was felt, that loss of material at the steep slopes will compensate swell.

Road C has been proposed to develop the second growth stand between Blaney Creek and road F. The stands to be developed are composed of Douglas-Fir, Western Hemlock and Western Redcedar.

The road was located by Professor Adamovich. All calculations are based on his field data.

Adamovich and Webster (1968) suggested road design standards in the University of British Columbia Research Forest. These standards have been chosen according to the principles discussed in the chapter on design elements.

The road design standards for the main haul road C in the University Research Forest are:

design speed 35 mph

horizontal sight distance 250 feet

sight distance for vertical curves 300 feet

absolute minimum radius 150 feet

minimum radius due to design speed 250 feet

surface width 20 feet

ditch width in soil 3 feet

The following road design standards were used directly as computer inputs:

widening in curves 1 foot per 10° curvature

maximum favourable grade 10%

maximum adverse grade 6%

subgrade width 26 feet

ditch width in rock 2 feet

ditch depth 1 foot

ditch slope 5 : 1

side slopes as shown in Figure 4

VI. COMPUTATION OF EARTH ALLOCATION

A computer is very suitable for reducing a great amount of tedious computations. A large number of computations due to changes of the center line is involved in volume calculations thus making the computer an excellent tool for forest road planning.

There are three consecutive computer programs involved for optimization of earth allocation by LP. Each program produces input for the following one.

The first program reads the raw field data and allows entrance of data in a few different formats. Then it transforms the data into a standard form which will be the standardized input for the second program. This program calculates the volumes which are the basis for the mass diagram and input for the LP program.

TRANSFORMATION PROGRAM

The first program reads the field data. It reads the accumulated chainage to the nearest foot, the elevation of the center line to the nearest 1/10th of a foot, the depth of unsuitable material as road construction material and the depth of common material over rock to the nearest foot.

The program permits four different ways of describing the terrain. The slope is measured in percent from the center line to the grade break or in percent from grade break to grade break (Figure 6).

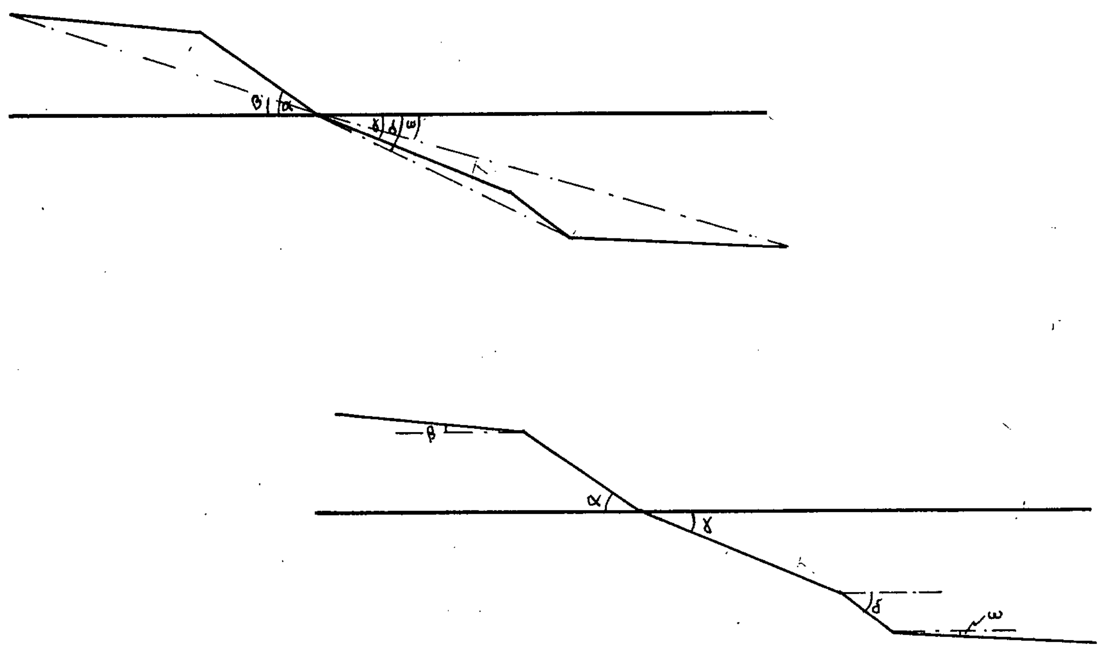
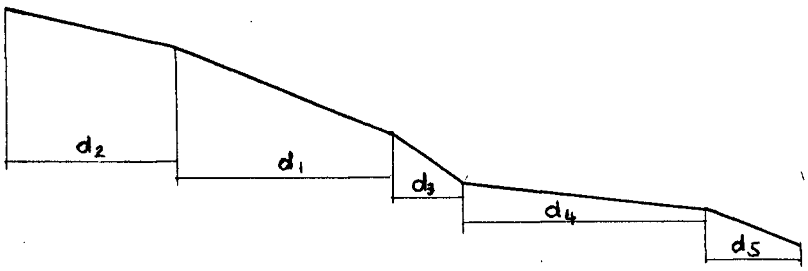


Figure 6. Grade Breaks: Vertical Measurements

The horizontal distances are measured in a similar way. It is the distance from all grade breaks to the center line or between the grade breaks (Figure 7).



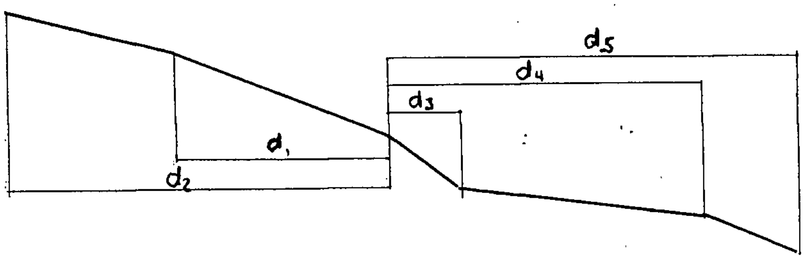


Figure 7. Grade Breaks: Horizontal Measurements

Provision is made in the program to read in up to eight grade breaks. The number of grade breaks read in to either side of the center line is printed as a control on the left hand side of a set of cross section field data. Then the program reads the accumulated chainage and elevation of the center line at a cross section. Based on this information, the program will calculate the difference in elevation between the center line and grade line.

The adjusted and unadjusted chainage and elevations with the number of affecting equations are printed out for control at every cross section set.

For calculations of the cross section area for cuts and fills, the depth of unsuitable material is deducted. If there are chainage or elevation equations, the program will adjust.

VOLUME CALCULATION AND ALLOCATION

The second program will calculate the volumes.

Basic input is the standardized output from the previous program, dealing mainly with cross sectional data. Additional input describes the road standards themselves.

The first set of input cards fixes the vertical points of intersection. The information required is the elevation and chainage of the vertical points of intersection and the length of the vertical curve. The program calculates the difference in elevation between the grade line and center line.

The second set contains the design elements. The slopes are entered as the tangents and are separated for cut and fill slopes. For realistic volume calculations, there is a facility provided for shrinkage or compression of common material and swell of rock on fills. Road C is located on very steep hills through rocky parts. Due to the steepness, it is assumed for volume calculations, that loss of material and swell are equal. Shrinkage of common material is 30 percent. For volume calculations, the ditch width must be added to the subgrade width. The ditch volume is not included in these calculations, because this is considered in road construction as a separate operation and is also accounted separately. The ditch width is calculated based on the ditch slope and ditch depth.

The stabilized subgrade width must be entered separately for the left and right hand side of the grade line. This provision takes widenings and turnouts into account, which are discussed in previous chapters.

The output of the volume calculations is self explanatory with the provided headings (Appendix 2). The first fourteen columns contain the description of the road. It may be looked at as an echoprint for control purposes.

Information about sidecast, the material used for fill from cut at a mixed profile, is of minor importance as input for the LP program, but required for the volume allocation using the station-to-station method. Of great interest is the backfill, the volume of gravel required between stations. This information contributes significantly to the cost predictions, because gravel hauled over a long distance is quite expensive.

The net accumulated mass was a basic requirement for earth allocation with the semi-graphical mass diagram. Using the LP technique for minimum earth allocation cost, interest is focussed on net volumes between stations as the constraints for volumes required (fill) or available (cut). Only the net masses and their location provide information about the distances over which the earth is transported.

The 360/67 IBM computer used for solving the LP model is at the University of British Columbia Computing Center. The system operates generally under the Michigan Terminal System (MTS). However, the Mathematical Programming System (MPS), which solves the LP problem using the revised simplex method must run under IBM's Operating System (OS). Thus, three different systems are activated.

MPS, specifically set up for efficient processing of mathematical problems, is a library program and consists of a compiler which processes the control language and sets up the calls to subroutines. Thus, the first step makes the system ready and the second step is the executing one. An executor processes the subroutine calls and reads the data. The job is terminated by the executor by producing the results.

Data for the LP Formulation

Excavation is the removal and relocation of various types of earth and rock. The excavation costs are a function of soil type, earth moving equipment and transportation distance. Sometimes, there are separate cost classes for excavation, for rock and earth or common material (Ritter and Paquette, 1967). If the material can only be removed with blasting or heavy ripping equipment, it is referred to as rock excavation. All other types of excavation are referred to as common excavation. Only one cost class for excavation is considered for contracts in the University of British Columbia Research Forest, and in accordance with this practice, only one class is considered in the model.

It is anticipated that a D9 type caterpillar bulldozer will be used for construction. Performance data were taken from Caterpillar Tractor Company's "Fundamentals of Earthmoving" (1965) and are as follows:

average speed - 2.4 mph in first gear under stress

average speed - 6.5 mph in third gear reverse empty

push capacity with a U-blade 10.5 cubic yards

effective working time - 50 minutes per hour

load factor $f_1 = 0.7$ (rock $f_1 = 0.6$, common material $f_1 = 0.8$)

fixed time in cycle zero minutes, because there is only hauling and returning time

the hauling distance equals the return distance

Computation of Excavation Cost

The variable time for one round trip is calculated as follows:

$$t = \frac{d}{s_h \cdot f} + \frac{d}{s_r \cdot f} = \frac{d}{f}\left(\frac{1}{s_h} + \frac{1}{s_r}\right)$$

where

t = variable time of a cycle in minutes

d = hauling distance in feet

s_h = hauling speed in mph

s_r = return speed in mph

f = conversion factor for converting mph into feet per minute $f = 88$

In this equation, the variable time is a linear function of speed and transportation distance. Therefore, the optimum freehaul distance is a function of the maximum economic return time cycle. A cost analysis showed an optimal freehaul distance of 200 feet for rock and 400 feet for common material. Dodic (1969) found good results in assuming a freehaul distance of 300 feet independent of the material to be moved. Thus, the variable time is calculated as follows:

$$t = \frac{300}{24 \cdot 88} + \frac{300}{6.5 \cdot 88}$$

$$t = \frac{300}{211.2} + \frac{300}{572.0}$$

$$\underline{t = 1.94 \text{ minutes}}$$

Production

The hourly production depends on the blade capacity, the load factor and the number of hourly trips.

$$v = b_c \cdot b_f$$

where

v = bank cu yd per trip

b_c = blade capacity, 10.5 cu yd

b_f = load factor = 0.7

$$v = 10.5 \cdot 0.7$$

$$v = 7.35 \text{ cu yd per trip}$$

production:

$$p = \frac{t_{eff} \cdot v}{t}$$

where

p = production in cu yd per hour

t = variable time per hour

t_{eff} = effective working time in minutes

v = bank cubic yards per trip

$$p = \frac{50 \cdot 7.35}{1.94} = \frac{367.5}{1.94}$$

$$p = 189.43 \text{ cu yd per hour}$$

$$p \cong 190 \text{ cu yd per hour}$$

Hourly Rate of The D9 Operation

The cost per hour for a D9 Caterpillar was derived in the following manner:

cost (investment) of a D9	$143,000.00
depreciation on a 1000 hour basis	$ 14.30 per hour
interest and insurance	$ 4.72 per hour
total owning cost	$ 19.02 per hour
fuel and lubrication	$ 3.79 per hour
repair and labour	$ 12.87 per hour
total variable cost	$ 16.66 per hour

machine rate	$ 35.68 per hour
profit 20%	$ 7.14 per hour
operator including fringe benefits	$ 6.00 per hour
total hourly cost for a D9	$ 48.82

This cost calculation applies to a new bulldozer. Older bulldozers with less depreciation are rented to government agencies at $39.50 per hour (Finning, personal communication).

Based on the foregoing results, the excavation cost are calculated as follows:

$$c_v = \frac{c_h}{p}$$

where

c_v = excavation cost per cu yd

c_h = machine rate per hours in dollars

p = production per hour in cu yds

$$c_v = \frac{\$48.82}{189.43}$$

$$c_v = \$0.26 \text{ per cu yd}$$

These are the excavation cost plus transportation cost within freehaul distance. The average excavation cost will be greater, except equal in the case where no overhaul or borrow occurs.

Haul

Haul is the product of volume and distance and is divided into freehaul and overhaul. Within the freehaul, every cubic yard moved is without an additional charge for haul. There is one unit price per unit volume moved. Obviously, increased freehaul increases the price for each unit volume moved. Overhaul is the volume hauled in excess of freehaul. The additional charge for volume transportation is expressed in station yards. Maximum overhaul distance is a function of earth moving production. The U. S. Forest Service (1970) found, based on a 100 yard freehaul distance, that the overhaul costs are an exponential function of the overhaul distance.

However, in this thesis the overhaul costs are assumed to increase linearly with the distance. This has proved to be true for the University of British Columbia Research Forest. The overhaul costs are calculated as follows:

$$c_o = c_m \cdot \frac{t}{p}$$

where

c_o = cost of overhaul in dollars per station per cu yd

c_m = machine rate per minute in dollars

t = cycle time in minutes

p = production per trip in cu yd

$$c_o = \frac{\$48.82}{60 \text{ min}} \cdot \frac{0.65 \text{ min}}{7.35 \text{ cu yd}}$$

$$= 0.81 \cdot 0.08$$

$$c_o = \$0.07$$

Obviously, there will be a limit to the overhaul distance. This occurs, when the overhaul equals to the freehaul plus the quotient of borrow cost and overhaul cost.

Borrow is excavation outside the limits of the proposed road. Therefore, there are some additional clearing, grubbing and transportation cost to the excavation cost. Experience shows, that there is a cost increase of 10% relative to the excavation cost for the University of British Columbia Research Forest.

$$c_b = c_e + 0.1 \cdot c_e$$

where

c_b = borrow cost in dollars

c_e = excavation cost in dollars

$c_b = \$0.26 + \$0.03$

$c_b = \$0.29$

The maximum overhaul distance is

$$d_o = d_f + \frac{c_b}{c_o} \qquad \text{(Meyer, 1965)}$$

where

d_o = maximum overhaul in feet

d_f = maximum freehaul in feet

c_b = borrow cost in dollars

c_o = overhaul cost in dollars per station yard

All components are available in order to calculate the maximum overhaul distance

$$d_o = 300 + \frac{0.29}{0.07}$$

$$= 300 + 403$$

$$d_o \cong 700 \text{ feet}$$

The maximum overhaul distance, interpreted in terms of dollars, means a maximum expenditure for excavation cost plus overhaul cost per cubic yard before borrowing. Excavation cost per cubic yard is

$0.26. At maximum economic overhaul distance the total cost is $0.26 plus $0.07 per station yard times 4.03 stations, or $0.55 per cubic yard. The 4.03 stations are obtained by subtracting the freehaul distance from the maximum economic overhaul distance. Thus, it is cheaper to borrow at a cost of $0.29 per cubic yard within freehaul distance and to waste the excess cut than to pay more than $0.55 per cubic yard for excavation and overhaul. The sum of all costs related to earth moving costs are of three kinds: either excavation, excavation and overhaul, and waste and borrow.

VII. ANALYSIS OF EARTH ALLOCATION

ANALYSIS OF THE MASS DIAGRAM

The same road section as for the LP problem was analysed for earth volume and distribution using a mass diagram (Appendix 4). The freehaul in both cases is laid out in order to maximize its distance and to minimize transportation and borrow.

From the volume calculations and the mass diagram the following results were obtained. There are 33,604 cu yd cut and 34,526 cu yd fill, which are the same quantities as in the LP model input. The borrow determined with the mass diagram is 11,000 cu yd, the waste 10,000 cu yd.

cut	33,604 cu yd	$ 8,737.00
borrow	11,000 cu yd	$ 3,190.00
excavation	44,604 cu yd	$11,828.00
fill	34,526 cu yd	
waste	10.000 cu yd	
total fill	44,526 cu yd	
overhaul	17,300 sta yd	$ 1,250.00
total cost		$13,177.00

The difference between total excavation and total fill originates from inaccuracies in the graph. However, more trials could improve the solution, but the effort would be greater than the benefit from the improved solution. The total overhaul equals to 17,300 sta yd at $0.07 per station yard. Therefore, the transportation cost are $1,250.00.

ANALYSIS OF LINEAR PROGRAMMING SOLUTION

Iterations

The optimal solution was found after 161 iterations (Appendix 3). The smallest improvement of the function value due to any iteration was $0.06 at the least. It took the computer 0.65 seconds to perform all iterations of the 68 by 418 matrix; thus, the time needed for calculating one iteration takes approximately .0025 seconds. One hour of central processing unit (CPU) time costs at this computer (IBM 360/67) $250.00, or per second $0.07. Therefore, the iterations were justified, because the lower function value was greater than the cost of the iteration. However, it is desirable to terminate the iterations, if the improvement of the objective function is less than a specified amount. This specified amount could be for instance the computing cost per iteration or any other criteria chosen by the programmer.

Optimum Volume Allocation

The optimum volume allocation is printed as output in Appendix 3. However, the "A" in column 1 indicates, that there are alternate solutions.

Earth Moving Statistics Obtained by Linear Programming

Given the net volumes at a particular station, optimum earth allocation is reached after 33,604 cubic yards of excavation and 10,538 cubic yards borrowed. This adds up to a total excavation of 43,220 cubic yards. The volume is allocated to fill with 34,526 cubic yards and 9,616 cubic yards were wasted. These statistics are summarized in the following table:

cut	33,604 cubic yards	$ 8,737.00
borrow	10,538 cubic yards	$ 3,056.00
excavation	44,142 cubic yards	$11,793.00
fill	34,526 cubic yards	
waste	9,616 cubic yards	
total fill	44,142 cubic yards	

<u>Minimum Earth Moving Cost</u>

The minimum earth moving cost is the value of the objective function after the final iteration. This value is given in Appendix 3. The cut, borrow, and minimum earth moving cost for the excavation and moving of 44,142 cu yd to fill stations was $13,003.73. The average excavation and moving costs per cubic yard are $0.29.

TOTAL COSTS: MASS DIAGRAM VERSUS LINEAR PROGRAMMING

The total costs include earth moving and office work in planning the earth moving. A summary of these total costs is shown in the following Figure 8:

	mass diagram	LP-allocation	savings by LP
cut	8,737.00	8,737.00	-
borrow	3,190.00	3,056.00	134.00
earth allocation	1,250.00	1,210.00	40.00
total fieldwork cost	13,177.00	13,003.00	174.00

Figure 8. Summary of Total Earth Allocation Cost

	mass diagram	LP-allocation	savings by LP
cost of calculations for input	-	70.00	-70.00
data processing cost	20.00	40.00	-20.00
office work cost	20.00	110.00	-90.00
total cost	13,197.00	13,113.00	84.00

Figure 8. Summary of Total Earth Allocation Cost

The costs of cut are equal for both approaches, because the cost calculations are based on the same volume calculations. The cost difference for borrow is due to non optimal allocation of cuts to fills by the mass diagram, and graphical errors. The overhaul costs obtained by LP are true overhaul costs, because these are calculated by hand for moving one cubic yard from cutsstation i to fill station j, where the fill stations are located within maximum economic overhaul distance from cut station i. These calculations and the coding cost $70.00. The freehaul distance for the mass diagram is simplified and drawn in the graph as the distance from one volume balance point to the next. The saving thus obtained by LP due to greater precision is $40.00, which will increase with the number of freehauls in the mass diagram. The saving by using LP is $174.00 for earth moving, where the office work is $90.00 more expensive than for the mass diagram.

It can be seen from the total costs obtained by the mass diagram and LP, that the LP solution yields a total saving of $84.00 or 0.6% of the earth moving and planning costs based on the mass diagram.

VIII. SUMMARY AND CONCLUSION

The purpose of the thesis is a comparative study of earthwork cost. Earthwork costs are obtained by the traditional mass diagram method and the new LP technique. The new approach with the LP technique is explained in detail. The same basic data are used for both methods for valid comparison, particularly the concept of freehaul and overhaul for cost calculations.

The LP solution is known to yield the optimum due to the proof of optimality for the revised simplex method which was used in the MPS library program. It is known, that the earthwork and its associated cost obtained by the mass diagram are not optimal due to graphical inaccuracies and simplifications, but the extent of the deviation from the optimal result is not known.

No significant difference in either earthwork volume or earthwork cost is found. The existing difference between the results obtained are partly due to the graphical solution procedure of the mass diagram, and partly to a difference in freehaul. The freehaul distance is used in the LP model according to the definition, whereas the freehaul distance in the mass diagram is taken, for reasons of simplicity in drawing, as the distance between volume balance points. The same is true for the overhaul distance. The earthwork cost obtained with the mass diagram will deviate more from the true cost, as determined from the LP model, the greater the haul in station yards.

There are many alternative solutions in the LP solution due to the freehaul, where every cubic yard moved costs the same amount independent of the transportation distance. This is not true in practice and there are two ways to overcome this disadvantage. If the distance, for some reason, must still be partitioned into freehaul and overhaul, each cubic yard moved within freehaul distance should be penalized on a foot-yard basis. The penalty must be extremely small, so that it does not change the functional value; a value added could be in the order of $0.0001 per foot yard.

The second possibility is to disregard freehaul and calculate the excavation cost and add to each station a station yard cost. The earth moving costs calculated are closer to the existing conditions with the latter system, rather than separating freehaul and overhaul distances with freehaul penalties. An LP formulation including the excavation cost only plus the station yard cost will give a greatly improved result in the accuracy of earthwork cost compared with the results obtained by the mass diagram analysis.

IX. SUGGESTIONS FOR FURTHER RESEARCH

The results obtained by the LP technique are closer to the real conditions than the results obtained by the mass diagram. The difference increases, as the overhaul becomes greater. Therefore, the LP formulation of the problem is valid and further research is justified.

However, the tedius calculations for the mass distribution are not excluded for either allocation method and only the earth allocation cost is minimized. Therefore, the problem of minimizing excavation cost due to road lay-out should be studied in greater detail. An attempt was made by Lloyd and Sharpels (1969). The choice of the location of a grade line becomes a sequential decision process, for which solution by the dynamic programming (DP) technique (Bellman, 1957; Bellman and Dreyfus, 1962),is the most suitable. Use of the DP part of the model would minimize the excavation cost and the LP part minimizes allocation cost. The combined model using DP and LP would minimize total earthwork cost on a road.

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APPENDIX I TRANSFORMATION PROGRAM

8 SETS OF ELEV + DISTANCES - LEFT SIDE - TOP ROW, RIGHT SIDE - BOTTOM ROW

CHAIN	EQ	COR CHG	GND ELV	Q	COR ELV	1ELEV	1DIST	2ELEV	2DIST	3ELEV	3DIST	4ELEV	4DIST	5ELEV	5DIST	6ELEV	6DIST	7ELEV	7DIST	8ELEV	8DI
0.	1	0.	500.0	1	500.0	499.5	0	499.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						499.5	0	499.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
100.	1	100.	507.0	1	507.0	506.5	0	529.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						506.5	0	506.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
200.	1	200.	517.0	1	517.0	516.5	0	524.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						516.5	0	501.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
300.	1	300.	522.0	1	522.0	521.5	0	529.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						521.5	0	506.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
350.	1	350.	526.4	1	526.4	525.9	0	525.9	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						525.9	0	525.9	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
400.	1	400.	531.0	1	531.0	530.5	0	523.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						530.5	0	538.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
500.	1	500.	529.0	1	529.0	528.5	0	500.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						528.5	0	546.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
550.	1	550.	534.2	1	534.2	533.7	0	488.7	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						533.7	0	548.7	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					

8 SETS OF ELEV + DISTANCES - LEFT SIDE - TOP ROW, RIGHT SIDE - BOTTOM ROW

CHAIN	EQ	COR CHG	GND ELV	Q	COR ELV	1ELEV	1DIST	2ELEV	2DIST	3ELEV	3DIST	4ELEV	4DIST	5ELEV	5DIST	6ELEV	6DIST	7ELEV	7DIST	8ELEV	8DI
600.	1	600.	540.0	1	540.0	539.5	0	509.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						539.5	0	554.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
700.	1	700.	555.0	1	555.0	554.5	0	517.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						554.5	0	592.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
800.	1	800.	562.0	1	562.0	561.5	0	546.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						561.5	0	591.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
850.	1	850.	560.2	1	560.2	559.7	0	529.7	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						559.7	0	604.7	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
900.	1	900.	559.0	1	559.0	558.5	0	513.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						558.5	0	611.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
1000.	1	1000.	557.0	1	557.0	556.5	0	511.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						556.5	0	616.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
1100.	1	1100.	552.5	1	552.5	552.0	0	499.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						552.0	0	604.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
1200.	1	1200.	547.0	1	547.0	546.5	0	509.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						546.5	0	576.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					

CHAIN	EQ	COR CHG	GND ELV	Q	COR ELV	1ELEV	1DIST	2ELEV	2DIST	3ELEV	3DIST	4ELEV	4DIST	5ELEV	5DIST	6ELEV	6DIST	7ELEV	7DIST	8ELEV	8DI
						8 SETS OF ELEV + DISTANCES - LEFT SIDE - TOP ROW,RIGHT SIDE - BOTTOM ROW															
1300.	1	1300.	542.0	1	542.0	541.5	0	481.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						541.5	0	571.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
1320.	1	1320.	540.6	1	540.6	540.1	0	480.1	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						540.1	0	577.6	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
1367.	1	1367.	538.0	1	538.0	537.5	0	507.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						537.5	0	567.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
1400.	1	1400.	535.0	1	535.0	534.5	0	497.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						534.5	0	564.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
1500.	1	1500.	566.0	1	566.0	565.5	0	535.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						565.5	0	618.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
1573.	1	1573.	570.0	1	570.0	569.5	0	539.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						569.5	0	607.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
1600.	1	1600.	568.0	1	568.0	567.5	0	537.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						567.5	0	620.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
1634.	1	1634.	567.0	1	567.0	566.5	0	551.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						566.5	0	634.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					

CHAIN EG COR CHG GND ELV Q COR ELV 8 SETS OF ELEV + DISTANCES - LEFT SIDE - TOP ROW,RIGHT SIDE - BOTTOM ROW

CHAIN	EG	COR CHG	GND ELV	Q	COR ELV	1ELEV	1DIST	2ELEV	2DIST	3ELEV	3DIST	4ELEV	4DIST	5ELEV	5DIST	6ELEV	6DIST	7ELEV	7DIST	8ELEV	8DI
1700.	1	1700.	550.0	1	550.0	549.5	0	519.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						549.5	0	609.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
1800.	1	1800.	525.0	1	525.0	524.5	0	517.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						524.5	0	563.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
1831.	1	1831.	523.0	1	523.0	522.5	0	515.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						522.5	0	537.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
1890.	1	1890.	540.0	1	540.0	539.5	0	532.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						539.5	0	539.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
1900.	1	1900.	541.4	1	541.4	540.9	0	540.9	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						540.9	0	540.9	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
2000.	1	2000.	561.0	1	561.0	560.5	0	530.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						560.5	0	560.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
2100.	1	2100.	577.0	1	577.0	576.5	0	576.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						576.5	0	569.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
2200.	1	2200.	590.0	1	590.0	589.5	0	589.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						589.5	0	589.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					

CHAIN EQ COR CHG GND ELV Q COR ELV 8 SETS OF ELEV + DISTANCES - LEFT SIDE - TOP ROW,RIGHT SIDE - BOTTOM ROW

CHAIN	EQ	COR CHG	GND ELV	Q	COR ELV	1ELEV	1DIST	2ELEV	2DIST	3ELEV	3DIST	4ELEV	4DIST	5ELEV	5DIST	6ELEV	6DIST	7ELEV	7DIST	8ELEV	8DI
2370.	1	2370.	609.0	1	609.0	608.5	0	601.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						608.5	0	631.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
2470.	1	2470.	631.0	1	631.0	630.5	0	623.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						630.5	0	608.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
2515.	1	2515.	628.0	1	628.0	627.5	0	612.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						627.5	0	612.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
2570.	1	2570.	631.0	1	631.0	630.5	0	638.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						630.5	0	638.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
2670.	1	2670.	642.5	1	642.5	642.0	0	634.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						642.0	0	664.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
2770.	1	2770.	657.0	1	657.0	656.5	0	626.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						656.5	0	694.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
2870.	1	2870.	660.0	1	660.0	659.5	0	592.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						659.5	0	704.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
2877.	1	2877.	659.1	1	659.1	658.6	0	591.1	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						658.6	0	703.6	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					

CHAIN EQ COR CHG GND ELV Q COR ELV 8 SETS OF ELEV + DISTANCES - LEFT SIDE - TOP ROW,RIGHT SIDE - BOTTOM ROW

CHAIN	EQ	COR CHG	GND ELV	Q	COR ELV	1ELEV	1DIST	2ELEV	2DIST	3ELEV	3DIST	4ELEV	4DIST	5ELEV	5DIST	6ELEV	6DIST	7ELEV	7DIST	8ELEV	8DI
2952.	1	2952.	650.0	1	650.0	649.5	0	634.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						649.5	0	664.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
2970.	1	2970.	650.0	1	650.0	649.5	0	634.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						649.5	0	664.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
3070.	1	3070.	658.0	1	658.0	657.5	0	620.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						657.5	0	680.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
3124.	1	3124.	658.0	1	658.0	657.5	0	627.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						657.5	0	672.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
3170.	1	3170.	654.0	1	654.0	653.5	0	608.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						653.5	0	706.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
3240.	1	3240.	656.5	1	656.5	656.0	0	633.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						656.0	0	686.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
3270.	1	3270.	658.0	1	658.0	657.5	0	627.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						657.5	0	665.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
3320.	1	3320.	669.0	1	669.0	668.5	0	631.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						668.5	0	698.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					

8 SETS OF ELEV + DISTANCES - LEFT SIDE - TOP ROW,RIGHT SIDE - BOTTOM ROW

CHAIN	EQ	COR CHG	GND ELV	Q	COR ELV	1ELEV	1DIST	2ELEV	2DIST	3ELEV	3DIST	4ELEV	4DIST	5ELEV	5DIST	6ELEV	6DIST	7ELEV	7DIST	8ELEV	8DI
3370.	1	3370.	684.0	1	684.0	683.5	0	646.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						683.5	0	698.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
3470.	1	3470.	700.0	1	700.0	699.5	0	654.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						699.5	0	737.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
3570.	1	3570.	695.0	1	695.0	694.5	0	649.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						694.5	0	709.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
3670.	1	3670.	715.0	1	715.0	714.5	0	662.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						714.5	0	759.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
3770.	1	3770.	722.0	1	722.0	721.5	0	684.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						721.5	0	759.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
3779.	1	3779.	723.0	1	723.0	722.5	0	677.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						722.5	0	752.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
3870.	1	3870.	726.0	1	726.0	725.5	0	710.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						725.5	0	718.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
3970.	1	3970.	738.0	1	738.0	737.5	0	745.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						737.5	0	745.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			

CHAIN EG COR CHG GND ELV Q COR ELV 8 SETS OF ELEV + DISTANCES - LEFT SIDE - TOP ROW, RIGHT SIDE - BOTTOM ROW

CHAIN	EG	COR CHG	GND ELV	Q	COR ELV	1ELEV	1DIST	2ELEV	2DIST	3ELEV	3DIST	4ELEV	4DIST	5ELEV	5DIST	6ELEV	6DIST	7ELEV	7DIST	8ELEV	8DI
4070.	1	4070.	747.5	1	747.5	747.0	0	769.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						747.0	0	762.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
4170.	1	4170.	757.0	1	757.0	756.5	0	734.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						756.5	0	771.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
4270.	1	4270.	761.0	1	761.0	760.5	0	693.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						760.5	0	820.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
4320.	1	4320.	764.0	1	764.0	763.5	0	681.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						763.5	0	786.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
4370.	1	4370.	767.0	1	767.0	766.5	0	661.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						766.5	0	826.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
4420.	1	4420.	778.6	1	778.6	778.1	0	725.6	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						778.1	0	838.1	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
4470.	1	4470.	791.0	1	791.0	790.5	0	738.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						790.5	0	828.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
4570.	1	4570.	803.0	1	803.0	802.5	0	750.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						802.5	0	832.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					

CHAIN EQ COR CHG GND ELV Q COR ELV — 8 SETS OF ELEV + DISTANCES - LEFT SIDE - TOP ROW,RIGHT SIDE - BOTTOM ROW

CHAIN	EQ	COR CHG	GND ELV	Q	COR ELV	1ELEV	1DIST	2ELEV	2DIST	3ELEV	3DIST	4ELEV	4DIST	5ELEV	5DIST	6ELEV	6DIST	7ELEV	7DIST	8ELEV	8DI
4670.	1	4670.	820.0	1	820.0	819.5	0	782.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						819.5	0	864.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
4770.	1	4770.	822.0	1	822.0	821.5	0	776.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						821.5	0	859.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
4870.	1	4870.	821.0	1	821.0	820.5	0	760.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						820.5	0	835.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
4970.	1	4970.	813.0	1	813.0	812.5	0	775.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						812.5	0	827.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
5070.	1	5070.	831.0	1	831.0	830.5	0	740.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						830.5	0	883.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
5170.	1	5170.	842.2	1	842.2	841.7	0	819.2	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						841.7	0	916.7	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
5270.	1	5270.	857.0	1	857.0	856.5	0	871.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						856.5	0	856.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
5370.	1	5370.	849.0	1	849.0	848.5	0	826.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						848.5	0	841.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					

8 SETS OF ELEV + DISTANCES - LEFT SIDE - TOP ROW,RIGHT SIDE - BOTTOM ROW

CHAIN	EQ	COR CHG	GND ELV	Q	COR ELV	1ELEV	1DIST	2ELEV	2DIST	3ELEV	3DIST	4ELEV	4DIST	5ELEV	5DIST	6ELEV	6DIST	7ELEV	7DIST	8ELEV	8DI
5420.	1	5420.	860.1	1	860.1	859.6	0	829.6	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						859.6	0	867.1	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
5470.	1	5470.	871.0	1	871.0	870.5	0	840.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						870.5	0	885.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
5570.	1	5570.	875.0	1	875.0	874.5	0	822.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						874.5	0	919.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
5670.	1	5670.	912.0	1	912.0	911.5	0	881.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						911.5	0	986.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
5770.	1	5770.	919.0	1	919.0	918.5	0	851.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						918.5	0	971.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
5870.	1	5870.	928.0	1	928.0	927.5	0	837.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						927.5	0	1002.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
5970.	1	5970.	936.0	1	936.0	935.5	0	868.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						935.5	0	1010.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
6070.	1	6070.	934.0	1	934.0	933.5	0	858.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						933.5	0	1023.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					

CHAIN EQ COR CHG GND ELV Q COR ELV 8 SETS OF ELEV + DISTANCES - LEFT SIDE - TOP ROW,RIGHT SIDE - BOTTOM ROW

CHAIN	EQ	COR CHG	GND ELV	Q	COR ELV	1ELEV	1DIST	2ELEV	2DIST	3ELEV	3DIST	4ELEV	4DIST	5ELEV	5DIST	6ELEV	6DIST	7ELEV	7DIST	8ELEV	8DI
6170.	1	6170.	946.0	1	946.0	945.5	0	878.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						945.5	0	1020.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
6270.	1	6270.	952.5	1	952.5	952.0	0	884.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						952.0	0	1004.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
6370.	1	6370.	971.0	1	971.0	970.5	0	903.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						970.5	0	1045.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
6420.	1	6420.	980.5	1	980.5	980.0	0	905.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						980.0	0	1055.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
6470.	1	6470.	991.0	1	991.0	990.5	0	893.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						990.5	0	1073.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
6520.	1	6520.	986.2	1	986.2	985.7	0	880.7	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						985.7	0	1053.2	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
6570.	1	6570.	985.0	1	985.0	984.5	0	894.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						984.5	0	1067.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
6620.	1	6620.	986.0	1	986.0	985.5	0	918.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						985.5	0	1053.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			

CHAIN EQ COR CHG GND ELV Q COR ELV — 8 SETS OF ELEV + DISTANCES - LEFT SIDE - TOP ROW, RIGHT SIDE - BOTTOM ROW

CHAIN	EQ	COR CHG	GND ELV	Q	COR ELV	1ELEV	1DIST	2ELEV	2DIST	3ELEV	3DIST	4ELEV	4DIST	5ELEV	5DIST	6ELEV	6DIST	7ELEV	7DIST	8ELEV	8DI
6670.	1	6670.	987.0	1	987.0	986.5	0	926.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						986.5	0	1039.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
6720.	1	6720.	985.1	1	985.1	984.6	0	954.6	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						984.6	0	1044.6	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
6770.	1	6770.	985.0	1	985.0	984.5	0	939.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						984.5	0	1052.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
6820.	1	6820.	988.0	1	988.0	987.5	0	920.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						987.5	0	1055.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
6870.	1	6870.	991.0	1	991.0	990.5	0	953.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						990.5	0	1050.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
6970.	1	6970.	1002.0	1	1002.0	1001.5	0	949.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1001.5	0	1054.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
7070.	1	7070.	1006.0	1	1006.0	1005.5	0	1005.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1005.5	0	1058.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
7095.	1	7095.	1010.0	1	1010.0	1009.5	0	1039.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1009.5	0	1069.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					

CHAIN EQ COR CHG GND ELV Q COR ELV — 8 SETS OF ELEV + DISTANCES - LEFT SIDE - TOP ROW,RIGHT SIDE - BOTTOM ROW

CHAIN	EQ	COR CHG	GND ELV	Q	COR ELV	1ELEV	1DIST	2ELEV	2DIST	3ELEV	3DIST	4ELEV	4DIST	5ELEV	5DIST	6ELEV	6DIST	7ELEV	7DIST	8ELEV	8DI
7145.	1	7145.	1014.4	1	1014.4	1013.9	0	1051.4	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1013.9	0	1036.4	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
7195.	1	7195.	1023.1	1	1023.1	1022.6	0	1060.1	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1022.6	0	1015.1	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
7245.	1	7245.	1024.3	1	1024.3	1023.8	0	1076.3	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1023.8	0	963.8	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
7274.	1	7274.	1025.0	1	1025.0	1024.5	0	1099.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1024.5	0	957.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
7295.	1	7295.	1023.0	1	1023.0	1022.5	0	1105.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1022.5	0	985.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
7450.	1	7450.	1014.0	1	1014.0	1013.5	0	1028.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1013.5	0	1006.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
7550.	1	7550.	1007.0	1	1007.0	1006.5	0	1006.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1006.5	0	1006.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
7650.	1	7650.	1014.0	1	1014.0	1013.5	0	1036.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1013.5	0	998.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			

CHAIN EQ COR CHG GND ELV Q COR ELV 8 SETS OF ELEV + DISTANCES - LEFT SIDE - TOP ROW,RIGHT SIDE - BOTTOM ROW

CHAIN	EQ	COR CHG	GND ELV	Q	COR ELV	1ELEV	1DIST	2ELEV	2DIST	3ELEV	3DIST	4ELEV	4DIST	5ELEV	5DIST	6ELEV	6DIST	7ELEV	7DIST	8ELEV	8DI
7750.	1	7750.	1030.0	1	1030.0	1029.5	0	1022.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1029.5	0	1022.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
7850.	1	7850.	1020.0	1	1020.0	1019.5	0	997.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1019.5	0	1064.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
7950.	1	7950.	1055.0	1	1055.0	1054.5	0	1092.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1054.5	0	1054.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
8000.	1	8000.	1065.0	1	1065.0	1064.5	0	1109.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1064.5	0	1027.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
8050.	1	8050.	1075.0	1	1075.0	1074.5	0	1097.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1074.5	0	1059.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
8100.	1	8100.	1073.6	1	1073.6	1073.1	0	1020.6	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1073.1	0	1043.1	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
8150.	1	8150.	1070.0	1	1070.0	1069.5	0	987.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1069.5	0	1152.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			
8200.	1	8200.	1073.0	1	1073.0	1072.5	0	1020.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1072.5	0	1132.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2	NOBSR= 2	SOIL = 0 0 0																			

CHAIN EQ COR CHG GND ELV G COR ELV 8 SETS OF ELEV + DISTANCES - LEFT SIDE - TOP ROW,RIGHT SIDE - BOTTOM ROW

CHAIN	EQ	COR CHG	GND ELV	G	COR ELV	1ELEV	1DIST	2ELEV	2DIST	3ELEV	3DIST	4ELEV	4DIST	5ELEV	5DIST	6ELEV	6DIST	7ELEV	7DIST	8ELEV	8DI
8250.	1	8250.	1076.0	1	1076.0	1075.5	0	1053.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1075.5	0	1098.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
8300.	1	8300.	1082.0	1	1082.0	1081.5	0	1051.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1081.5	0	1104.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
8350.	1	8350.	1082.0	1	1082.0	1081.5	0	1029.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1081.5	0	1179.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
8450.	1	8450.	1092.0	1	1092.0	1091.5	0	1016.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1091.5	0	1159.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
8550.	1	8550.	1108.0	1	1108.0	1107.5	0	1032.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1107.5	0	1130.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
8600.	1	8600.	1101.0	1	1101.0	1100.5	0	1093.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1100.5	0	1130.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
8650.	1	8650.	1096.0	1	1096.0	1095.5	0	1103.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1095.5	0	1155.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
8700.	1	8700.	1097.0	1	1097.0	1096.5	0	1081.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1096.5	0	1104.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					

CHAIN EQ COR CHG GND ELV Q COR ELV 8 SETS OF ELEV + DISTANCES - LEFT SIDE - TOP ROW, RIGHT SIDE - BOTTOM ROW

CHAIN	EQ	COR CHG	GND ELV	Q	COR ELV	1ELEV	1DIST	2ELEV	2DIST	3ELEV	3DIST	4ELEV	4DIST	5ELEV	5DIST	6ELEV	6DIST	7ELEV	7DIST	8ELEV	8DI
8750.	1	8750.	1098.0	1	1098.0	1097.5	0	1082.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1097.5	0	1135.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NCBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
8800.	1	8800.	1100.0	1	1100.0	1099.5	0	1024.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1099.5	0	1129.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
8850.	1	8850.	1102.0	1	1102.0	1101.5	0	1019.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1101.5	0	1161.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
8900.	1	8900.	1107.0	1	1107.0	1106.5	0	1039.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1106.5	0	1129.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
8950.	1	8950.	1111.0	1	1111.0	1110.5	0	1058.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1110.5	0	1170.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NCBSL= 2 NCBSR= 2 SOIL = 0 0 0																					
9050.	1	9050.	1115.0	1	1115.0	1114.5	0	1084.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1114.5	0	1197.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NCBSR= 2 SCIL = 0 0 0																					
9100.	1	9100.	1110.2	1	1110.2	1109.7	0	1079.7	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1109.7	0	1169.7	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NCBSL= 2 NCBSR= 2 SOIL = 0 0 0																					
9150.	1	9150.	1104.0	1	1104.0	1103.5	0	1058.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1103.5	0	1141.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					

8 SETS OF ELEV + DISTANCES - LEFT SIDE - TOP ROW,RIGHT SIDE - BOTTOM ROW

CHAIN	EQ	COR CHG	GND ELV	Q	COR ELV	1ELEV	1DIST	2ELEV	2DIST	3ELEV	3DIST	4ELEV	4DIST	5ELEV	5DIST	6ELEV	6DIST	7ELEV	7DIST	8ELEV	8DI
9200.	1	9200.	1105.6	1	1105.6	1105.1	0	1052.6	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1105.1	0	1127.6	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
9250.	1	9250.	1107.0	1	1107.0	1106.5	0	1054.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1106.5	0	1144.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
9350.	1	9350.	1111.8	1	1111.8	1111.3	0	1058.8	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1111.3	0	1148.8	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
9400.	1	9400.	1107.1	1	1107.1	1106.6	0	1046.6	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1106.6	0	1166.6	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
9450.	1	9450.	1103.0	1	1103.0	1102.5	0	1042.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1102.5	0	1155.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
9500.	1	9500.	1100.0	1	1100.0	1099.5	0	1047.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1099.5	0	1137.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
9550.	1	9550.	1097.0	1	1097.0	1096.5	0	1059.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1096.5	0	1126.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
9600.	1	9600.	1095.6	1	1095.6	1095.1	0	1095.1	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1095.1	0	1110.1	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					

CHAIN EQ COR CHG GND ELV C COR ELV 8 SETS OF ELEV + DISTANCES - LEFT SIDE - TOP ROW,RIGHT SIDE - BOTTOM ROW

CHAIN	EQ	COR CHG	GND ELV	C	COR ELV	1ELEV	1DIST	2ELEV	2DIST	3ELEV	3DIST	4ELEV	4DIST	5ELEV	5DIST	6ELEV	6DIST	7ELEV	7DIST	8ELEV	8DI
9612.	1	9612.	1095.0	1	1095.0	1094.5	0	1087.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1094.5	0	1102.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
9641.	1	9641.	1094.0	1	1094.0	1093.5	0	1086.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1093.5	0	1101.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
9700.	1	9700.	1103.7	1	1103.7	1103.2	0	1095.7	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1103.2	0	1103.2	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
9750.	1	9750.	1114.0	1	1114.0	1113.5	0	1106.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1113.5	0	1128.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
9850.	1	9850.	1119.0	1	1119.0	1118.5	0	1096.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1118.5	0	1096.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
9950.	1	9950.	1128.0	1	1128.0	1127.5	0	1105.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1127.5	0	1120.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
10050.	1	10050.	1128.0	1	1128.0	1127.5	0	1097.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1127.5	0	1135.0	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					
10250.	1	10250.	1135.0	1	1135.0	1134.5	0	1134.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
						1134.5	0	1164.5	150	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NOBSL= 2 NOBSR= 2 SOIL = 0 0 0																					

APPENDIX 2 VOLUME CALCULATION

THESIS PROJECT, UNIVERSITY OF BRITISH COLUMBIA RESEARCH FOREST; ROAD C

CHAINAGE	ELEVATN	SLOPES CUT RK	SLOPES CUT CM	SLOPES FILL	SHRINK	SWELL	O.M. DITCH DEPTH	ROCK DITCH DEPTH	DITCH SLOPE	SCRAPER DITCH WIDTH	SUBGRADE WIDTHS LEFT	SUBGRADE WIDTHS RIGHT	EXCAVATION ROCK	EXCAVATION OM	FILL	SIDECAST	NET ACC MASS	BACK FILL
1+00	507.0	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	0	0	0	0	0
2+00	514.0	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	175	19	19	156	0
3+00	521.0	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	180	10	10	327	0
3+50	524.5	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	61	5	5	382	0
4+00	528.0	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	135	0	0	517	0
5+00	535.0	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	180	657	180	40	0
5+50	538.5	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	0	616	0	-576	0
6+00	542.0	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	0	418	0	-994	0
7+00	549.0	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	404	261	261	-851	0
8+00	555.8	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	843	0	0	-8	0
8+50	557.8	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	312	2	2	302	0
9+00	558.4	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	135	45	45	392	0
10+00	557.0	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	14	14	0	175	218	175	348	0
11+00	555.4	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	14	14	0	115	506	115	-43	0
12+00	553.8	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	14	14	0	24	1100	24	-1119	0
13+00	552.1	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	14	14	0	0	2113	0	-3231	0
13+20	551.8	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	14	14	0	0	583	0	-3814	0
13+67	551.1	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	0	1440	0	-5254	0
14+00	550.5	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	0	1171	0	-6425	0
15+00	548.9	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	1738	2012	1738	-6699	0
15+73	547.7	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	2909	0	0	-3790	0
16+00	547.2	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	1204	0	0	-2586	0
16+34	546.7	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	17	17	0	1654	0	0	-932	0
17+00	546.1	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	17	17	0	2051	0	0	1119	0
18+00	548.7	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	17	17	0	454	3146	454	-1573	0
18+31	550.4	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	17	17	0	0	2263	0	-3836	0
18+90	554.7	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	17	17	0	0	3580	0	-7416	0
19+00	555.6	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	17	17	0	0	368	0	-7784	0
20+00	565.0	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	17	17	0	0	2340	0	-10124	0
21+00	574.5	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	17	17	0	140	573	140	-10558	0
22+00	583.9	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	17	17	0	599	0	0	-9959	0
23+70	599.9	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	17	17	0	2163	0	0	-7796	0
24+70	609.3	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	17	17	0	2388	0	0	-5408	0
25+15	613.6	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	17	17	0	1149	0	0	-4258	0
25+70	618.8	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	17	17	0	1051	0	0	-3207	0
26+70	628.2	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	17	17	0	2037	0	0	-1171	0
27+70	637.5	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	17	17	0	2630	0	0	1460	0
28+70	644.8	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	17	17	0	2956	0	0	4416	0
28+77	645.2	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	17	17	0	190	0	0	4606	0
29+52	649.1	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	17	17	0	1004	17	17	5593	0
29+70	650.0	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	17	17	0	15	16	15	5592	0
30+70	654.9	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	17	17	0	225	83	83	5735	0
31+24	657.7	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	119	43	43	5812	0
31+70	660.4	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	10	323	10	5498	0
32+40	665.0	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	0	997	0	4502	0
32+70	667.2	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	0	529	0	3973	0
33+20	671.1	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	14	14	0	2	615	2	3360	0
33+70	675.3	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	14	14	0	243	125	125	3478	0
34+70	684.7	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	14	14	0	1447	0	0	4925	0
35+70	694.9	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	14	14	0	981	127	127	5779	0
36+70	705.1	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	14	14	0	611	127	127	6264	0
37+70	715.4	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	966	0	0	7230	0
37+79	716.3	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	65	0	0	7295	0
38+70	725.6	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	319	36	36	7577	0
39+70	735.8	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	124	40	40	7662	0

THESIS PROJECT, UNIVERSITY OF BRITISH COLUMBIA RESEARCH FOREST; ROAD C

CHAINAGE	ELEVATN	SLOPES CUT RK	SLOPES CUT OM	SLOPES FILL	SHRINK	SWELL	O.M. DITCH DEPTH	ROCK DITCH DEPTH	DITCH SLOPE	SCRAPER DITCH WIDTH	SUBGRADE WIDTHS LEFT	SUBGRADE WIDTHS RIGHT	EXCAVATION ROCK	EXCAVATION OM	FILL	SIDECAST	NET ACC MASS	BACK FILL
40+70	746.0	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	242	0	0	7904	0
41+70	756.2	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	150	27	27	8027	0
42+70	766.4	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	34	728	34	7333	0
43+20	771.5	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	1	985	1	6348	0
43+70	776.6	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	0	1761	0	4587	0
44+20	781.8	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	8	1306	8	3289	0
44+70	786.9	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	110	181	110	3218	0
45+70	797.1	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	14	14	0	512	4	4	3725	0
46+70	807.3	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	14	14	0	1127	0	0	4852	0
47+70	815.2	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	14	14	0	1211	0	0	6063	0
48+70	823.0	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	392	414	392	6042	0
49+70	830.7	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	0	2910	0	3132	0
50+70	838.5	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	0	4055	0	-924	0
51+70	846.3	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	35	1890	35	-2778	0
52+70	854.1	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	226	331	226	-2882	0
53+70	861.8	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	191	1488	191	-4179	0
54+20	865.7	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	0	1032	0	-5211	0
54+70	869.7	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	28	300	28	-5483	0
55+70	880.4	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	56	627	56	-6053	0
56+70	891.4	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	2294	602	602	-4361	0
57+70	902.4	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	3702	0	0	-659	0
58+70	913.3	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	2768	0	0	2109	0
59+70	924.3	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	2443	0	0	4552	0
60+70	935.3	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	1250	337	337	5465	0
61+70	946.3	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	365	618	365	5212	0
62+70	957.2	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	204	1017	204	4399	0
63+70	968.2	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	380	835	380	3943	0
64+20	973.7	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	416	53	53	4306	0
64+70	979.2	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	623	4	4	4926	0
65+20	983.7	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	500	213	213	5212	0
65+70	986.5	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	159	527	159	4844	0
66+20	988.2	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	82	538	82	4389	0
66+70	989.9	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	40	454	40	3975	0
67+20	991.6	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	11	537	11	3449	0
67+70	993.2	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	0	716	0	2733	0
68+20	994.9	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	0	845	0	1888	0
68+70	996.6	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	1	688	1	1202	0
69+70	999.9	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	184	551	184	835	0
70+70	1003.3	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	459	48	48	1246	0
70+95	1004.1	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	258	0	0	1503	0
71+45	1005.8	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	819	0	0	2323	0
71+95	1007.4	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	1204	0	0	3527	0
72+45	1009.1	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	1463	0	0	4990	0
72+74	1010.1	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	868	0	0	5858	0
72+95	1010.8	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	508	0	0	6366	0
74+50	1016.0	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	1275	256	256	7385	0
75+50	1020.7	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	0	1568	0	5817	0
76+50	1027.1	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	0	2711	0	3107	0
77+50	1034.8	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	0	1757	0	1349	0
78+50	1042.5	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	14	14	0	0	3247	0	-1898	0
79+50	1050.2	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	14	14	0	337	2798	337	-4358	0
80+00	1054.1	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	14	14	0	619	0	0	-3739	0
80+50	1058.0	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	14	14	0	1185	0	0	-2554	0
81+00	1061.8	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	14	14	0	1043	0	0	-1511	0
81+50	1065.7	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	448	28	28	-1091	0

THESIS PROJECT, UNIVERSITY OF BRITISH COLUMBIA RESEARCH FOREST; ROAD C

CHAINAGE	ELEVATN	SLOPES CUT RK	SLOPES CUT OM	SLOPES FILL	SHRINK	SWELL	O.M. DITCH DEPTH	ROCK DITCH DEPTH	DITCH SLOPE	SCRAPER DITCH WIDTH	SUBGRADE WIDTHS LEFT	SUBGRADE WIDTHS RIGHT	EXCAVATION ROCK	EXCAVATION OM	FILL	SIDECAST	NET ACC MASS	BACK FILL
82+00	1069.6	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	245	35	35	-881	0
82+50	1073.4	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	166	7	7	-721	0
83+00	1077.3	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	181	0	0	-541	0
83+50	1081.2	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	205	48	48	-384	0
84+50	1088.9	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	522	215	215	-77	0
85+50	1095.8	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	1042	119	119	847	0
86+00	1098.4	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	439	0	0	1286	0
86+50	1100.3	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	99	128	99	1257	0
87+00	1101.7	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	6	369	6	895	0
87+50	1102.4	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	0	430	0	465	0
88+00	1102.7	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	1	488	1	-23	0
88+50	1102.9	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	40	530	40	-512	0
89+00	1103.1	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	131	259	131	-640	0
89+50	1103.3	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	15	15	0	350	28	28	-318	0
90+50	1103.7	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	1717	0	0	1399	0
91+00	1103.9	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	869	0	0	2268	0
91+50	1104.1	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	289	60	60	2497	0
92+00	1104.3	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	50	99	50	2448	0
92+50	1104.5	5.00	5.00	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	93	57	57	2483	0
93+50	1105.0	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	569	37	37	3016	0
94+00	1105.2	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	321	37	37	3301	0
94+50	1105.4	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	114	206	114	3208	0
95+00	1105.6	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	14	487	14	2735	0
95+50	1105.8	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	0	773	0	1962	0
96+00	1106.1	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	0	922	0	1040	0
96+12	1106.2	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	0	243	0	797	0
96+41	1106.8	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	0	691	0	106	0
97+00	1108.6	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	0	1023	0	-917	0
97+50	1110.2	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	115	221	115	-1023	0
98+50	1113.4	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	476	0	0	-547	0
99+50	1116.5	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	961	0	0	414	0
100+50	1119.7	5.00	1.33	1.00	1.33	1.00	1.00	1.00	0.50	0	13	13	0	1209	0	0	1623	0

IHE330I ZERODIVIDE IN STATEMENT 00158 AT OFFSET +0221A FROM ENTRY POINT DESIGN

EXECUTION TERMINATED

INVALID COMMAND
$SIGNOFF

```
CONVERT VOLALOC  TO PBFILE

TIME =   0.03

     SUMMARY
     CHECK

1- ROWS SECTION.

    0 MINOR ERROR(S) -    0 MAJOR ERROR(S).
2- COLUMNS SECTION.

    0 MINOR ERROR(S) -    0 MAJOR ERROR(S).
3- RHS'S SECTION.

   TOTVOA

    0 MINOR ERROR(S) -    0 MAJOR ERROR(S).
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NUMBER OF ELEMENTS BY COLUMN ORDER

69	F050C020.....3	F050C030.....3	F050C035.....3	F050C040.....3	F050C070.....3	F050C080.....3	F050C085.....3
76	F050C090.....3	F050BORR.....2	F055C020.....3	F055C030.....3	F055C035.....3	F055C040.....3	F055C070.....3
83	F055C080.....3	F055C085.....3	F055C090.....3	F055BORR.....2	F060C020.....3	F060C030.....3	F060C035.....3
90	F060C040.....3	F060C070.....3	F060C080.....3	F060C085.....3	F060C090.....3	F060BORR.....2	F100C030.....3
97	F100C035.....3	F100C040.....3	F100C070.....3	F100C080.....3	F100C085.....3	F100C090.....3	F100C157.....3
104	F100C160.....3	F100C163.....3	F100C170.....3	F100BORR.....2	F110C040.....3	F110C070.....3	F110C080.....3
111	F110C085.....3	F110C090.....3	F110C157.....3	F110C160.....3	F110C163.....3	F110C170.....3	F110BORR.....2
118	F120C070.....3	F120C080.....3	F120C085.....3	F120C090.....3	F120C157.....3	F120C160.....3	F120C163.....3
125	F120C170.....3	F120BORR.....2	F130C070.....3	F130C080.....3	F130C085.....3	F130C090.....3	F130C157.....3
132	F130C160.....3	F130C163.....3	F130C170.....3	F130BORR.....2	F132C070.....3	F132C080.....3	F132C085.....3
139	F132C090.....3	F132C157.....3	F132C160.....3	F132C163.....3	F132C170.....3	F132BORR.....2	F136C070.....3
146	F136C080.....3	F136C085.....3	F136C090.....3	F136C157.....3	F136C160.....3	F136C163.....3	F136C170.....3
153	F136BORR.....2	F140C070.....3	F140C080.....3	F140C085.....3	F140C090.....3	F140C157.....3	F140C160.....3
160	F140C163.....3	F140C170.....3	F140BORR.....2	F150C080.....3	F150C085.....3	F150C090.....3	F150C157.....3
167	F150C160.....3	F150C163.....3	F150C170.....3	F150C220.....3	F150BORR.....2	F180C157.....3	F180C160.....3
174	F180C163.....3	F180C170.....3	F180C220.....3	F180C237.....3	F180C247.....3	F180BORR.....2	F183C157.....3
181	F183C160.....3	F183C163.....3	F183C170.....3	F183C220.....3	F183C237.....3	F183C247.....3	F183C251.....3
188	F183BORR.....2	F189C157.....3	F189C160.....3	F189C163.....3	F189C170.....3	F189C220.....3	F189C237.....3
195	F189C247.....3	F189C251.....3	F189C257.....3	F189BORR.....2	F190C157.....3	F190C160.....3	F190C163.....3
202	F190C170.....3	F190C220.....3	F190C237.....3	F190C247.....3	F190C251.....3	F190C257.....3	F190BORR.....2
209	F200C157.....3	F200C160.....3	F200C163.....3	F200C170.....3	F200C220.....3	F200C237.....3	F200C247.....3
216	F200C251.....3	F200C257.....3	F200C267.....3	F200BORR.....2	F210C157.....3	F210C160.....3	F210C163.....3
223	F210C170.....3	F210C220.....3	F210C237.....3	F210C247.....3	F210C251.....3	F210C257.....3	F210C267.....3
230	F210C277.....3	F210BORR.....2	F297C237.....3	F297C247.....3	F297C251.....3	F297C257.....3	F297C267.....3
237	F297C277.....3	F297C287.....3	F297C288.....3	F297C295.....3	F297C307.....3	F297C312.....3	F297C337.....3
244	F297C347.....3	F297C357.....3	F297C367.....3	F297BORR.....2	F317C247.....3	F317C251.....3	F317C257.....3
251	F317C267.....3	F317C277.....3	F317C287.....3	F317C288.....3	F317C295.....3	F317C307.....3	F317C312.....3
258	F317C337.....3	F317C347.....3	F317C357.....3	F317C367.....3	F317C377.....3	F317C378.....3	F317C387.....3
265	F317BORR.....2	F324C257.....3	F324C267.....3	F324C277.....3	F324C287.....3	F324C288.....3	F324C295.....3
272	F324C307.....3	F324C312.....3	F324C337.....3	F324C347.....3	F324C357.....3	F324C367.....3	F324C377.....3
279	F324C378.....3	F324C387.....3	F324BORR.....2	F327C257.....3	F327C267.....3	F327C277.....3	F327C287.....3
286	F327C289.....3	F327C295.....3	F327C307.....3	F327C312.....3	F327C337.....3	F327C347.....3	F327C357.....3
293	F327C367.....3	F327C377.....3	F327C378.....3	F327C387.....3	F327C397.....3	F327BORR.....2	F332C267.....3
300	F332C277.....3	F332C287.....3	F332C288.....3	F332C295.....3	F332C307.....3	F332C312.....3	F332C337.....3
307	F332C347.....3	F332C357.....3	F332C367.....3	F332C377.....3	F332C378.....3	F332C387.....3	F332C397.....3
314	F332BORR.....2	F427C357.....3	F427C367.....3	F427C377.....3	F427C378.....3	F427C387.....3	F427C397.....3
321	F427C407.....3	F427C417.....3	F427C457.....3	F427C467.....3	F427C477.....3	F427BORR.....2	F432C367.....3
328	F432C377.....3	F432C378.....3	F432C387.....3	F432C397.....3	F432C407.....3	F432C417.....3	F432C457.....3
335	F432C467.....3	F432C477.....3	F432BORR.....2	F437C367.....3	F437C377.....3	F437C378.....3	F437C387.....3
342	F437C397.....3	F437C407.....3	F437C417.....3	F437C457.....3	F437C467.....3	F437C470.....3	F437BORR.....2
349	F442C377.....3	F442C378.....3	F442C387.....3	F442C397.....3	F442C407.....3	F442C417.....3	F442C457.....3
356	F442C467.....3	F442C477.....3	F442BORR.....2	F447C377.....3	F447C378.....3	F447C387.....3	F447C397.....3
363	F447C407.....3	F447C417.....3	F447C457.....3	F447C467.....3	F447C477.....3	F447BORR.....2	F487C417.....3
370	F487C457.....3	F487C467.....3	F487C477.....3	F487BORR.....2	F497C457.....3	F497C467.....3	F497C477.....3
377	F497BORR.....2	F507C457.....3	F507C467.....3	F507C477.....3	F507BORR.....2	WASTC020.....2	WASTC030.....2
384	WASTC035.....2	WASTC040.....2	WASTC070.....2	WASTC080.....2	WASTC085.....2	WASTC090.....2	WASTC157.....2
391	WASTC160.....2	WASTC163.....2	WASTC170.....2	WASTC220.....2	WASTC237.....2	WASTC247.....2	WASTC251.....2
398	WASTC257.....2	WASTC267.....2	WASTC277.....2	WASTC287.....2	WASTC288.....2	WASTC295.....2	WASTC307.....2
405	WASTC312.....2	WASTC337.....2	WASTC347.....2	WASTC375.....2	WASTC367.....2	WASTC377.....2	WASTC378.....2
412	WASTC387.....2	WASTC397.....2	WASTC407.....2	WASTC417.....2	WASTC457.....2	WASTC467.....2	WASTC477.....2

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NUMBER OF ELEMENTS BY ROW ORDER, EXCLUDING RHS'S, INCLUDING SLACK ELEMENT

 1 N VOLACO  ...351  E 02+00C .....5  E 03+00C .....6  E 03+50C .....6  E 04+00C .....7  E 07+00C ....12  E 08+00C ....13
 8 E 08+50C  ....13  E 09+00C ....13  E 15+73C ....16  E 16+00C ....16  E 16+34C ....16  E 17+00C ....16  E 22+00C .....9
15 E 23+70C  .....9  E 24+70C ....10  E 25+15C .....9  E 25+70C ....10  E 26+70C .....9  E 27+70C .....8  E 28+70C .....7
22 E 28+77C  .....7  E 29+52C .....7  E 30+70C .....7  E 31+24C .....7  E 33+70C .....7  E 34+70C .....7  E 35+70C .....8
29 E 36+70C  ....10  E 37+70C ....11  E 37+79C ....11  E 38+70C ....11  E 39+70C .....9  E 40+70C .....7  E 41+70C .....8
36 E 45+70C  ....10  E 46+70C ....10  E 47+70C ....10  E F05+00 ....10  E F05+50 ....10  E F06+00 ....10  E F10+00 ....13
43 E F11+00  ....11  E F12+00 ....10  E F13+00 ....10  E F13+20 ....10  E F13+67 ....10  E F14+00 ....10  E F15+00 ....10
50 E F18+00  .....9  E F18+31 ....10  E F18+90 ....11  E F19+00 ....11  E F20+00 ....12  E F21+00 ....13  E F29+70 ....17
57 E F31+70  ....19  E F32+40 ....17  E F32+70 ....18  E F33+20 ....17  E F42+70 ....13  E F43+20 ....12  E F43+70 ....12
64 E F44+20  ....11  E F44+70 ....11  E F48+70 .....6  E F49+70 .....5  E F50+70 .....5

PROBLEM STATISTICS -    68 ROWS,     418 VARIABLES,     1051 ELEMENTS, DENSITY =    3.69

THESE STATISTICS INCLUDE ONE SLACK VARIABLE FOR EACH ROW.

   0 MINOR ERRORS,     0 MAJOR ERRORS.
```

SETUP PBFILE

TIME = 0.43

MIN

MATRIX1 ASSIGNED TO MATRIX1
MATRIX2 ASSIGNED TO MATRIX2

ETA1 ASSIGNED TO ETA1
ETA2 ASSIGNED TO ETA2

SCRATCH1 ASSIGNED TO SCRATCH1
SCRATCH2 ASSIGNED TO SCRATCH2
MPSCRAT ASSIGNED TO MPSCRAT

MAXIMUM PRICING NOT REQUIRED - MAXIMUM POSSIBLE 5

NO CYCLING

POOLS	NUMBER	SIZE	CORE
H.REG-BITS MAP			284
WORK REGIONS	7	568	3976
MATRIX BUFFERS	3	6728	20184
ETA BUFFERS	5	3504	17520

	TOTAL	NORMAL	.FREE.	FIXED	BOUNDED
ROWS (LOG.VAR.)	68	0	1	67	0
COLUMNS (STR.VAR.)	350	350	0	0	0

1051 ELEMENTS - DENSITY = 3.69 - 3 MATRIX RECORDS (WITHOUT RHS'S)

PICTURE - USING PBFILE

TIME = 0.51

1, 2

Station	Type	F120C1 63	F120C1 70	F120B0 RR	F130C0 70	F130C0 80	F130C0 85	F130C0 90	F130C1 57	F130C1 60	F130C1 63	F130C1 70	F130B0 RR	F132C0 70	F132C0 80	F132C0 85	F132C0 90	F132C1 57	F132C1 60	F132C1 63	F132C1 70	F132B0 RR	F136C0 70	F136C0 80	F136C0 85	F136C0 90	F136C1 57	F136C1 60	F136C1 63	F136C1 70	F136B0 RR
VOLACO	N	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
02+00C	E																														
03+00C	E																														
03+50C	E																														
04+00C	E																														
07+00C	E				1									1									1								
08+00C	E					1									1									1							
08+50C	E						1									1									1						
09+00C	E							1									1									1					
15+73C	E								1									1									1				
16+00C	E									1									1									1			
16+34C	E	1									1									1									1		
17+00C	E		1									1									1									1	
22+00C	E																														
23+70C	E																														
24+70C	E																														
25+15C	E																														
25+70C	E																														
26+70C	E																														
27+70C	E																														
28+70C	E																														
28+77C	E																														
29+52C	E																														
30+70C	E																														
31+24C	E																														
33+70C	E																														
34+70C	E																														
35+70C	E																														
36+70C	E																														
37+70C	E																														
37+79C	E																														
38+70C	E																														
39+70C	E																														
40+70C	E																														
41+70C	E																														
45+70C	E																														
46+70C	E																														
47+70C	E																														
F05+00	E																														
F05+50	E																														
F06+00	E																														
F10+00	E																														
F11+00	E																														
F12+00	E	1	1	1																											
F13+00	E				1	1	1	1	1	1	1	1	1																		
F13+20	E													1	1	1	1	1	1	1	1	1									
F13+67	E																						1	1	1	1	1	1	1	1	1

Station	F140C0 70	F140C0 80	F140C0 85	F140C0 90	F140C1 57	F140C1 60	F140C1 63	F140C1 70	F140B0 RR	F150C0 80	F150C0 85	F150C0 90	F150C1 57	F150C1 60	F150C1 63	F150C1 70	F150C2 20	F150B0 RR	F180C1 57	F180C1 60	F180C1 63	F180C1 70	F180C2 20	F180C2 37	F180C2 47
VOLACO	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
02+00C																									
03+00C																									
03+50C																									
04+00C																									
07+00C	1																								
08+00C		1								1															
08+50C			1								1														
09+00C				1								1													
15+73C					1								1						1						
16+00C						1								1						1					
16+34C							1								1						1				
17+00C								1								1						1			
22+00C																	1						1		
23+70C																								1	
24+70C																									1
25+15C																									
25+70C																									
26+70C																									
27+70C																									
28+70C																									
28+77C																									
29+52C																									
30+70C																									
31+24C																									
33+70C																									
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35+70C																									
36+70C																									
37+70C																									
37+79C																									
38+70C																									
39+70C																									
40+70C																									
41+70C																									
45+70C																									
46+70C																									
47+70C																									
F05+00																									
F05+50																									
F06+00																									
F10+00																									
F11+00																									
F12+00																									
F13+00																									
F13+20																									
F13+67																									

		F120C163	F120C170	F120B0RR	F130C070	F130C080	F130C085	F130C090	F130C157	F130C160	F130C163	F130C170	F130B0RR	F132C070	F132C080	F132C085	F132C090	F132C157	F132C160	F132C163	F132C170	F132B0RR	F136C070	F136C080	F136C085	F136C090	F136C157	F136C160	F136C163	F136C170	F136B0RR
F14+00	E																														
F15+00	E																														
F18+00	E																														
F18+31	E																														
F18+90	E																														
F19+00	E																														
F20+00	E																														
F21+00	E																														
F29+70	E																														
F31+70	E																														
F32+40	E																														
F32+70	E																														
F33+20	E																														
F42+70	E																														
F43+20	E																														
F43+70	E																														
F44+20	E																														
F44+70	E																														
F48+70	E																														
F49+70	E																														
F50+70	E																														

	F140C070	F140C080	F140C085	F140C090	F140C157	F140C160	F140C163	F140C170	F140B0RR	F150C080	F150C085	F150C090	F150C157	F150C160	F150C163	F150C170	F150C220	F150B0RR	F180C157	F180C160	F180C163	F180C170	F180C220	F180C237	F180C247
F14+00	1	1	1	1	1	1	1	1	1																
F15+00										1	1	1	1	1	1	1	1	1							
F18+00																			1	1	1	1	1	1	1
F18+31																									
F18+90																									
F19+00																									
F20+00																									
F21+00																									
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F44+20																									
F44+70																									
F48+70																									
F49+70																									
F50+70																									

		F180B0RR	F183C157	F183C160	F183C163	F183C170	F183C220	F183C237	F183C247	F183C251	F183B0RR	F189C157	F189C160	F189C163	F189C170	F189C220	F189C237	F189C247	F189C251	F189C257	F189B0RR	F190C157	F190C160	F190C163	F190C170	F190C220	F190C237	F190C247	F190C251	F190C257	F190B0RR	F200C157	F200C160	F200C163	F200C170	F200C220	F200C237	F200C247	F200C251	F200C257	F200C267	F200B0RR	F210C157	F210C160	F210C163	F210C170	F210C220	F210C237	F210C247	F210C251	F210C257	F210C267	F210C277	F210B0RR	F297C237	F297C247
VOLACO	N	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
02+00C	E																																																							
03+00C	E																																																							
03+50C	E																																																							
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07+00C	E																																																							
08+00C	E																																																							
08+50C	E																																																							
09+00C	E																																																							
15+73C	E		1									1										1										1											1													
16+00C	E			1									1										1										1											1												
16+34C	E				1									1										1										1											1											
17+00C	E					1									1										1										1											1										
22+00C	E						1									1										1										1											1									
23+70C	E							1									1										1										1											1							1	
24+70C	E								1									1										1										1											1							1
25+15C	E									1									1										1										1											1						
25+70C	E																			1										1										1											1					
26+70C	E																																							1											1				
27+70C	E																																																				1			
28+70C	E																																																							
28+77C	E																																																							
29+52C	E																																																							
30+70C	E																																																							
31+24C	E																																																							
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36+70C	E																																																							
37+70C	E																																																							
37+79C	E																																																							
38+70C	E																																																							
39+70C	E																																																							
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46+70C	E																																																							
47+70C	E																																																							
F05+00	E																																																							
F05+50	E																																																							
F06+00	E																																																							
F10+00	E																																																							
F11+00	E																																																							
F12+00	E																																																							
F13+00	E																																																							
F13+20	E																																																							
F13+67	E																																																							

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		F050C0 20	F050C0 30	F050C0 35	F050C0 40	F050C0 70	F050C0 80	F050C0 85	F050C0 90	F050B0 RR	F055C0 20	F055C0 30	F055C0 35	F055C0 40	F055C0 70	F055C0 80	F055C0 85	F055C0 90	F055B0 RR	F060C0 20	F060C0 30	F060C0 35	F060C0 40	F060C0 70	F060C0 80	F060C0 85	F060C0 90	F060B0 RR	F100C0 30	F100C0 35	F100C0 40	F100C0 70	F100C0 80	F100C0 85	F100C0 90	F100C1 57	F100C1 60	F100C1 63	F100C1 70	F100B0 RR	F110C0 40	F110C0 70	F110C0 80	F110C0 85	F110C0 90	F110C1 57	F110C1 60	F110C1 63	F110C1 70	F110B0 RR	F120C0 70	F120C0 80	F120C0 85	F120C0 90	F120C1 57	F120C1 60
VOLACO	N	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
02+00C	E	1									1									1																																				
03+00C	E		1									1									1								1																											
03+50C	E			1									1									1								1																										
04+00C	E				1									1									1								1										1															
07+00C	E					1									1									1								1										1									1					
08+00C	E						1									1									1								1										1									1				
08+50C	E							1									1									1								1										1									1			
09+00C	E								1									1									1								1										1									1		
15+73C	E																																			1										1									1	
16+00C	E																																				1										1									1
16+34C	E																																					1										1								
17+00C	E																																						1										1							
22+00C	E																																																							
23+70C	E																																																							
24+70C	E																																																							
25+15C	E																																																							
25+70C	E																																																							
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28+70C	E																																																							
28+77C	E																																																							
29+52C	E																																																							
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37+70C	E																																																							
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41+70C	E																																																							
45+70C	E																																																							
46+70C	E																																																							
47+70C	E																																																							
F05+00	E	1	1	1	1	1	1	1	1	1																																														
F05+50	E										1	1	1	1	1	1	1	1	1																																					
F06+00	E																			1	1	1	1	1	1	1	1	1																												
F10+00	E																												1	1	1	1	1	1	1	1	1	1	1	1																
F11+00	E																																								1	1	1	1	1	1	1	1	1	1						
F12+00	E																																																		1	1	1	1	1	1
F13+00	E																																																							
F13+20	E																																																							
F13+67	E																																																							

2, 1

		F050C0 20	F050C0 30	F050C0 35	F050C0 40	F050C0 70	F050C0 80	F050C0 85	F050C0 90	F050B0 RR	F055C0 20	F055C0 30	F055C0 35	F055C0 40	F055C0 70	F055C0 80	F055C0 85	F055C0 90	F055B0 RR	F060C0 20	F060C0 30	F060C0 35	F060C0 40	F060C0 70	F060C0 80	F060C0 85	F060C0 90	F060B0 RR	F100C0 30	F100C0 35	F100C0 40	F100C0 70	F100C0 80	F100C0 85	F100C0 90	F100C1 57	F100C1 60	F100C1 63	F100C1 70	F100B0 RR	F110C0 40	F110C0 70	F110C0 80	F110C0 85	F110C0 90	F110C1 57	F110C1 60	F110C1 63	F110C1 70	F110B0 RR	F120C0 70	F120C0 80	F120C0 85	F120C0 90	F120C1 57	F120C1 60
F14+00	E																																																							
F15+00	E																																																							
F18+00	E																																																							
F18+31	E																																																							
F18+90	E																																																							
F19+00	E																																																							
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F31+70	E																																																							
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F32+70	E																																																							
F33+20	E																																																							
F42+70	E																																																							
F43+20	E																																																							
F43+70	E																																																							
F44+20	E																																																							
F44+70	E																																																							
F48+70	E																																																							
F49+70	E																																																							
F50+70	E																																																							

2, 3

Station		F180B0RR	F183C157	F183C160	F183C163	F183C170	F183C220	F183C237	F183C247	F183C251	F183B0RR
F14+00	E										
F15+00	E										
F18+00	E	1									
F18+31	E		1	1	1	1	1	1	1	1	1
F18+90	E										
F19+00	E										
F20+00	E										
F21+00	E										
F29+70	E										
F31+70	E										
F32+40	E										
F32+70	E										
F33+20	E										
F42+70	E										
F43+20	E										
F43+70	E										
F44+20	E										
F44+70	E										
F48+70	E										
F49+70	E										
F50+70	E										

Station	F189C157	F189C160	F189C163	F189C170	F189C220	F189C237	F189C247	F189C251	F189C257	F189B0RR
F14+00										
F15+00										
F18+00										
F18+31										
F18+90	1	1	1	1	1	1	1	1	1	1
F19+00										
F20+00										
F21+00										
F29+70										
F31+70										
F32+40										
F32+70										
F33+20										
F42+70										
F43+20										
F43+70										
F44+20										
F44+70										
F48+70										
F49+70										
F50+70										

Station	F190C157	F190C160	F190C163	F190C170	F190C220	F190C237	F190C247	F190C251	F190C257	F190B0RR
F14+00										
F15+00										
F18+00										
F18+31										
F18+90										
F19+00	1	1	1	1	1	1	1	1	1	1
F20+00										
F21+00										
F29+70										
F31+70										
F32+40										
F32+70										
F33+20										
F42+70										
F43+20										
F43+70										
F44+20										
F44+70										
F48+70										
F49+70										
F50+70										

Station	F200C157	F200C160	F200C163	F200C170	F200C220	F200C237	F200C247	F200C251	F200C257	F200C267	F200B0RR
F14+00											
F15+00											
F18+00											
F18+31											
F18+90											
F19+00											
F20+00	1	1	1	1	1	1	1	1	1	1	1
F21+00											
F29+70											
F31+70											
F32+40											
F32+70											
F33+20											
F42+70											
F43+20											
F43+70											
F44+20											
F44+70											
F48+70											
F49+70											
F50+70											

Station	F210C157	F210C160	F210C163	F210C170	F210C220	F210C237	F210C247	F210C251	F210C257	F210C267	F210C277	F210B0RR	F297C237	F297C247
F14+00														
F15+00														
F18+00														
F18+31														
F18+90														
F19+00														
F20+00														
F21+00	1	1	1	1	1	1	1	1	1	1	1	1		
F29+70													1	1
F31+70														
F32+40														
F32+70														
F33+20														
F42+70														
F43+20														
F43+70														
F44+20														
F44+70														
F48+70														
F49+70														
F50+70														

1, 4

		F2297C251	F2297C257	F2297C267	F2297C277	F2297C287	F2297C288	F2297C295	F2297C307	F2297C312	F2297C337	F2297C347	F2297C357	F2297C367	F2297B0RR	F3117C247	F3117C251	F3117C257	F3117C267	F3117C277	F3117C287	F3117C288	F3117C295	F3117C307	F3117C312	F3117C337	F3117C347	F3117C357	F3117C367	F3117C377	F3117C378	F3117C387	F3117B0RR	F3124C257	F3124C267	F3124C277	F3124C287	F3124C288	F3124C295	F3124C307	F3124C312	F3124C337	F3124C347	F3124C357	F3124C367	F3124C377	F3124C378	F3124C387	F3124B0RR	F3127C257	F3127C267	F3127C277	F3127C287	F3127C289	F3127C295	F3127C307
VOLACO	N	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
02+00C	E																																																							
03+00C	E																																																							
03+50C	E																																																							
04+00C	E																																																							
07+00C	E																																																							
08+00C	E																																																							
08+50C	E																																																							
09+00C	E																																																							
15+73C	E																																																							
16+00C	E																																																							
16+34C	E																																																							
17+00C	E																																																							
22+00C	E																																																							
23+70C	E																																																							
24+70C	E														1																																									
25+15C	E	1															1																																							
25+70C	E		1															1																1																1						
26+70C	E			1															1																1																1					
27+70C	E				1															1																1																1				
28+70C	E					1															1																1																1			
28+77C	E						1															1																1																1		
29+52C	E							1															1																1																1	
30+70C	E								1															1																1																1
31+24C	E									1															1																1															
33+70C	E										1															1																1														
34+70C	E											1															1																1													
35+70C	E												1															1																1												
36+70C	E													1															1																1											
37+70C	E																													1																1										
37+79C	E																														1																1									
38+70C	E																															1																1								
39+70C	E																																																							
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45+70C	E																																																							
46+70C	E																																																							
47+70C	E																																																							
F05+00	E																																																							
F05+50	E																																																							
F06+00	E																																																							
F10+00	E																																																							
F11+00	E																																																							
F12+00	E																																																							
F13+00	E																																																							
F13+20	E																																																							
F13+67	E																																																							

		F297C251	F297C257	F297C267	F297C277	F297C287	F297C288	F297C295	F297C307	F297C312	F297C337	F297C347	F297C357	F297C367	F297B0RR
F14+00	E														
F15+00	E														
F18+00	E														
F18+31	E														
F18+90	E														
F19+00	E														
F20+00	E														
F21+00	E														
F29+70	E	1	1	1	1	1	1	1	1	1	1	1	1	1	1
F31+70	E														
F32+40	E														
F32+70	E														
F33+20	E														
F42+70	E														
F43+20	E														
F43+70	E														
F44+20	E														
F44+70	E														
F48+70	E														
F49+70	E														
F50+70	E														

		F317C247	F317C251	F317C257	F317C267	F317C277	F317C287	F317C288	F317C295	F317C307	F317C312	F317C337	F317C347	F317C357	F317C367	F317C377	F317C378	F317C387	F317B0RR
F14+00	E																		
F15+00	E																		
F18+00	E																		
F18+31	E																		
F18+90	E																		
F19+00	E																		
F20+00	E																		
F21+00	E																		
F29+70	E																		
F31+70	E	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
F32+40	E																		
F32+70	E																		
F33+20	E																		
F42+70	E																		
F43+20	E																		
F43+70	E																		
F44+20	E																		
F44+70	E																		
F48+70	E																		
F49+70	E																		
F50+70	E																		

		F324C257	F324C267	F324C277	F324C287	F324C288	F324C295	F324C307	F324C312	F324C337	F324C347	F324C357	F324C367	F324C377	F324C378	F324C387	F324B0RR
F14+00	E																
F15+00	E																
F18+00	E																
F18+31	E																
F18+90	E																
F19+00	E																
F20+00	E																
F21+00	E																
F29+70	E																
F31+70	E																
F32+40	E	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
F32+70	E																
F33+20	E																
F42+70	E																
F43+20	E																
F43+70	E																
F44+20	E																
F44+70	E																
F48+70	E																
F49+70	E																
F50+70	E																

		F327C257	F327C267	F327C277	F327C287	F327C289	F327C295	F327C307
F14+00	E							
F15+00	E							
F18+00	E							
F18+31	E							
F18+90	E							
F19+00	E							
F20+00	E							
F21+00	E							
F29+70	E							
F31+70	E							
F32+40	E							
F32+70	E	1	1	1	1	1	1	1
F33+20	E							
F42+70	E							
F43+20	E							
F43+70	E							
F44+20	E							
F44+70	E							
F48+70	E							
F49+70	E							
F50+70	E							

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		F327C312	F327C337	F327C347	F327C357	F327C367	F327C377	F327C378	F327C387	F327C397	F327B0RR	F332C267	F332C277	F332C287	F332C288	F332C295	F332C307	F332C312	F332C337	F332C347	F332C357	F332C367	F332C377	F332C378	F332C387	F332C397	F332B0RR	F427C357	F427C367	F427C377	F427C378	F427C387	F427C397	F427C407	F427C417	F427C457	F427C467	F427C477	F427B0RR	F432C367	F432C377	F432C378	F432C387	F432C397	F432C407	F432C417	F432C457	F432C467	F432C477	F432B0RR	F437C367	F437C377	F437C378	F437C387	F437C397	F437C407
VOLACO	N	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
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		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
		2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		7	7	7	7	7	7	7	7	7	7	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	7	7	7	7	7	7	7	7	7	7	7	7	2	2	2	2	2	2	2	2	2	2	2	7	7	7	7	7	7
		C	C	C	C	C	C	C	C	C	B	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	B	C	C	C	C	C	C	C	C	C	C	C	B	C	C	C	C	C	C	C	C	C	C	B	C	C	C	C	C	C
		3	3	3	3	3	3	3	3	3	0	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	0	3	3	3	3	3	3	4	4	4	4	4	0	3	3	3	3	3	4	4	4	4	4	0	3	3	3	3	3	4
		1	3	4	5	6	7	7	8	9	R	6	7	8	8	9	0	1	3	4	5	6	7	7	8	9	R	5	6	7	7	8	9	0	1	5	6	7	R	6	7	7	8	9	0	1	5	6	7	R	6	7	7	8	9	0
		2	7	7	7	7	7	8	7	7	R	7	7	7	8	5	7	2	7	7	7	7	7	8	7	7	R	7	7	7	8	7	7	7	7	7	7	7	R	7	7	8	7	7	7	7	7	7	7	R	7	7	8	7	7	7
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		F437C417	F437C457	F437C467	F437C470	F437B0RR	F442C377	F442C378	F442C387	F442C397	F442C407	F442C417	F442C457	F442C467	F442C477	F442B0RR	F447C377	F447C378	F447C387	F447C397	F447C407	F447C417	F447C457	F447C467	F447C477	F447B0RR	F487C417	F487C457	F487C467	F487C477	F487B0RR	F497C457	F497C467	F497C477	F497B0RR	F507C457	F507C467	F507C477	F507B0RR	WASTC020	WASTC030	WASTC035	WASTC040	WASTC070	WASTC080	WASTC085	WASTC090	WASTC157	WASTC160	WASTC163	WASTC170	WASTC220	WASTC237	WASTC247	WASTC251	WASTC257
VOLACO	N	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
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		WASTC267	WASTC277	WASTC287	WASTC288	WASTC295	WASTC307	WASTC312	WASTC337	WASTC347	WASTC375	WASTC367	WASTC377	WASTC378	WASTC387	WASTC397	WASTC407	WASTC417	WASTC457	WASTC467	WASTC477	TOTVOA
VCLACO	N	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	
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03+00C	E																					C
03+50C	E																					B
04+00C	E																					C
07+00C	E																					C
08+00C	E																					C
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09+00C	E																					B
15+73C	E																					D
16+00C	E																					D
16+34C	E																					D
17+00C	E																					D
22+00C	E																					C
23+70C	E																					D
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25+15C	E																					D
25+70C	E																					D
26+70C	E	1																				D
27+70C	E		1																			D
28+70C	E			1																		D
28+77C	E				1																	C
29+52C	E					1																C
30+70C	E						1															C
31+24C	E							1														B
33+70C	E								1													C
34+70C	E									1												D
35+70C	E										1											C
36+70C	E											1										C
37+70C	E												1									C
37+79C	E													1								B
38+70C	E														1							C
39+70C	E															1						B
40+70C	E																1					C
41+70C	E																	1				C
45+70C	E																		1			C
46+70C	E																			1		D
47+70C	E																				1	D
F05+00	E																					C
F05+50	E																					C
F06+00	E																					C
F10+00	E																					B
F11+00	E																					C
F12+00	E																					D
F13+00	E																					D
F13+20	E																					C
F13+67	E																					D

		WASTC267	WASTC277	WASTC287	WASTC288	WASTC295	WASTC307	WASTC312	WASTC337	WASTC347	WASTC375	WASTC367	WASTC377	WASTC378	WASTC387	WASTC397	WASTC407	WASTC417	WASTC457	WASTC467	WASTC477	TOTVOA
F14+00	E																					D
F15+00	E																					C
F18+00	E																					D
F18+31	E																					D
F18+90	E																					D
F19+00	E																					C
F20+00	E																					D
F21+00	E																					C
F29+70	E																					1
F31+70	E																					C
F32+40	E																					C
F32+70	E																					C
F33+20	E																					C
F42+70	E																					C
F43+20	E																					C
F43+70	E																					D
F44+20	E																					D
F44+70	E																					B
F48+70	E																					B
F49+70	E																					D
F50+70	E																					D

SUMMARY OF MATRIX

SYMBOL	RANGE		COUNT (INCL.RHS)
Z	LESS THAN	.000001	
Y	.000001 THRU	.000009	
X	.000010	.000099	
W	.000100	.000999	
V	.001000	.009999	
U	.010000	.099999	
T	.100000	.999999	350
1	1.000000	1.000000	634
A	1.000001	10.000000	
B	10.000001	100.000000	8
C	100.000001	1,000.000000	32
D	1,000.000001	10,000.000000	26
E	10,000.000001	100,000.000000	
F	100,000.000001	1,000,000.000000	
G	GREATER THAN	1,000,000.000000	

PRIMAL OBJ = VOLACO RHS = TOTVOA

TIME = 1.25 MINS. PRICING 5

INVERT CALLED TIME 1.26 CURRENT INVERSE ---- ETA-VECTORS .....0 ELEMENTS .....0 RECORDS .....1 ITERATION 0
BASIS ---- NO.OF ROWS ....68 LOGICALS ....68 STRUCTURALS .....0 ELEMENTS 68
INVERSE -- NUCLEUS ....0 TRANSFORMED .....0 ETA-VECTORS .....0 ELEMENTS .....0 RECORDS .....1 TIME TAKEN 0.00

PRIMAL OBJ = VOLACO RHS = TOTVOA

TIME = 1.26 MINS. PRICING 5
SCALE = .

	ITER NUMBER	NUMBER INFEAS	VECTOR OUT	VECTOR IN	REDUCED COST	SUM INFEAS
M	1	66	56	242	2.00000-	68128.0
M	2	65	66	371	2.00000-	68084.0
M	3	64	31	360	2.00000-	67953.9
	4		42	98	2.00000-	67867.9
M	5	62	65	362	2.00000-	67856.0
M	6	61	25	257	2.00000-	67706.0
	7		4	80	2.00000-	67594.0
M	8	59	9	165	2.00000-	67414.0
	9		33	313	2.00000-	67258.0
M	10	57	26	258	2.00000-	67022.0
	11		5	72	2.00000-	66838.0
M	12	55	57	254	2.00000-	66597.9
M	13	54	22	290	2.00000-	66458.0
M	14	53	6	73	2.00000-	66172.0
	15		35	322	2.00000-	65926.0
M	16	51	3	70	2.00000-	65585.9
	17		24	288	2.00000-	65302.0
	18		39	69	2.00000-	65158.0
M	19	48	2	109	2.00000-	64990.0
M	20	47	32	296	2.00000-	64424.0
	21		49	163	2.00000-	64056.0
M	22	45	59	261	2.00000-	63988.0
M	23	44	43	111	2.00000-	63374.0
	24		34	321	2.00000-	62890.0
M	25	42	8	88	2.00000-	62884.0
M	26	41	53	203	2.00000-	62148.0
	27		61	323	2.00000-	61490.0
M	28	39	14	224	2.00000-	61028.0
	29		36	334	2.00000-	60670.0
M	30	37	55	206	2.00000-	60266.0
M	31	36	29	309	2.00000-	59366.0
M	32	35	60	308	2.00000-	59196.0
M	33	34	41	92	2.00000-	58366.0
M	34	33	7	83	2.00000-	57878.0

INVERT DEMANDED AFTER 23 MAJOR/ 34 MINOR ITERATIONS - CLOCK CONTROL

INVERT CALLED TIME 1.38 CURRENT INVERSE ---- ETA-VECTORS ....34 ELEMENTS ...114 RECORDS .....1 ITERATION 34
BASIS ---- NO.OF ROWS ....68 LOGICALS ....34 STRUCTURALS ....34 ELEMENTS ...136
INVERSE -- NUCLEUS ....0 TRANSFORMED .....0 ETA-VECTORS ....34 ELEMENTS ...102 RECORDS .....1 TIME TAKEN 0.01

PRIMAL OBJ = VOLACO RHS = TOTVOA

TIME = 1.40 MINS. PRICING 5
SCALE = .

	ITER NUMBER	NUMBER INFEAS	VECTOR OUT	VECTOR IN	REDUCED COST	SUM INFEAS
M	35	33	163	167	2.00000-	57510.0
	36		109	115	2.00000-	57348.0
	37		98	104	2.00000-	57262.0
M	38	32	40	94	2.00000-	57246.0
M	39	31	46	141	2.00000-	56080.0
	40		313	331	2.00000-	55924.0
M	41	30	11	123	2.00000-	55152.0
M	42	30	309	327	2.00000-	54252.0
	43		28	315	2.00000-	53764.0
M	44	28	62	249	2.00000-	53698.0
M	45	28	203	170	2.00000-	53366.0
	46		257	273	2.00000-	53216.0
	47		258	274	2.00000-	53188.0
M	48	28	167	227	2.00000-	53136.0
	49		261	297	2.00000-	53134.0
	50		242	239	2.00000-	53132.0

INVERT DEMANDED AFTER 8 MAJOR/ 16 MINOR ITERATIONS - CLOCK CONTROL

INVERT CALLED TIME 1.45 CURRENT INVERSE ---- ETA-VECTORS ....50 ELEMENTS ...198 RECORDS .....1 ITERATION 50
BASIS ---- NO.OF ROWS ....68 LOGICALS ....29 STRUCTURALS ....39 ELEMENTS ...146
INVERSE -- NUCLEUS ....0 TRANSFORMED ......0 ETA-VECTORS ....39 ELEMENTS ...117 RECORDS .....1 TIME TAKEN 0.01

PRIMAL OBJ = VOLACO RHS = TOTVOA

TIME = 1.46 MINS. PRICING 5
SCALE = .

	ITER NUMBER	NUMBER INFEAS	VECTOR OUT	VECTOR IN	REDUCED COST	SUM INFEAS
M	51	28	165	139	2.00000-	52968.0
M	52	27	44	142	2.00000-	52136.0
M	53	26	17	187	2.00000-	51038.0
M	54	25	58	278	2.00000-	49226.0
M	55	25	274	351	2.00000-	49196.0

INVERT DEMANDED AFTER 5 MAJOR/ 5 MINOR ITERATIONS - CLOCK CONTROL

INVERT CALLED TIME 1.50 CURRENT INVERSE ---- ETA-VECTORS ....44 ELEMENTS ...144 RECORDS .....1 ITERATION 55
BASIS ---- NO.OF ROWS ....68 LOGICALS ....26 STRUCTURALS ....42 ELEMENTS ...152
INVERSE -- NUCLEUS ....0 TRANSFORMED ......0 ETA-VECTORS ....42 ELEMENTS ...126 RECORDS .....1 TIME TAKEN 0.01

PRIMAL OBJ = VOLACO RHS = TOTVOA

TIME = 1.51 MINS. PRICING 5
SCALE = .

	ITER NUMBER	NUMBER INFEAS	VECTOR OUT	VECTOR IN	REDUCED COST	SUM INFEAS
M	56	24	30	310	2.00000-	49106.0
M	57	24	296	282	2.00000-	48660.0
M	58	24	297	355	2.00000-	48568.0
M	59	24	323	266	2.00000-	48488.0
M	60	23	18	349	2.00000-	47004.0
M	61	22	64	335	2.00000-	46630.0
M	62	21	12	160	2.00000-	44316.0
M	63	20	48	116	2.00000-	44288.0
M	64	20	334	207	2.00000-	43818.0
M	65	20	206	356	2.00000-	43552.0
	66		249	261	2.00000-	43304.0
M	67	19	37	346	2.00000-	42452.0
M	68	19	356	287	2.00000-	42186.0
	69		261	255	2.00000-	41938.0
M	70	19	282	334	2.00000-	41666.0
M	71	19	254	270	2.00000-	41288.0
	72		310	306	2.00000-	41118.0
	73		335	274	2.00000-	41094.0
M	74	19	290	370	2.00000-	41052.0
M	75	19	371	304	2.00000-	41050.0
M	76	19	278	345	2.00000-	41020.0
M	77	19	288	332	2.00000-	40768.0
M	78	18	23	403	1.00000-	40623.0
	79		334	336	2.00000-	40031.0
M	80	17	63	338	2.00000-	39637.0
M	81	16	38	376	2.00000-	38201.0
M	82	16	227	229	2.00000-	37985.0
M	83	15	51	185	2.00000-	35757.0
M	84	14	15	216	2.00000-	33659.0
M	85	13	54	218	2.00000-	31077.0
M	86	13	321	299	2.00000-	30845.0
M	87	13	322	333	2.00000-	30599.0

INVERT DEMANDED AFTER 27 MAJOR/ 32 MINOR ITERATIONS - CLOCK CONTROL

INVERT CALLED TIME 1.63 CURRENT INVERSE ---- ETA-VECTORS ....74 ELEMENTS ...361 RECORDS .....2 ITERATION 87
BASIS ---- NO.OF ROWS ....68 LOGICALS ....14 STRUCTURALS ....54 ELEMENTS ...175
INVERSE -- NUCLEUS ....0 TRANSFORMED .....0 ETA-VECTORS ....54 ELEMENTS ...161 RECORDS .....1 TIME TAKEN 0.01

PRIMAL OBJ = VOLACO RHS = TOTVOA

TIME = 1.65 MINS. PRICING 5
SCALE = .

	ITER NUMBER	NUMBER INFEAS	VECTOR OUT	VECTOR IN	REDUCED COST	SUM INFEAS
M	88	12	19	177	2.00000-	29801.0
M	89	11	47	152	2.00000-	26921.0
M	90	10	13	134	2.00000-	25727.0
M	91	10	299	307	2.00000-	25249.0
	92		116	140	2.00000-	25221.0
M	93	9	45	131	2.00000-	22217.0
	94		306	197	2.00000-	22079.0

INVERT DEMANDED AFTER 5 MAJOR/ 7 MINOR ITERATIONS - CLOCK CONTROL

INVERT CALLED TIME 1.68 CURRENT INVERSE ---- ETA-VECTORS ....61 ELEMENTS ...200 RECORDS .....1 ITERATION 94
BASIS ---- NO.OF ROWS ....68 LOGICALS ....10 STRUCTURALS ....58 ELEMENTS ...183
INVERSE -- NUCLEUS ....0 TRANSFORMED .....0 ETA-VECTORS ....58 ELEMENTS ...173 RECORDS .....1 TIME TAKEN 0.01

PRIMAL OBJ = VCLACC RHS = TOTVOA

TIME = 1.70 MINS. PRICING 5
SCALE = .

	ITER NUMBER	NUMBER INFEAS	VECTOR OUT	VECTOR IN	REDUCED COST	SUM INFEAS
M	95	9	229	223	2.00000-	21863.0
M	96	9	134	175	2.00000-	20857.0
	97		142	174	2.00000-	20053.0
	98		141	173	2.00000-	19883.0
M	99	9	223	220	2.00000-	19667.0
	100		104	100	2.00000-	19581.0
M	101	8	10	213	2.00000-	19293.0
M	102	7	50	178	2.00000-	17971.0
M	103	7	266	275	2.00000-	16743.0
M	104	7	255	259	1.00000-	16430.0
	105		308	408	1.00000-	16267.0
M	106	6	27	407	1.00000-	16218.0
M	107	6	175	192	2.00000-	14996.0
	108		174	191	2.00000-	14192.0
	109		207	206	2.00000-	13456.0
	110		213	193	2.00000-	13168.0
	111		173	190	2.00000-	12912.0
M	112	5	16	229	2.00000-	12764.0
M	113	5	224	230	2.00000-	12550.0
	114		115	117	1.00000-	12469.0
M	115	5	220	122	2.00000-	11965.0
	116		229	196	2.00000-	11817.0
M	117	5	216	219	1.00000-	11514.0
	118		94	93	1.00000-	11463.0
M	119	4	52	208	1.00000-	11161.0
M	120	3	67	377	1.00000-	9208.00
M	121	2	20	400	1.00000-	7011.00
M	122	1	21	401	1.00000-	4055.00
M	123	0	68	381	1.00000-	.

FEASIBLE SOLUTION

PRIMAL OBJ = VCLACO RHS = TOTVOA

TIME = 1.80 MINS. PRICING 5
SCALE = .
SCALE RESET TO 1.00000

	ITER NUMBER	NUMBER NONOPT	VECTOR OUT	VECTOR IN	REDUCED COST	FUNCTION VALUE
M	124	77	170	171	.27000-	13783.9
M	125	70	338	348	.15000-	13754.4

	ITER NUMBER	NUMBER NONOPT	VECTOR OUT	VECTOR IN	REDUCED COST	FUNCTION VALUE
	126		362	367	.21000-	13753.1
M	127	58	139	121	.14000-	13740.5
	128		336	329	.22000-	13729.3
	129		360	318	.15000-	13727.2
	130		329	328	.11000-	13721.6
M	131	55	206	226	.12000-	13680.8
	132		351	319	.11000-	13649.7
	133		331	320	.11000-	13640.4
M	134	47	230	179	.20000-	13621.8
M	135	59	219	217	.15000-	13576.4
	136		345	317	.11000-	13574.3
M	137	50	177	399	.13000-	13530.0
	138		315	356	.11000-	13503.2
M	139	40	218	215	.12000-	13299.7
	140		187	186	.01000-	13298.7
M	141	48	178	203	.09000-	13275.4
	142		367	364	.07000-	13270.4
M	143	36	332	343	.07000-	13253.5
	144		208	126	.09000-	13243.7
	145		333	344	.07000-	13240.0
M	146	34	123	173	.07000-	13193.6
M	147	29	122	149	.07000-	13178.7
	148		186	180	.03000-	13175.7
	149		407	402	.05000-	13173.2
M	150	29	270	271	.05000-	13166.2
M	151	26	349	341	.04000-	13158.0
	152		149	214	.04000-	13153.5
M	153	21	217	188	.06000-	13137.2
M	154	14	287	292	.02000-	13126.6
	155		190	195	.06000-	13123.3
M	156	14	192	183	.06000-	13086.7
	157		191	182	.06000-	13057.7
M	158	8	185	398	.04000-	13032.5
	159		188	153	.02000-	13013.4
	160		182	151	.02000-	13003.7
M	161	7	152	175	.02000-	13003.7

OPTIMAL SOLUTION

SOLUTION (OPTIMAL)

TIME = 1.90 MINS. ITERATION NUMBER = 161

...NAME...	...ACTIVITY...	DEFINED AS
FUNCTIONAL RESTRAINTS	13003.73000	VOLACO TOTVOA

SECTION 1 - ROWS

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
1	VOLACO	BS	13003.73000	13003.73000-	NONE	NONE	1.00000
2	02+00C	EQ	156.00000	.	156.00000	156.00000	.03000
3	03+00C	EQ	170.00000	.	170.00000	170.00000	.03000
4	03+50C	EQ	56.00000	.	56.00000	56.00000	.03000
5	04+00C	EQ	135.00000	.	135.00000	135.00000	.03000
6	07+00C	EQ	143.00000	.	143.00000	143.00000	.03000
7	C8+00C	EQ	843.00000	.	843.00000	843.00000	.03000
8	08+50C	EQ	310.00000	.	310.00000	310.00000	.03000
9	C9+00C	EQ	90.00000	.	90.00000	90.00000	.03000
10	15+73C	EQ	2909.00000	.	2909.00000	2909.00000	.03000
11	16+00C	EQ	1204.00000	.	1204.00000	1204.00000	.03000
12	16+34C	EQ	1654.00000	.	1654.00000	1654.00000	.03000
13	17+00C	EQ	2051.00000	.	2051.00000	2051.00000	.03000
14	22+00C	EQ	599.00000	.	599.00000	599.00000	.01000-
15	23+70C	EQ	2163.00000	.	2163.00000	2163.00000	.11000-
16	24+70C	EQ	2388.00000	.	2388.00000	2388.00000	.19000-
17	25+15C	EQ	1149.00000	.	1149.00000	1149.00000	.22000-
18	25+70C	EQ	1051.00000	.	1051.00000	1051.00000	.26000-
19	26+70C	EQ	2037.00000	.	2037.00000	2037.00000	.26000-
20	27+70C	EQ	2630.00000	.	2630.00000	2630.00000	.26000-
21	28+70C	EQ	2956.00000	.	2956.00000	2956.00000	.26000-
22	28+77C	EQ	190.00000	.	190.00000	190.00000	.26000-
23	29+52C	EQ	987.00000	.	987.00000	987.00000	.26000-
24	30+70C	EQ	142.00000	.	142.00000	142.00000	.26000-
25	31+24C	EQ	76.00000	.	76.00000	76.00000	.26000-
26	33+70C	EQ	118.00000	.	118.00000	118.00000	.26000-
27	34+70C	EQ	1447.00000	.	1447.00000	1447.00000	.26000-
28	35+70C	EQ	857.00000	.	857.00000	857.00000	.26000-
29	36+70C	EQ	484.00000	.	484.00000	484.00000	.25000-
30	37+70C	EQ	966.00000	.	966.00000	966.00000	.18000-
31	37+79C	EQ	65.00000	.	65.00000	65.00000	.18000-
32	38+70C	EQ	283.00000	.	283.00000	283.00000	.11000-
33	39+70C	EQ	84.00000	.	84.00000	84.00000	.04000-
34	40+70C	EQ	242.00000	.	242.00000	242.00000	.03000
35	41+70C	EQ	123.00000	.	123.00000	123.00000	.03000
36	45+70C	EQ	508.00000	.	508.00000	508.00000	.03000
37	46+70C	EQ	1127.00000	.	1127.00000	1127.00000	.03000
38	47+70C	EQ	1211.00000	.	1211.00000	1211.00000	.03000
39	FC5+00	EQ	477.00000	.	477.00000	477.00000	.29000-
40	F05+50	EQ	616.00000	.	616.00000	616.00000	.29000-
41	F06+00	EQ	418.00000	.	418.00000	418.00000	.29000-
42	F10+00	EQ	43.00000	.	43.00000	43.00000	.29000-
43	F11+00	EQ	391.00000	.	391.00000	391.00000	.29000-
44	F12+00	EQ	1076.00000	.	1076.00000	1076.00000	.29000-
45	F13+00	EQ	2113.00000	.	2113.00000	2113.00000	.29000-
46	F13+20	EQ	583.00000	.	583.00000	583.00000	.29000-
47	F13+67	EQ	1440.00000	.	1440.00000	1440.00000	.29000-
48	F14+00	EQ	1171.00000	.	1171.00000	1171.00000	.29000-
49	F15+00	EQ	274.00000	.	274.00000	274.00000	.29000-

	NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
	50	F18+00	EQ	2692.00000	.	2692.00000	2692.00000	.29000-
	51	F18+31	EQ	2263.00000	.	2263.00000	2263.00000	.29000-
	52	F18+90	EQ	3580.00000	.	3580.00000	3580.00000	.27000-
	53	F19+00	EQ	368.00000	.	368.00000	368.00000	.25000-
	54	F20+00	EQ	2340.00000	.	2340.00000	2340.00000	.20000-
	55	F21+00	EQ	433.00000	.	433.00000	433.00000	.12000-
A	56	F29+70	EQ	1.00000	.	1.00000	1.00000	.
A	57	F31+70	EQ	313.00000	.	313.00000	313.00000	.
A	58	F32+40	EQ	997.00000	.	997.00000	997.00000	.
A	59	F32+70	EQ	529.00000	.	529.00000	529.00000	.
A	60	F33+20	EQ	613.00000	.	613.00000	613.00000	.
	61	F42+70	EQ	694.00000	.	694.00000	694.00000	.22000-
	62	F43+20	EQ	984.00000	.	984.00000	984.00000	.26000-
	63	F43+70	EQ	1761.00000	.	1761.00000	1761.00000	.29000-
	64	F44+20	EQ	1298.00000	.	1298.00000	1298.00000	.29000-
	65	F44+70	EQ	71.00000	.	71.00000	71.00000	.29000-
	66	F48+70	EQ	22.00000	.	22.00000	22.00000	.29000-
	67	F49+70	EQ	2910.00000	.	2910.00000	2910.00000	.29000-
	68	F50+70	EQ	4055.00000	.	4055.00000	4055.00000	.29000-

SECTION 2 - COLUMNS

	NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
	69	F050C020	BS	156.00000	.26000	.	NONE	.
	70	F050C030	BS	43.00000	.26000	.	NONE	.
A	71	F050C035	LL	.	.26000	.	NONE	.
	72	F050C040	BS	135.00000	.26000	.	NONE	.
	73	F050C070	BS	143.00000	.26000	.	NONE	.
A	74	F050C080	LL	.	.26000	.	NONE	.
	75	F050C085	LL	.	.30000	.	NONE	.04000
	76	F050C090	LL	.	.33000	.	NONE	.07000
A	77	F050BORR	LL	.	.29000	.	NONE	.
	78	F055C020	LL	.	.30000	.	NONE	.04000
A	79	F055C030	LL	.	.26000	.	NONE	.
	80	F055C035	BS	56.00000	.26000	.	NONE	.
A	81	F055C040	LL	.	.26000	.	NONE	.
A	82	F055C070	LL	.	.26000	.	NONE	.
	83	F055C080	BS	560.00000	.26000	.	NONE	.
A	84	F055C085	LL	.	.26000	.	NONE	.
	85	F055C090	LL	.	.30000	.	NONE	.04000
A	86	F055BORR	LL	.	.29000	.	NONE	.
	87	F060C020	LL	.	.33000	.	NONE	.07000
	88	F060C030	BS	127.00000	.26000	.	NONE	.
A	89	F060C035	LL	.	.26000	.	NONE	.
A	90	F060C040	LL	.	.26000	.	NONE	.
A	91	F060C070	LL	.	.26000	.	NONE	.
	92	F060C080	BS	240.00000	.26000	.	NONE	.
	93	F060C085	BS	51.00000	.26000	.	NONE	.
A	94	F060C090	LL	.	.26000	.	NONE	.
A	95	F060BORR	LL	.	.29000	.	NONE	.
	96	F100C030	LL	.	.55000	.	NONE	.29000
	97	F100C035	LL	.	.51000	.	NONE	.25000
	98	F100C040	LL	.	.48000	.	NONE	.22000
A	99	F100C070	LL	.	.26000	.	NONE	.
	100	F100C080	BS	43.00000	.26000	.	NONE	.
A	101	F100C085	LL	.	.26000	.	NONE	.
A	102	F100C090	LL	.	.26000	.	NONE	.
	103	F100C157	LL	.	.46000	.	NONE	.20000
	104	F100C160	LL	.	.48000	.	NONE	.22000
	105	F100C163	LL	.	.49000	.	NONE	.23000
	106	F100C170	LL	.	.55000	.	NONE	.29000
A	107	F100BORR	LL	.	.29000	.	NONE	.
	108	F110C040	LL	.	.55000	.	NONE	.29000
	109	F110C070	LL	.	.33000	.	NONE	.07000
A	110	F110C080	LL	.	.26000	.	NONE	.
	111	F110C085	BS	259.00000	.26000	.	NONE	.
A	112	F110C090	LL	.	.26000	.	NONE	.
	113	F110C157	LL	.	.39000	.	NONE	.13000
	114	F110C160	LL	.	.40000	.	NONE	.14000
	115	F110C163	LL	.	.42000	.	NONE	.16000
	116	F110C170	LL	.	.48000	.	NONE	.22000
	117	F110BORR	BS	132.00000	.29000	.	NONE	.

	NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
	118	F120C070	LL	.	.40000	.	NONE	.14000
	119	F120C080	LL	.	.33000	.	NONE	.07000
	120	F120C085	LL	.	.30000	.	NONE	.04000
	121	F120C090	BS	90.00000	.26000	.	NONE	.
	122	F120C157	LL	.	.31000	.	NONE	.05000
	123	F120C160	LL	.	.33000	.	NONE	.07000
	124	F120C163	LL	.	.35000	.	NONE	.09000
	125	F120C170	LL	.	.40000	.	NONE	.14000
	126	F120BORR	BS	986.00000	.29000	.	NONE	.
	127	F130C070	LL	.	.48000	.	NONE	.22000
	128	F130C080	LL	.	.40000	.	NONE	.14000
	129	F130C085	LL	.	.37000	.	NONE	.11000
	130	F130C090	LL	.	.33000	.	NONE	.07000
	131	F130C157	BS	2113.00000	.26000	.	NONE	.
A	132	F130C160	LL	.	.26000	.	NONE	.
	133	F130C163	LL	.	.28000	.	NONE	.02000
	134	F130C170	LL	.	.33000	.	NONE	.07000
A	135	F130BORR	LL	.	.29000	.	NONE	.
	136	F132C070	LL	.	.49000	.	NONE	.23000
	137	F132C080	LL	.	.42000	.	NONE	.16000
	138	F132C085	LL	.	.39000	.	NONE	.13000
	139	F132C090	LL	.	.35000	.	NONE	.09000
	140	F132C157	BS	583.00000	.26000	.	NONE	.
A	141	F132C160	LL	.	.26000	.	NONE	.
	142	F132C163	LL	.	.28000	.	NONE	.02000
	143	F132C170	LL	.	.31000	.	NONE	.05000
A	144	F132BORR	LL	.	.29000	.	NONE	.
	145	F136C070	LL	.	.53000	.	NONE	.27000
	146	F136C080	LL	.	.46000	.	NONE	.20000
	147	F136C085	LL	.	.42000	.	NONE	.16000
	148	F136C090	LL	.	.39000	.	NONE	.13000
A	149	F136C157	LL	.	.26000	.	NONE	.
A	150	F136C160	LL	.	.26000	.	NONE	.
	151	F136C163	BS	483.00000	.26000	.	NONE	.
	152	F136C170	LL	.	.28000	.	NONE	.02000
	153	F136BORR	BS	957.00000	.29000	.	NONE	.
	154	F140C070	LL	.	.55000	.	NONE	.29000
	155	F140C080	LL	.	.48000	.	NONE	.22000
	156	F140C085	LL	.	.44000	.	NONE	.18000
	157	F140C090	LL	.	.40000	.	NONE	.14000
A	158	F140C157	LL	.	.26000	.	NONE	.
A	159	F140C160	LL	.	.26000	.	NONE	.
	160	F140C163	BS	1171.00000	.26000	.	NONE	.
A	161	F140C170	LL	.	.26000	.	NONE	.
A	162	F140BORR	LL	.	.29000	.	NONE	.
	163	F150C080	LL	.	.55000	.	NONE	.29000
	164	F150C085	LL	.	.51000	.	NONE	.25000
	165	F150C090	LL	.	.48000	.	NONE	.22000
A	166	F150C157	LL	.	.26000	.	NONE	.
A	167	F150C160	LL	.	.26000	.	NONE	.
A	168	F150C163	LL	.	.26000	.	NONE	.

	NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
A	169	F150C170	LL	.	.26000	.	NONE	.
	170	F150C220	LL	.	.55000	.	NONE	.25000
	171	F150BORR	BS	274.00000	.29000	.	NONE	.
A	172	F180C157	LL	.	.26000	.	NONE	.
	173	F180C160	BS	1204.00000	.26000	.	NONE	.
A	174	F180C163	LL	.	.26000	.	NONE	.
	175	F180C170	BS	1.00000	.26000	.	NONE	.
	176	F180C220	LL	.	.33000	.	NONE	.03000
	177	F180C237	LL	.	.46000	.	NONE	.06000
	178	F180C247	LL	.	.53000	.	NONE	.05000
	179	F180BORR	BS	1487.00000	.29000	.	NONE	.
	180	F183C157	BS	213.00000	.26000	.	NONE	.
A	181	F183C160	LL	.	.26000	.	NONE	.
A	182	F183C163	LL	.	.26000	.	NONE	.
	183	F183C170	BS	2050.00000	.26000	.	NONE	.
	184	F183C220	LL	.	.31000	.	NONE	.01000
	185	F183C237	LL	.	.44000	.	NONE	.04000
	186	F183C247	LL	.	.51000	.	NONE	.03000
	187	F183C251	LL	.	.55000	.	NONE	.04000
A	188	F183BORR	LL	.	.29000	.	NONE	.
	189	F189C157	LL	.	.28000	.	NONE	.04000
	190	F189C160	LL	.	.26000	.	NONE	.02000
	191	F189C163	LL	.	.26000	.	NONE	.02000
	192	F189C170	LL	.	.26000	.	NONE	.02000
	193	F189C220	BS	231.00000	.28000	.	NONE	.
	194	F189C237	LL	.	.39000	.	NONE	.01000
	195	F189C247	BS	1778.00000	.46000	.	NONE	.
	196	F189C251	BS	1149.00000	.49000	.	NONE	.
	197	F189C257	BS	422.00000	.53000	.	NONE	.
	198	F189BORR	LL	.	.29000	.	NONE	.02000
	199	F190C157	LL	.	.28000	.	NONE	.06000
	200	F190C160	LL	.	.26000	.	NONE	.04000
	201	F190C163	LL	.	.26000	.	NONE	.04000
	202	F190C170	LL	.	.26000	.	NONE	.04000
	203	F190C220	BS	368.00000	.26000	.	NONE	.
	204	F190C237	LL	.	.39000	.	NONE	.03000
	205	F190C247	LL	.	.46000	.	NONE	.02000
	206	F190C251	LL	.	.49000	.	NONE	.02000
	207	F190C257	LL	.	.53000	.	NONE	.02000
	208	F190BORR	LL	.	.29000	.	NONE	.04000
	209	F200C157	LL	.	.35000	.	NONE	.18000
	210	F200C160	LL	.	.33000	.	NONE	.16000
	211	F200C163	LL	.	.31000	.	NONE	.14000
	212	F200C170	LL	.	.26000	.	NONE	.09000
	213	F200C220	LL	.	.26000	.	NONE	.05000
	214	F200C237	BS	2163.00000	.31000	.	NONE	.
	215	F200C247	BS	177.00000	.39000	.	NONE	.
A	216	F200C251	LL	.	.42000	.	NONE	.
A	217	F200C257	LL	.	.46000	.	NONE	.
	218	F200C267	LL	.	.53000	.	NONE	.07000
	219	F200BORR	LL	.	.29000	.	NONE	.09000

	NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
	220	F210C157	LL	.	.42000	.	NONE	.33000
	221	F210C160	LL	.	.40000	.	NONE	.31000
	222	F210C163	LL	.	.39000	.	NONE	.30000
	223	F210C170	LL	.	.33000	.	NONE	.24000
	224	F210C220	LL	.	.26000	.	NONE	.13000
	225	F210C237	LL	.	.26000	.	NONE	.03000
	226	F210C247	BS	433.00000	.31000	.	NONE	.
	227	F210C251	LL	.	.35000	.	NONE	.01000
	228	F210C257	LL	.	.39000	.	NONE	.01000
	229	F210C267	LL	.	.46000	.	NONE	.08000
	230	F210C277	LL	.	.53000	.	NONE	.15000
	231	F210BORR	LL	.	.29000	.	NONE	.17000
	232	F297C237	LL	.	.48000	.	NONE	.37000
	233	F297C247	LL	.	.40000	.	NONE	.21000
	234	F297C251	LL	.	.37000	.	NONE	.15000
	235	F297C257	LL	.	.33000	.	NONE	.07000
A	236	F297C267	LL	.	.26000	.	NONE	.
A	237	F297C277	LL	.	.26000	.	NONE	.
A	238	F297C287	LL	.	.26000	.	NONE	.
	239	F297C288	BS	1.00000	.26000	.	NONE	.
A	240	F297C295	LL	.	.26000	.	NONE	.
A	241	F297C307	LL	.	.26000	.	NONE	.
A	242	F297C312	LL	.	.26000	.	NONE	.
	243	F297C337	LL	.	.33000	.	NONE	.07000
	244	F297C347	LL	.	.40000	.	NONE	.14000
	245	F297C357	LL	.	.48000	.	NONE	.22000
	246	F297C367	LL	.	.55000	.	NONE	.30000
	247	F297BORR	LL	.	.29000	.	NONE	.29000
	248	F317C247	LL	.	.55000	.	NONE	.36000
	249	F317C251	LL	.	.51000	.	NONE	.29000
	250	F317C257	LL	.	.48000	.	NONE	.22000
	251	F317C267	LL	.	.40000	.	NONE	.14000
	252	F317C277	LL	.	.33000	.	NONE	.07000
A	253	F317C287	LL	.	.26000	.	NONE	.
A	254	F317C288	LL	.	.26000	.	NONE	.
A	255	F317C295	LL	.	.26000	.	NONE	.
A	256	F317C307	LL	.	.26000	.	NONE	.
A	257	F317C312	LL	.	.26000	.	NONE	.
A	258	F317C337	LL	.	.26000	.	NONE	.
	259	F317C347	BS	313.00000	.26000	.	NONE	.
	260	F317C357	LL	.	.33000	.	NONE	.07000
	261	F317C367	LL	.	.40000	.	NONE	.15000
	262	F317C377	LL	.	.48000	.	NONE	.30000
	263	F317C378	LL	.	.48000	.	NONE	.30000
	264	F317C387	LL	.	.55000	.	NONE	.44000
	265	F317BORR	LL	.	.29000	.	NONE	.29000
	266	F324C257	LL	.	.53000	.	NONE	.27000
	267	F324C267	LL	.	.46000	.	NONE	.20000
	268	F324C277	LL	.	.39000	.	NONE	.13000
	269	F324C287	LL	.	.31000	.	NONE	.05000
	270	F324C288	LL	.	.31000	.	NONE	.05000

	NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
	271	F324C295	BS	140.00000	.26000	.	NONE	.
A	272	F324C307	LL	.	.26000	.	NONE	.
	273	F324C312	BS	76.00000	.26000	.	NONE	.
	274	F324C337	BS	118.00000	.26000	.	NONE	.
	275	F324C347	BS	663.00000	.26000	.	NONE	.
	276	F324C357	LL	.	.28000	.	NONE	.02000
	277	F324C367	LL	.	.35000	.	NONE	.10000
	278	F324C377	LL	.	.42000	.	NONE	.24000
	279	F324C378	LL	.	.42000	.	NONE	.24000
	280	F324C387	LL	.	.49000	.	NONE	.38000
	281	F324BORR	LL	.	.29000	.	NONE	.29000
	282	F327C257	LL	.	.55000	.	NONE	.29000
	283	F327C267	LL	.	.48000	.	NONE	.22000
	284	F327C277	LL	.	.40000	.	NONE	.14000
	285	F327C287	LL	.	.33000	.	NONE	.07000
	286	F327C289	LL	.	.33000	.	NONE	.07000
	287	F327C295	LL	.	.28000	.	NONE	.02000
A	288	F327C307	LL	.	.26000	.	NONE	.
A	289	F327C312	LL	.	.26000	.	NONE	.
A	290	F327C337	LL	.	.26000	.	NONE	.
A	291	F327C347	LL	.	.26000	.	NONE	.
	292	F327C357	BS	529.00000	.26000	.	NONE	.
	293	F327C367	LL	.	.33000	.	NONE	.08000
	294	F327C377	LL	.	.40000	.	NONE	.22000
	295	F327C378	LL	.	.40000	.	NONE	.22000
	296	F327C387	LL	.	.48000	.	NONE	.37000
	297	F327C397	LL	.	.55000	.	NONE	.51000
	298	F327BORR	LL	.	.29000	.	NONE	.29000
	299	F332C267	LL	.	.51000	.	NONE	.25000
	300	F332C277	LL	.	.44000	.	NONE	.18000
	301	F332C287	LL	.	.37000	.	NONE	.11000
	302	F332C288	LL	.	.37000	.	NONE	.11000
	303	F332C295	LL	.	.31000	.	NONE	.05000
	304	F332C307	BS	142.00000	.26000	.	NONE	.
A	305	F332C312	LL	.	.26000	.	NONE	.
A	306	F332C337	LL	.	.26000	.	NONE	.
	307	F332C347	BS	471.00000	.26000	.	NONE	.
A	308	F332C357	LL	.	.26000	.	NONE	.
	309	F332C367	LL	.	.30000	.	NONE	.05000
	310	F332C377	LL	.	.37000	.	NONE	.19000
	311	F332C378	LL	.	.37000	.	NONE	.19000
	312	F332C387	LL	.	.44000	.	NONE	.33000
	313	F332C397	LL	.	.51000	.	NONE	.47000
	314	F332BORR	LL	.	.29000	.	NONE	.29000
	315	F427C357	LL	.	.55000	.	NONE	.07000
	316	F427C367	LL	.	.48000	.	NONE	.01000
	317	F427C377	BS	466.00000	.40000	.	NONE	.
	318	F427C378	BS	65.00000	.40000	.	NONE	.
	319	F427C387	BS	79.00000	.33000	.	NONE	.
	320	F427C397	BS	84.00000	.26000	.	NONE	.
	321	F427C407	LL	.	.26000	.	NONE	.07000

NUMBER		.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
	322	F427C417	LL	.	.26000	.	NONE	.07000
	323	F427C457	LL	.	.26000	.	NONE	.07000
	324	F427C467	LL	.	.33000	.	NONE	.14000
	325	F427C477	LL	.	.40000	.	NONE	.21000
	326	F427BORR	LL	.	.29000	.	NONE	.07000
	327	F432C367	BS	484.00000	.51000	.	NONE	.
	328	F432C377	BS	500.00000	.44000	.	NONE	.
A	329	F432C378	LL	.	.44000	.	NONE	.
A	330	F432C387	LL	.	.37000	.	NONE	.
A	331	F432C397	LL	.	.30000	.	NONE	.
	332	F432C407	LL	.	.26000	.	NONE	.03000
	333	F432C417	LL	.	.26000	.	NONE	.03000
	334	F432C457	LL	.	.26000	.	NONE	.03000
	335	F432C467	LL	.	.30000	.	NONE	.07000
	336	F432C477	LL	.	.37000	.	NONE	.14000
	337	F432BORR	LL	.	.29000	.	NONE	.03000
	338	F437C367	LL	.	.55000	.	NONE	.01000
	339	F437C377	LL	.	.48000	.	NONE	.01000
	340	F437C378	LL	.	.48000	.	NONE	.01000
	341	F437C387	BS	204.00000	.40000	.	NONE	.
A	342	F437C397	LL	.	.33000	.	NONE	.
	343	F437C407	BS	242.00000	.26000	.	NONE	.
	344	F437C417	BS	52.00000	.26000	.	NONE	.
A	345	F437C457	LL	.	.26000	.	NONE	.
	346	F437C467	BS	315.00000	.26000	.	NONE	.
	347	F437C470	LL	.	.33000	.	NONE	.07000
	348	F437BORR	BS	548.00000	.29000	.	NONE	.
	349	F442C377	LL	.	.51000	.	NONE	.04000
	350	F442C378	LL	.	.51000	.	NONE	.04000
	351	F442C387	LL	.	.44000	.	NONE	.04000
	352	F442C397	LL	.	.37000	.	NONE	.04000
	353	F442C407	LL	.	.30000	.	NONE	.04000
A	354	F442C417	LL	.	.26000	.	NONE	.
	355	F442C457	BS	486.00000	.26000	.	NONE	.
	356	F442C467	BS	812.00000	.26000	.	NONE	.
	357	F442C477	LL	.	.30000	.	NONE	.04000
A	358	F442BORR	LL	.	.29000	.	NONE	.
	359	F447C377	LL	.	.55000	.	NONE	.08000
	360	F447C378	LL	.	.55000	.	NONE	.08000
	361	F447C387	LL	.	.48000	.	NONE	.08000
	362	F447C397	LL	.	.40000	.	NONE	.07000
	363	F447C407	LL	.	.33000	.	NONE	.07000
	364	F447C417	BS	71.00000	.26000	.	NONE	.
A	365	F447C457	LL	.	.26000	.	NONE	.
A	366	F447C467	LL	.	.26000	.	NONE	.
A	367	F447C477	LL	.	.26000	.	NONE	.
A	368	F447BORR	LL	.	.29000	.	NONE	.
	369	F487C417	LL	.	.55000	.	NONE	.29000
	370	F487C457	BS	22.00000	.26000	.	NONE	.
A	371	F487C467	LL	.	.26000	.	NONE	.
A	372	F487C477	LL	.	.26000	.	NONE	.

	NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
A	373	F487BORR	LL	.	.29000	.	NONE	.
	374	F497C457	LL	.	.33000	.	NONE	.07000
A	375	F497C467	LL	.	.26000	.	NONE	.
	376	F497C477	BS	1211.00000	.26000	.	NONE	.
	377	F497BORR	BS	1699.00000	.29000	.	NONE	.
	378	F507C457	LL	.	.40000	.	NONE	.14000
	379	F507C467	LL	.	.33000	.	NONE	.07000
A	380	F507C477	LL	.	.26000	.	NONE	.
	381	F507BORR	BS	4055.00000	.29000	.	NONE	.
	382	WASTC020	LL	.	.26000	.	NONE	.29000
	383	WASTC030	LL	.	.26000	.	NONE	.29000
	384	WASTC035	LL	.	.26000	.	NONE	.29000
	385	WASTC040	LL	.	.26000	.	NONE	.29000
	386	WASTC070	LL	.	.26000	.	NONE	.29000
	387	WASTC080	LL	.	.26000	.	NONE	.29000
	388	WASTC085	LL	.	.26000	.	NONE	.29000
	389	WASTC090	LL	.	.26000	.	NONE	.29000
	390	WASTC157	LL	.	.26000	.	NONE	.29000
	391	WASTC160	LL	.	.26000	.	NONE	.29000
	392	WASTC163	LL	.	.26000	.	NONE	.29000
	393	WASTC170	LL	.	.26000	.	NONE	.29000
	394	WASTC220	LL	.	.26000	.	NONE	.25000
	395	WASTC237	LL	.	.26000	.	NONE	.15000
	396	WASTC247	LL	.	.26000	.	NONE	.07000
	397	WASTC251	LL	.	.26000	.	NONE	.04000
	398	WASTC257	BS	629.00000	.26000	.	NONE	.
	399	WASTC267	BS	2037.00000	.26000	.	NONE	.
	400	WASTC277	BS	2630.00000	.26000	.	NONE	.
	401	WASTC287	BS	2956.00000	.26000	.	NONE	.
	402	WASTC288	BS	189.00000	.26000	.	NONE	.
	403	WASTC295	BS	847.00000	.26000	.	NONE	.
A	404	WASTC307	LL	.	.26000	.	NONE	.
A	405	WASTC312	LL	.	.26000	.	NONE	.
A	406	WASTC337	LL	.	.26000	.	NONE	.
A	407	WASTC347	LL	.	.26000	.	NONE	.
	408	WASTC375	BS	328.00000	.26000	.	NONE	.
	409	WASTC367	LL	.	.26000	.	NONE	.01000
	410	WASTC377	LL	.	.26000	.	NONE	.08000
	411	WASTC378	LL	.	.26000	.	NONE	.08000
	412	WASTC387	LL	.	.26000	.	NONE	.15000
	413	WASTC397	LL	.	.26000	.	NONE	.22000
	414	WASTC407	LL	.	.26000	.	NONE	.29000
	415	WASTC417	LL	.	.26000	.	NONE	.29000
	416	WASTC457	LL	.	.26000	.	NONE	.29000
	417	WASTC467	LL	.	.26000	.	NONE	.29000
	418	WASTC477	LL	.	.26000	.	NONE	.29000

EXIT - TIME = 2.45

```
IEF373I STEP /G        / START 70331.0225
IEF374I STEP /G        / STOP  70331.0228 CPU   01MIN 16.00SEC MAIN   80K LCS    OK
IEF375I  JOB /OPTVOL   / START 70331.0224
IEF376I  JOB /OPTVOL   / STOP  70331.0228 CPU   01MIN 32.00SEC

 NUMBER OF I/O INTERRUPTS:        10283
 NUMBER LOCKED OUT:                  11
 NUMBER IN NON-VIRTUAL STATE:      9626
 NUMBER OF SVC INTERRUPTS:        19081
EXECUTION TERMINATED

$SIGNOFF
```

Appendix 4 Mass Diagram 137
mass diagram for road C, station 0+00 to station 50+00
accumulated volume
+8000
+7000
+6000
+5000
+4000
+3000
+2000
+1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
stations 0+00
1+00
2+00
3+00
4+00
5+00
6+00
7+00
8+00
9+00
10+00
11+00
12+00
13+00
14+00
15+00
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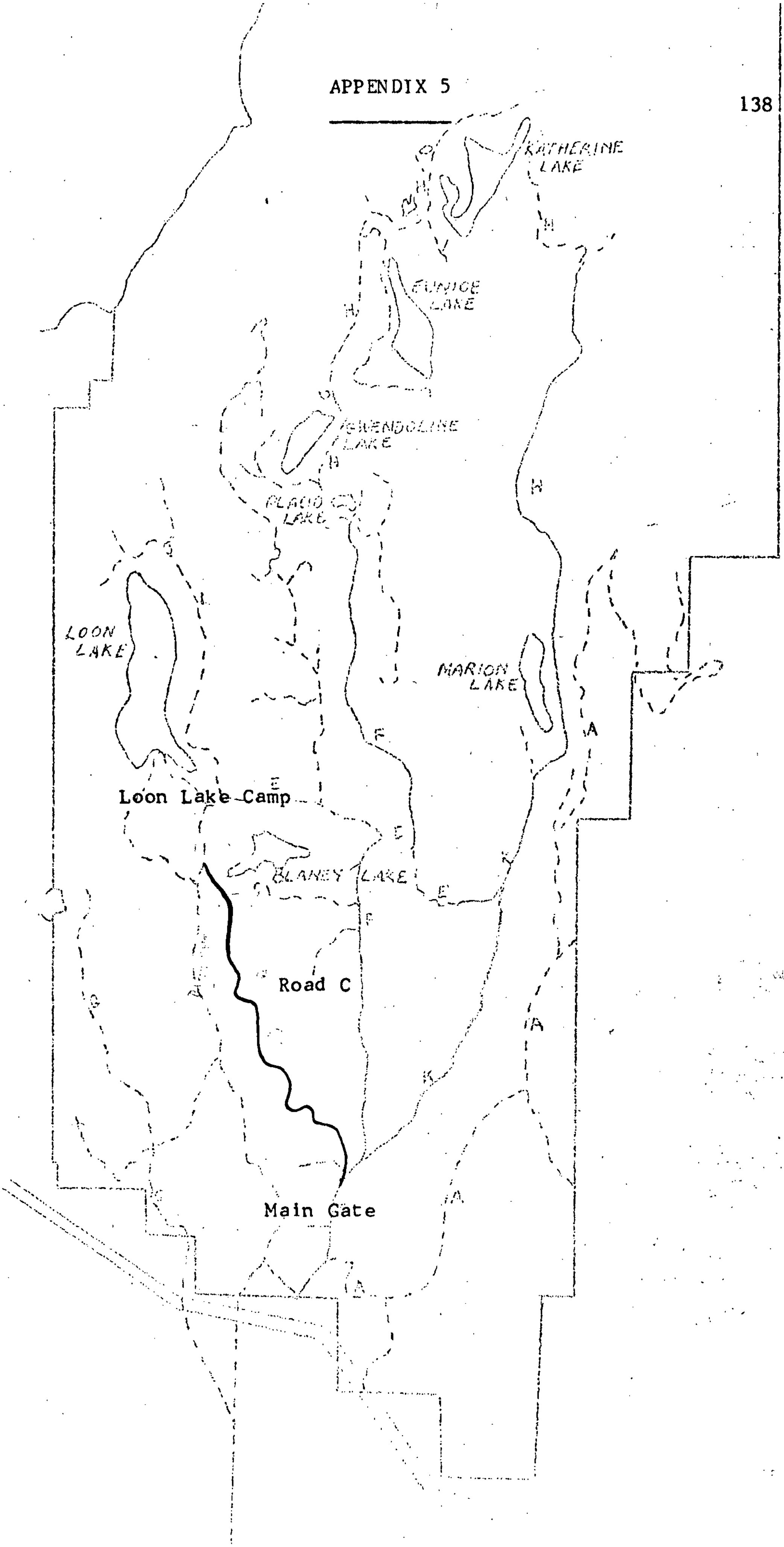
35+00
36+00
37+00
38+00
39+00
40+00
41+00
42+00
43+00
44+00
45+00
46+00
47+00
48+00
49+00
50+00
overhaul 210 sta yd
freehaul 520 cu yd
freehaul 980 cu yd
freehaul 400 cu yd
area ABCD 600 sta yd
average haul distance 600/130 = 4.62 sta
overhaul distance 4.62 - 3.0 = 1.62 sta
overhaul 130 × 1.62 = 210 sta yd
overhaul cost $ 14.-
overhaul volume 130 cu yd
borrow 3,000 cu yd
freehaul 3,150 cu yd
freehaul 4,140 cu yd
borrow 800 cu yd
area EFGH 28,820 sta yd
average haul distance 28,820/5,400 = 5.33 sta
overhaul distance 5.33 - 3.0 = 2.33 sta
overhaul 2.33 × 5,400 = 12,590 sta yd
overhaul cost $ 910.-
overhaul volume 5,400 cu yd
overhaul 12,590 sta yd
freehaul 1,230 cu yd
8,800 cu yd
freehaul 810 cu yd
freehaul 1,600 cu yd
waste 1,100 cu yd
freehaul 430 cu yd
overhaul 4,500 sta yd
area IJKL 8,970 sta yd
average haul distance 8,970/1,500 = 6.00 sta
overhaul distance 6.0 - 3.0 = 3.0 sta
overhaul 3.0 × 1,500 = 4,500 sta yd
overhaul cost $ 325.-
overhaul volume 1,500 cu yd
borrow 1,300 cu yd
freehaul 1,720 cu yd
freehaul 1,180 cu yd
3,800 cu yd

APPENDIX 5


KATHERINE LAKE
EUNICE LAKE
GWENDOLINE LAKE
PLACID LAKE
LOON LAKE
MARION LAKE
Loon Lake Camp
BLANEY LAKE
Road C
Main Gate
H
A
E
F
K
G