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A RATIONAL PROCEDURE FOR REORGANISING A COMMERCIAL DISTRIBUTION SYSTEM

(with special reference to the distribution of petroleum fuels in Ceylon)

A Thesis submitted for the degree of Doctor of Philosophy

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SYNOPSIS

This study establishes a method of analysing a physical distribution system with a view to rationalising its structure and minimising overall costs of distribution. The technique is demonstrated with a real case involving 1 central source, 13 existing depots, 72 potential depots and 613 centres of demand. It is, however, flexible enough to cope with considerable variation in these numbers and to handle the design of a "grass roots" system. The results of the analysis indicate the number and location of depots in the ideal pattern, from which can be deduced the changes, if any, that are required in the existing network.

A brief description is given of a distribution system which could be used for any commodity. This generalised approach is then narrowed down to the petroleum industry, where much effort is being spent on the re-shaping of existing networks to improve overall economy and productivity. The problem is a formidable one and it is the intention behind this study to assist oil company executives in their task by presenting them with an analytical technique that is both simple and efficient.

A typical petroleum distribution system is described and likely areas of development are indicated. The broad aspects of distribution theory are discussed, and links are established with Planning, Forecasting, Investment Appraisal, Inventory Control and other techniques of scientific management.

A survey is made of the important work already done in

this field. The bulk of this is concerned with the use of fairly sophisticated algorithms adapted for computer application. The proposed technique is based on simple logic. Relevant comparisons are made between published work and the new technique.

A computer program (in FORTRAN IV) has been specially written for use on the ICT 1905 configuration installed at the Loughborough University of Technology. The algorithm that has been employed is based upon the reduction of total distribution cost by using varying combinations of depots in the distribution network. The program is heuristic - it generates an "acceptable" solution, while not guaranteeing "optimality". Its most important feature is that it adopts a Total Systems approach - there are no sub-optimisations. Each successive step is self-contained, but it is the last iteration which provides the best solution.

The case study that has been tackled is the analysis of the distribution system now operated by the Ceylon Petroleum Corporation, which has a monopoly of the refining and internal distribution of oil products in Ceylon. It acquired 3 entirely separate and self-sufficient distribution networks from three international oil companies and operates them as one. The need for rationalisation is clearly seen. Actual data and costs have been used; the few estimates that have been made are fully compatible with the data.

The analysis shows that a few small changes in the network - the closure of 5 existing depots and the opening of 5 new ones - could reduce overall distribution costs by more than 4.2%, a saving of over Rs. 114,000.00 (£ 8000) per month. The findings have been analysed and pertinent comments made upon the implications of their implementation.

ACKNOWLEDGEMENTS

I wish to place on record my sincere thanks to Professor D. C. Freshwater, and Mr. R. H. Beresford, Senior Lecturer, of the Department of Chemical Engineering, Loughborough University of Technology, for creating the opportunity for me to undertake this research; and to the Board of Directors of the Ceylon Petroleum Corporation for releasing me from my substantive duties in order that I could do so.

My thanks are also due to my colleagues in the Ceylon Petroleum Corporation for readily supplying me with the relevant facts and figures; and to the staff of the Computer Centre at Loughborough University for their assistance during my use of the facilities installed in that department.

CONTENTS

1. Economists tend to separate the activities that comprise Distribution from the process of Production. Production is described as those steps which convert one or more raw materials, which in their original state are of no direct use to man (except, of course, as raw materials), through one or more manufacturing processes, into a commodity that can be used and is desired by man. Production is, therefore, the addition of Physical or Form utility to goods.

1.1. Distribution, on the other hand, is the addition of Place, Time and Ownership utilities to goods. It consists of several functions of which the more important are :-

1.1.1. the <u>transportation</u> of raw materials and goods from the point of original location, through the point/points of intermediate/final production to the point of sale or consumption. It is the movement of goods from places where their economic value is low to places where it is higher. The principal economic basis for this function is the increase in value of the commodity by the addition of Place utility.

1.1.2. the <u>storage</u> of goods at various stages of the manufacturing process and, more important, after the completion of manufacture and before final sale/consumption. In its strictest sense, Distribution would include all intermediate storage in the production line, e.g., the storage of semi-finished goods, but it would be convenient at this stage to assign the responsibility for intermediate storage to the Production function, particularly because it is caused by the lack of smoothness in the various stages of manufacture itself. While recognising that storage of raw materials too could be a function of Distribution, it too will be delegated to Manufacture.

The storage of finished products is the result of factors other than discontinuity in the process of manufacture. One has now got to cope not only with internal problems, but also with those problems created by the consuming public. It is impossible to pick out an industry where the demand for its finished goods is continuous and absolutely predictable. Commodities such as electric power, town's gas and water are notorious for fluctuations in the short run (peak hours) and in the longer run (seasonal variations, etc.), while even basic goods such as bread show small unpredictable variations.

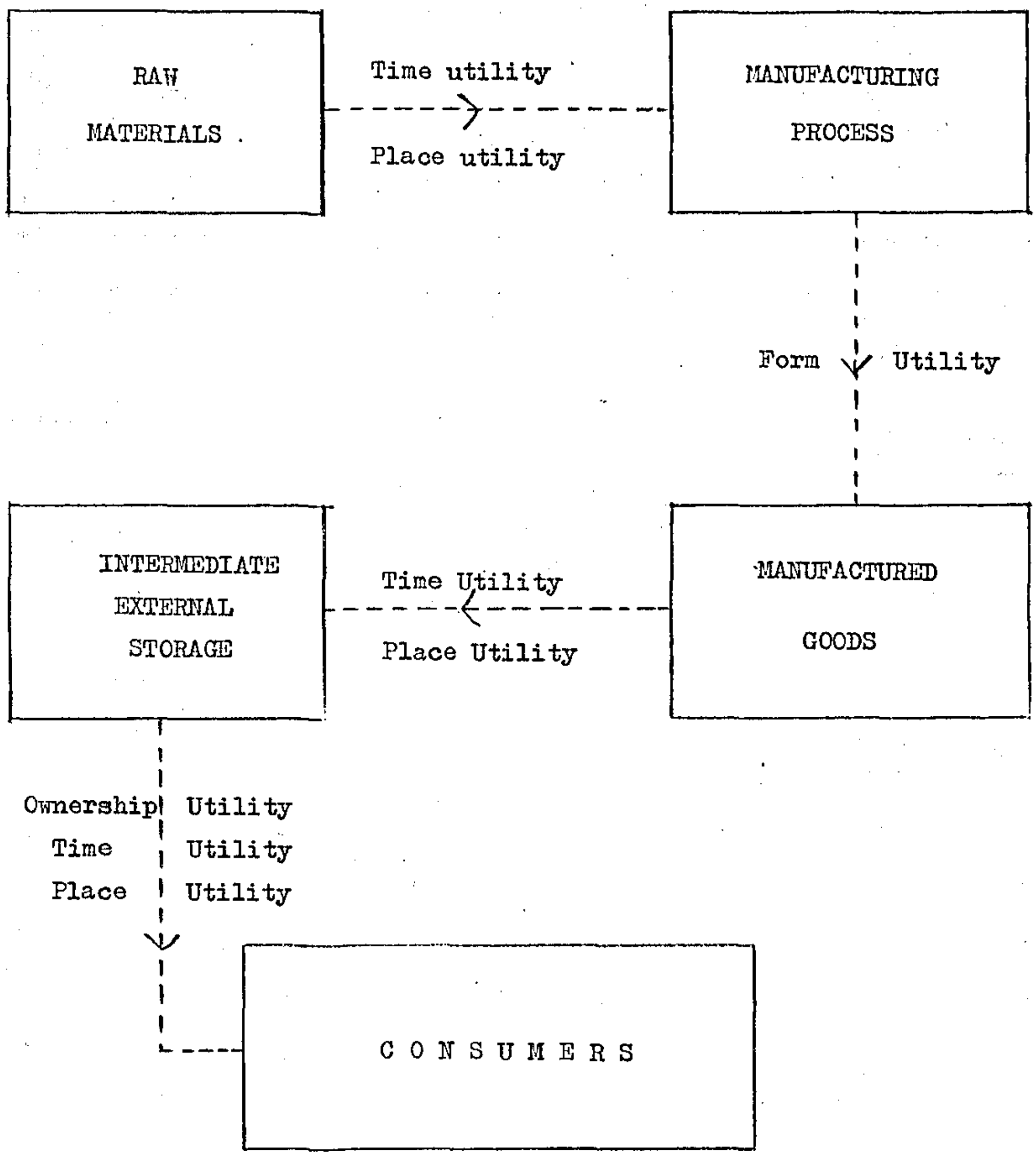
One has therefore to provide an effective bridge between what may well be a smooth production process and a demand which is intermittent and varying in intensity in both the short and long term. This bridge is Storage, which also acts as a resevoir for finished goods. Goods are received from the production line and stored until such time as they are needed. The form and period of storage will depend upon the nature of the goods,(8) but it is the necessity for some form of storage that is common to all commodities. Storage, therefore, adds a Time utility to a commodity that has already obtained Form utility.

1.1.3. Ownership utility is added to a commodity after a series of steps which includes packaging, purchasing and delivery. These are the last links in the chain of activities which lie between manufacture and sale/consumption. The merchandising, display and actual sale or transfer of goods into the hands of the ultimate consumer gives ownership utility to goods.

1.1.4. Fig. 1 illustrates a hypothetical case which exhibits all the typical characteristics. This example includes provision for an intermediate storage point or <u>depot</u> in the distribution network.

1.2. A <u>depot</u> can, in addition to conferring Time and Place utility, serve other important functions, such as cost reduction, creation

Fig. 1


RAW MATERIALS
Time utility
Place utility
MANUFACTURING PROCESS
Form Utility
MANUFACTURED GOODS
Time Utility
Place Utility
INTERMEDIATE EXTERNAL STORAGE
Ownership Utility
Time Utility
Place Utility
C O N S U M E R S

of strategic reserves, customer convenience and customer goodwill. Of these four, the last three may be difficult to quantify; it is left to management to decide how much emphasis has to be placed on them. However, cost reductions are easier to determine and can show more striking results. This study focuses attention on this aspect.

FUNCTION OF A DISTRIBUTION SYSTEM

1.3. A commodity has value only because someone wants either to eat it, burn it, wear it, look at it or use it in some other way. Its ultimate value depends upon the consumer; it is not achieved unless the commodity is in a fit state to be used and is available where and when it is needed. The most advanced type of motor car at the end of a production line has only built up a cost; it still has no value. A small movement of the car, say into a showroom, immediately gives it value as it then becomes available to satisfy some consumer's need. Many people may handle the car or its components during the course of manufacture and sale. They are people who do so because they can sell it at a higher price than which they paid for it - with the last sale taking place to the consumer. During the short life of the car it has changed from a lump of iron ore in the earth to the complicated piece of machinery that it finally becomes. The miner extracted the ore, the smelter converted it into metal, the manufacturer changed its shape, and last but not the least, the distributor changed its position.

The essential function of a distribution system is to bridge the area between production and sale to the ultimate consumer. It requires movement in space and time, and the provision of storage to balance the flow of demand and the flow of production; it also involves the concept of economy in distribution by the proper use of the facilities of the system.

A distribution system can range from the extreme case of a manufacturer supplying a single item direct to the consumer (e.g., an airplane), through varying stages of complexity (e.g., a system which handles large volumes of liquid in bulk, such as our case study will tackle), to the instance of a number of factories, each producing a range of goods, and linked to a large number of retail outlets through warehouses and wholesalers.

CHANNELS OF DISTRIBUTION

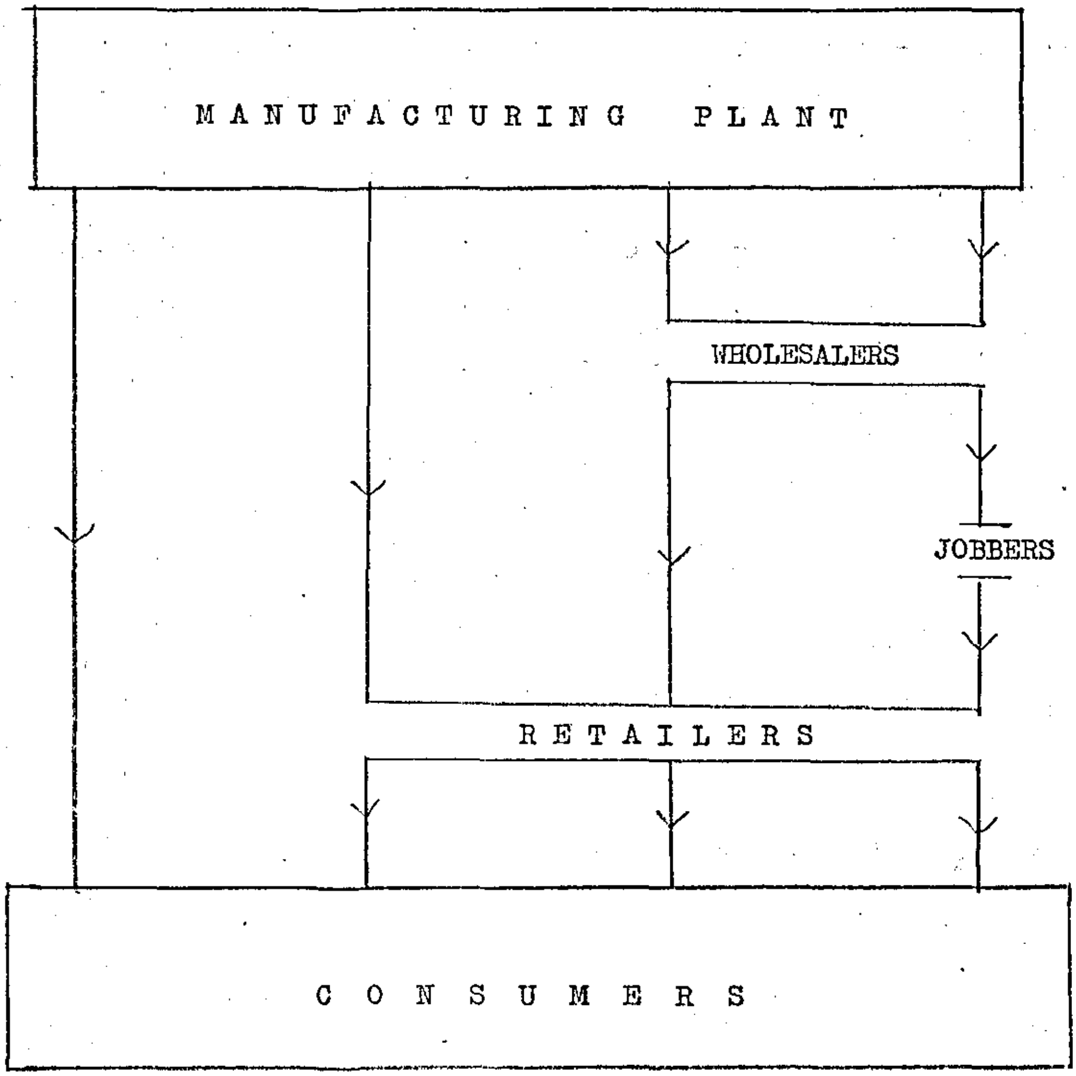
1.4. Fig. 2 is a diagrammatic representation of the normal channels of distribution which may be employed in everyday commerce and industry. Distribution here means the movement of finished goods from the point of manufacture to the point of consumption.

There are four main types of distribution channel.

1.4.1. The manufacturer can sell/supply goods direct to consumers. This method is relatively uncommon and where used is usually confined to very specialised goods. Commodities like computers, ships and other complicated machinery are dealt with in this manner. It is in the best interests of all concerned that the consumer has direct access to the manufacturer, and a middleman is redundant.

1.4.2. The next channel is created by the insertion of a retailer between the manufacturer and the consumers. The nature of the goods is such that a direct connection is either undesirable or impracticable. Consumer goods, foodstuffs and other high volume commodities are handled this way. The retailer plays a vital part in the system. He creates a source of supply close to the consumers; he saves the manufacturer the trouble of dealing with large quantities of small orders; he evens out fluctuations in demand of individual consumers by placing regular large orders on the manufacturer, and gives the consumer a choice of commodities which would otherwise require connections with several manufacturers.

Fig. 2

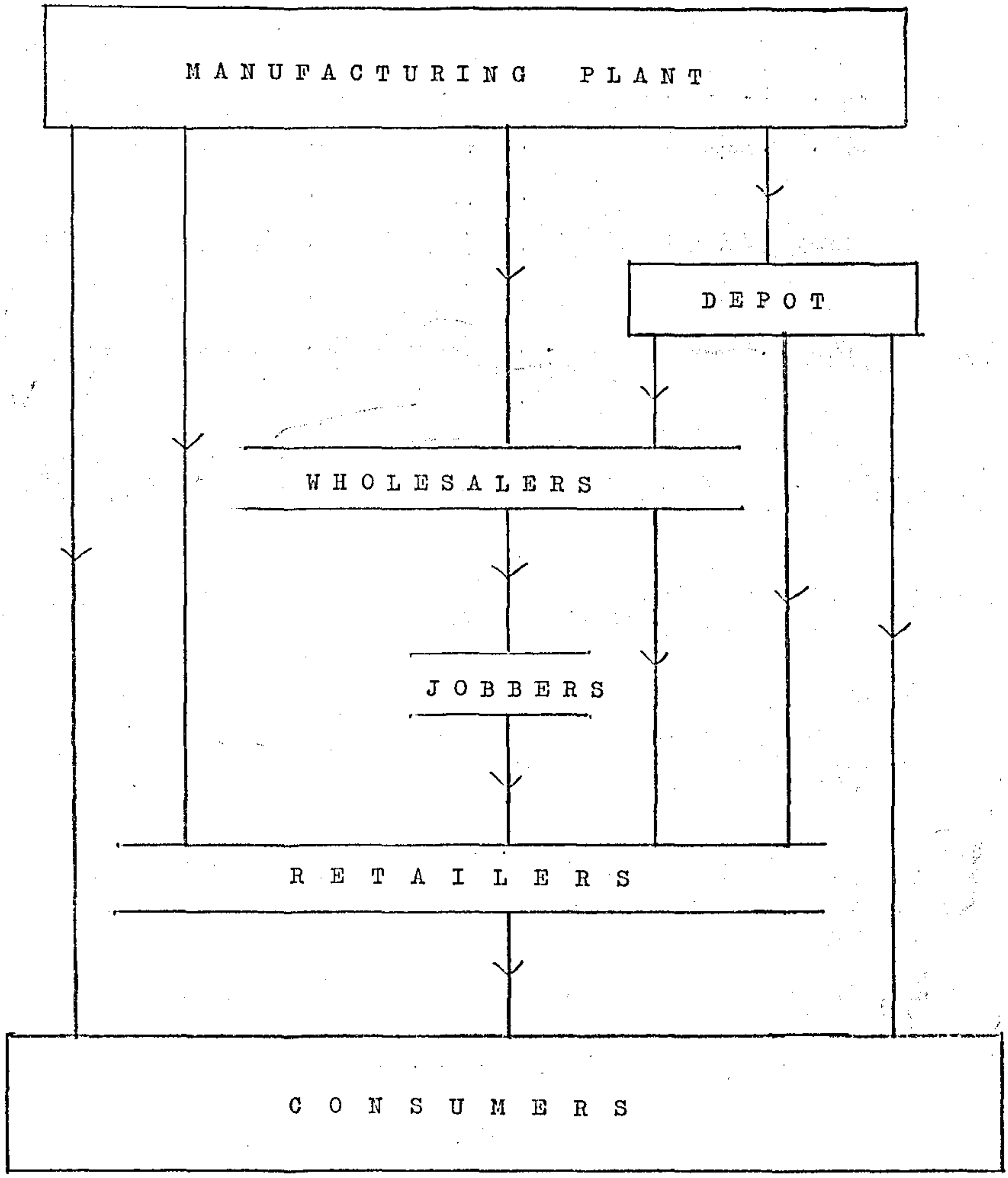

M A N U F A C T U R I N G   P L A N T
WHOLESALERS
JOBBERS
R E T A I L E R S
C O N S U M E R S

1.4.3. The next channel is created when a wholesaler intervenes between manufacturer and retailers. The wholesaler maintains the same relationship with retailers as the latter have with their customers. The wholesaler becomes essential when the number of retailers increases. The factory finds it inconvenient to deal with so many retailers, particularly if their individual requirements are relatively small. The many retailers would be assigned to a few wholesalers thereby having a two-fold effect on the factory; the number of orders is reduced and the size of each one is increased. These two factors help factory management to plan their production more efficiently.

1.4.4. The last important channel is created when jobbers are introduced between wholesalers and retailers. The jobber comes into prominence when retailers are scattered over a wide area. His first function is usually one of specialised transport and the removal of this activity allows both wholesaler and retailer to concentrate on other important aspects of marketing/distribution.

1.4.4.1. The representation given in Fig. 2 is still not fully compatible with the set up shown in Fig. 1. The difference is the non-existence of depots in the former. These depots belong to the manufacturer. If not, it is in reality a wholesaler's depot. A depot operated by a manufacturer serves a different function. The wholesaler adds Time and Place utility after the goods have left the manufacturer's control. Ownership utility is added later. A manufacturer's depot also adds Time and Place utility and, in addition, assists in smoothing out demand on the factory. A depot also assists in the creation of reserves to cope with seasonal variations or strategic requirements. While storage at the factory may also serve the same purpose, the depot does so at a location which is much closer to the market. This brings out the most important function of a depot - it enables goods to be moved over the greatest possible distance by the most economical means of transport. The introduction of depots into the network creates the new set up depicted in Fig. 3.

Fig. 3


MANUFACTURING PLANT
DEPOT
WHOLESALERS
JOBBERS
RETAILERS
CONSUMERS

1.4.4.2. Jefferys[(6)] has prepared comprehensive data upon the channels of distribution used for various consumer goods ranging from basic foodstuffs, through clothing and footwear, to newspapers and petrol. The results have been based upon figures collected for 1938. While being far out of date as regards detail, they are still valid in the broader aspects.

Hepner[(13)] lists several other channels of distribution. They are less important than the four given earlier, now that quantities of commodities in transit are increasing, but are included in order to provide a full description of these channels.

1.4.5. The manufacturer can sell through salesmen. Door-to-door selling is the most common manifestation of this channel. Salesmen are usually retained upon promise of payment of commission and do not, generally, take title to goods. They solicit orders and accept payment on behalf of the manufacturer, and request shipment direct to the consumer. The channel is not very popular because it can be rather expensive. Salesmen's costs can be high; so can the cost of packaging and development, and delivery.

Firms which specialise in mail orders can attain an advantage over other traders by carrying this type of distribution still further. They are wholesalers who employ salesmen to contact customers direct. A mail order firm has to carry high costs on account of commissions, packaging and delivery. In addition certain customers may be given the privilege of payment on easy terms, sometimes with no extra charge for credit. In such instances, the cost of credit too has to be considered. The big advantage, however, is that such firms do not need to maintain expensive shops, nor spend on direct advertising, display and counter staff.

1.4.6. Manufacturers may sell to consumers through their own shops. Here the manufacturer displaces an independent retailer. He enjoys the normal profit of the retailer in return for the additional function of retailing.

1.4.7. Manufacturers may sell to consumers through "wagon retailers". The simplest illustration of a wagon retailer is a mobile shop. The traditional village market or the travelling shop are further examples. This channel accounts for a relatively insignificant volume of trade.

1.4.8. Salesmen may be used to canvass business from retailers or wholesalers. Sales agents or brokers too may be employed for this purpose. Such parties usually represent the manufacturer. They handle a limited line of goods and are consequently more knowledgeable than the wholesaler or retailer. They do not take title to goods. Their costs are low but problems can arise due to lack of control or even loyalty.

1.4.9. Just as much as the manufacturer can take the place of the retailer, so can he take the place of the wholesaler.

1.4.10. The handling of industrial goods introduces a new type of organisation to the picture. They are Industrial distributors, who handle a general line of industrial goods and sell largely to industrial consumers. They act as middlemen, taking title to and carrying stocks. They assume some of the risks of distribution and maintain reasonably close contact with their customers. Alexander,Cross and Cunningham (14) have studied their performance in detail and have adduced several reasons for their success.

The comments made in the next few sections are under the assumption that Distribution includes not only the use of warehouses/ depots, but also wholesalers and retailers in the supply network.

COSTS OF DISTRIBUTION

1.5. The costs of distribution are taken to be the total outlay, including profit, in getting commodities from the manufacturer to the consumer at the right time, in the right place, in the right quantity, in the right quality, and at the right price. The total would include manufacturers' cost in addition to those incurred by wholesalers and retailers.

1.5.1. Manufacturers could theoretically build up costs from the stage that the production process has been completed. Packaging could therefore be considered as a distribution cost. One could differentiate between the costs of inner and outer pacgaking, the former being assigned to manufacturing and the latter to distribtuion. It is often an individual decision as to where these costs should be allocated.

The next item of manufacturer's distribution cost would be that of carriage. Here too practice varies from industry to industry. In the motor car industry, delivery cost is specifically added to the retail price. In other cases it is hidden in either wholesaler's or retailer's cost. In the newspaper industry, maintenance of an elaborate distribution network is an integral part of the business.

Other items of cost which could be included are the expenses of advertising, promotion, merchandising, etc., but practice varies so much that generalisations would be valueless.

The final major item of manufacturer's cost is that incurred in field storage/selling operations. The cost of building and administering depots, salesmen's costs, invoicing costs, etc., are all relevant; the chief difficulty lying in isolating these costs not only in absolute terms but also in differentiating them between the various products that are handled.

Certain elements of manufacturer's cost, such as transportation and warehousing costs, form the subject of this study.

1.5.2. There seems to be less difficulty in determining costs incurred by wholesalers and retailers. It becomes a very simple matter if the interests of these traders are confined to a single line of goods, e.g., light agricultural machinery or hardware. The difference between the outlay on the goods and the revenue derived from their sale consists of cost and profit (before tax). We come across a new element here, namely, profit. Manufacturers rarely make a profit from their distribution operations; their profit comes from production. A wholesaler or retailer, on the other hand, depends solely upon the intermediate activities of storage and resale to make his profit. This is his only line of activity and he must make a profit if he is to survive.

The elements that make up the expenses of a wholesaler or retailer will include costs of ordering, storage, breaking bulk, display, merchandising, shrinkage, obsolescence and even bad debts. Problems arise when these costs have to be allocated between numerous lines of products, and the trader has to divide his costs often on an arbitrary basis.

1.5.3. The consumer may in some instances be called upon to pay more than the retail price of a commodity. We have already referred to the delivery cost of a motor car. Additions such as purchase tax are mentioned only in passing, because while they exist, they cannot be changed easily. The most common cost which is solely the responsibility of the consumer is that of hire-purchase or credit. The consumer has the choice of deciding whether or not he has to bear it. He need not purchase a commodity on hire-purchase terms - if he chooses to do so, he has to pay for the privilege.

COST CONCEPTS

1.6. Howard,(15) Plowman(30) and Smith(31) set out the following concepts of cost as applied to marketing, that "bring together the accountant's view of the problem and the theory of cost, and focus both on marketing decisions".(15)

1.6.1. Outlay vs. Opportunity Costs. Opportunity cost is a central concept in cost analysis. It is said to be the price that the factor of production would command in the most profitable alternative use. The actual expenditure involved is the initial outlay. It is usual to add opportunity cost to the other costs when determining the profitability of a project.

1.6.2. Future vs. Historical Costs. The distinction between future and historical costs is often ignored. Historical data is often factual and correct in detail, and also has the benefit of hindsight in its compilation. The common assumption is that the future is merely an extension of the past. This is often true, as cost structure does not change quickly, but there can be variations in individual elements of cost. Therefore future costs can sometimes show marked variations from historical costs.

1.6.3. Short-Run vs. Long-Run Costs. Howard quotes three periods in economic analysis - "market", short-run" and"long-run". He describes "market" as being applicable when the rate of output is constant; "short-run" when scale of output (plant capacity) is constant but rate of output can change; and "long-run" when both scale and rate of output can change. Constantin (16) elaborates on this theme and uses many clear diagrams to illustrate his argument.

1.6.4. Variable vs. Fixed Costs. Fixed costs are those which are constant in total, and do not vary with output (or else, wide ranges of output). When fixed costs are divided by the output, and expressed as an average, it varies inversely with output. Variable costs are those which are proportional to output. Howard suggests on the basis of empirical evidence that average variable cost may be roughly equal to marginal cost within narrow ranges of output.

1.6.5. Incremental vs. Marginal Costs. One can differentiate between incremental and marginal costs on the basis of scale. Marginal cost is the additional cost of one more unit. (Similarly, marginal revenue is the additional revenue from the sale of one more unit). Incremental cost, on the other hand, is the additional cost of several more units.

1.6.6. <u>Traceable vs. Common Costs.</u> A traceable cost is one that can be isolated "as a practical matter"[15], from any sector of the organisation's activities. Common costs are those which cannot be so identified for technological reasons alone. A classic case of common costs arises in an oil refinery where crude petroleum is treated to produce various combinations of different products. Much of the processing is common to many products, and the isolation of costs for individual products becomes difficult, if not impossible.

1.6.7. <u>Direct vs. Indirect Costs.</u> The difference between Direct and Indirect costs is an extension of the distinction between traceable and common costs. Direct costs can usually be traced to a single product, while indirect costs may apply to several.

1.6.8. All these concepts are relevant when considering the case of a distribution system. The act of 'production' is substituted by the act of 'distribution'; the other factors are still applicable. Outlay can represent the construction of a new warehouse, or the purchase of specialised vehicles which may improve transportation practice, or even the installation of a computer to speed up operations at a large storage depot. Opportunity cost would be the income that could have been earned from the most profitable alternative investment, which may not necessarily be in the field of distribution. The case study is confined to the construction of new storage depots, and the opportunity cost is the income that could have been obtained by investment in gilt edged securities. (Opportunity costs have always been treated in this way by the organisation which forms the subject of the case study. While having a commercial outlook, it is still a government-owned corporation and uses relatively conservative estimates of opportunity costs).

1.6.9. Historical costs are particularly important in the management of a distribution system. A Distribution Manager must ensure that actual cost data is available as soon as possible, so that he can plan for future using information that is not stale. Distribution is an area where the difference in structure between historical and future costs is not great, certainly in the short run. Furthermore prediction of cost even without historical data can be relatively easy. e.g., in a system which uses rail tank wagons for transporting fuel oil, conversion to a pipeline could be undertaken after a fairly accurate prediction of costs. Costs of pipe, wayleaves, and actual installation could be forecast even without historical data.

Day to day activities would tend to reflect in the future the same order of costs as they have in the past, and one would not be too far wrong to extend historical costs into the future. Foreseeable changes in cost structure should be incorporated into the estimates, but this is easy when the basis of preparation of the past data is known. In the case study, historical costs have been used as future costs. The proviso has however been made that the study will not produce absolutely accurate results. The study is not intended to give the actual cost of the distribution network, but to reorganise its structure so that costs will be minimised.

1.6.10. The concepts of short and long run costs are less important when considering a distribution system, particularly a grass roots system. A distribution system consists of a network of physical assets and one or more organisations which use various combinations of these assets. The assets are either fixed, such as depots (storage tanks, loading equipment, etc.,), and movable assets such as vehicles. The fixed assets are much more valuable than, say a single tank lorry. It would be relatively easy to purchase a new vehicle, but the increase in capacity of a storage area is a more difficult undertaking. A wide range of variation is therefore built into the design of fixed assets. A detailed study is made of market development (outside the distribution department) and an adequate margin is left for increase in throughput. This means that Howard's long run developments are really a long time away.

The pattern of demand for a considerable period has been incorporated into the design of the plant.

This outlook has been adopted for the case study, where market forecasts have been used in conjunction with certain cost estimates to determine both the capacity and the costs of new storage points. Operating costs are unlikely to change significantly from the present levels since no drastic changes in operating practice has been planned.

1.6.11. The identification of Fixed and Variable costs in a distribution system is less complicated than for a production system. The costs of distribution facilities can be isolated without difficulty: it is the differentiation between fixed and variable costs which can vary from case to case. Certain activities are clear cut, for instance fuel cost varies with throughput. Other costs, such as maintenance, insurance may be deemed to be fixed. Once a basis for allocation has been decided, matters become easy.

In the case study, salaries and wages, amortisation, opportunity cost and certain other costs were deemed as fixed. Maintenance and operating costs were taken as variable with throughput.

1.6.12. The scale of operations in distribution is such that the theoretical "one more unit" is infeasible. We deal with "several more units" and therefore with Incremental rather than marginal costs.

In the case study, a compromise has been struck. The concept of incremental costs has been used, but in quantifying these costs, they have adjusted to a per unit basis.

1.6.13. Traceable and Common costs present problems in distribution. Products may be handled individually and certain costs can be so allocated. e.g., premium gasoline is stored in a separate tank and all costs of this tank can be assigned to this product. However, it would be difficult to determine the cost of a single delivery, because the lorry may be used for other products at other times. The variable cost of that journey can be allocated to premium gasoline, but the fixed cost presents a problem. Similarly the cost of staff cannot be easily divided and therefore becomes a common cost.

The approach adopted in the case study has been to convert all products into a "standard" product. This step has been taken because of the nature of the problem. Petroleum fuels are similar enough. They are handled similarly and are moved in the same type of vehicle. The need for tracing costs by product does not arise; costs have been spread over a homogeneous product and a single activity.

THE SYSTEMS APPROACH

1.7. A distribution system does not consist only of a central source - the manufacturing plant. The network radiates from this. Stasch (57) has described the distribution function by using the analogy of a wheel. The producing plant is the hub, while the market is the rim. Each spoke represents a form of high-volume long-distance transport, while each point where a spoke meets the rim is a warehouse. The activities that together comprise a physical distribution system are then easily discernible. Transportation is represented in two scales - the large scale low cost movement in bulk from the central plant to each warehouse (from the hub to the rim along the spokes), and the low volume high-cost movement from each warehouse to the market (along the rim). Inventory/storage/despatch activities are necessary at each warehouse to change the scale of the transportation operations.

1.7.1. The nature of these activities is such that it is not easy to evaluate any one of these components without affecting at least one other activity. The introduction of high-capacity vehicles affects loading/discharging facilities. This in turn affects storage/handling costs. This point has been proved in the oil industry when Gulf Oil Company had to build a massive new transshipment depot at Bantry Bay to

handle

the mammoth 300,000 ton tankers that could not be handled elsewhere. Also, reductions in lead time could result in lower inventories. There are numerous such examples all of which serve to emphasise that a distribution network must be treated as a single system. This approach will result in an overall optimisation. Piecewise optimisation is not acceptable as the combination of several such optimisations will not produce an optimum for the complete system. Certain components may have to be operated in an "inefficient" manner, to produce a system optimum. Magee (61) refers to such instances as "trade-offs", where one replaces a component of a distribution system with a more expensive alternative if the exchange is accompanied by a greater saving elsewhere in the system.

1.7.2. The systems approach in distribution analysis can best be implemented by using the unifying factor of cost. All components of the system either add to or reduce overall costs. There are several unquantifiable factors that need consideration - customers' convenience, strategic reasons, and the maintenance of an institutional reputation. These factors do contribute to an overall decision, but the overriding consideration is that of cost.

1.7.3. The total cost concept has been emphasised throughout this study. It has influenced not only the solution, but also the logic employed in reaching it. All possible factors have been quantified and have been expressed as a series of cost elements which enter the calculation.

1.7.4. The total cost/systems approach ensures each iteration in the calculation is self contained. Each is completely feasible, though the initial iterations may not be desirable. The objective, which is to reduce total cost is achieved in steps and each step has been designed so that it can be implemented without alteration as a complete network. All costs in the system are taken into account. Provision has been made for non-linearities in transport cost, and the fixed costs of depots figure prominently in the study.

1.7.5. This approach shows a marked improvement over certain techniques set out in earlier work. These techniques tend to break up a network into several components and tackle them separately, or tend to ignore the effect of certain components on the entire system.

PHYSICAL DISTRIBUTION

1.8. In the past, much of the effort made in increasing productivity and efficiency in modern industry has been directed towards the manufacturing process. These efforts have been greatly assisted by the development of modern techniques of scientific management, which can vary from relatively basic work study to highly sophisticated computer exercises. But until recently management has either not realised or tended to overlook the economies which could be achieved in the field of distribution.

The element of physical distribution costs in the final price that the consumer pays for a commodity can be large. Gentry and Shawver[56] have estimated it to be between 1/4 and 1/3 of the final price; a British Government publication[1] claims an even higher figure - 40%; while Seelye's collection of papers[64] take the figure to be close to 50%. Despite these high costs the change in emphasis came only recently. More and more firms have begun to exercise centralised control over their physical distribution systems and are looking to these activities to bring about reductions in operating costs. Physical distribution appeared to have been the "neglected cousin" of the manufacturing and marketing divisions.

1.8.1. Physical distribution has been defined by Smykay et alia[2] as being that area of business management which is responsible for the movement of raw materials and finished products and for the development of systems of movement. It is concerned with the geographic arrangement of manufacturing capacity and warehousing facilities in such a manner that while the marketing requirements of a firm are satisfied, movement costs are cut to a minimum. The activity that links together the manufacturing facilities, the network of warehouses and the final consumers is transportation. The scope of physical distribution therefore encompasses the proper location of manufacturing plant, the determination of the number, size and dispersion of warehouses and the selection of the most efficient means of transportation available, with the object of maximising both the short and long term profits of the firm while maintaining the required standards of customer service.

1.8.1.1. Taff's (3) reference to the management of movement, control of inventory, protection and storage or stockpiling of raw materials and processed/finished goods to and from the line of production, is similar to Smykay's definition. While including transportation, materials handling, packaging and warehousing, it also includes the importance of an efficient system of communications linking together all these phases of the firm's activities. The communications network is emphasised by Beckman and Davidson, (4) who describe a physical distribution network as consisting of not only the combination of transportation agencies, plant/storage locations and levels of inventory, but also the interconnecting flows of information, which together form the least combination commensurate with service requirements.

1.8.1.2. The conditional clause in these definitions is vital. The physical distribution effort should be an integral part of the marketing activities of a firm. It should be, to a large extent, subservient to marketing policy and the needs, preferences and convenience of customers should be considered when planning a physical distribution network. There will be nothing served by having a system that could operate perfectly, but for the fact that there are no customers providing the demand for the goods that it will handle. Turner (5) emphasises that distribution is a component of customer service, while Converse (12) calls it "the other half of marketing".

1.8.2. The petroleum industry is one which has of necessity to spread its operations over the length and breadth of a country. The nature and quantity of its main commodities, petroleum fuels, require the use of highly specialised equipment for storage as well as distribution. The need to keep down the investment in expensive equipment, while still ensuring adequate coverage of a country, via a series of depots, presents an interesting problem of optimisation.. The problem is complicated by the fact that oil companies have always owned and kept full control of their distributive networks, at least at the wholesale level. The burden of expenditure falls squarely on the oil industry, in contrast with, for instance, the steel industry, where the distribution structure tends to be operated by organisations other than the manufacturers.

INDUSTRIAL LOCATION

1.9. The scope of Physical Distribution includes location of manufacturing plant as well as depots. It would therefore be appropriate to review the theories of industrial location. Mention must be made of the work of von Thunen [33], who studied the effect of transportation upon the location of production. He dealt with agricultural products in a highly artificial "isolated state" - with a single city located at the centre of a level plain, surrounded by farms which were of identical size and efficiency and having identical climatic conditions, production costs, etc. von Thunen assumed that the price of produce at the origin would be the price at the city minus transportation cost. It then follows that location of production of individual commodities would depend upon the ratio of the weight of the product to its value. The heavier the product in relation to its value, the nearer to the city will it be produced. It also follows that the value of product at its origin decreases with increasing distance from the market.

1.9.1. Weber [36] widened the scope of von Thunen's argument by considering more than one centre of consumption in an industrially oriented market. He reasoned that there were three general factors influencing location. They were

1.9.1.1. Transportation Costs (including fuel and raw materials). Processing would move towards the point where the transfer costs of raw material and finished product would be a minimum. A product which lost weight heavily in processing would be dealt with closer to the source of the raw material, while those with low weight loss would gravitate towards the area of consumption. If more than one raw material was used, processing would take place at that point where the total transportation costs would be a minimum.[35] Losch, elaborating on this point, mentions 3 methods of determining the point of minimum transport cost - where the total freight costs are the lowest.

1.9.1.1.1. The first is the construction of the point of minimum transport cost in the locational triangle by the proposition of exterior angles, discovered by Laundhart, and rediscovered by Weber. Palander[38] has described the method in detail. Losch has deemed this method to be of neither theoretical nor practical importance. It applies only when the number of sources of materials and planes of consumption adds up to 3, and when freight costs are proportional to weight and distance.

1.9.1.1.2. The second is the mechanical model. Perforations are made in a stiff map of the area at sites of materials sources and markets. Threads bearing proportional weights are passed through these holes and tied together in one knot. The position of rest for the knot is the desired location of production. The mathematical proof of the method, which depends on the assumption that the problem of finding the lowest freight cost is that of finding the position of equilibrium of forces, is given by Palander.[38] This method is discussed in greater detail later on (paragraph 4.9.).

1.9.1.1.3. The third method uses Isodapanes. Weber's isodapanes are lines of equal total freight per unit of product; that is, lines connecting points for which a definite combination of hauls is equally expensive. The combination consists of the shipment of raw materials and intermediate products to, and finished products from the factory. Isodapanes must be distinguished from Isovectures (after Palander), which are lines representing equal unit freight rates for simple transport to and from a certain place. For a homogeneous transport surface, isovectures are concentric circles that follow one another at equal intervals for similar freight differences. They are proportional to distance as one proceeds outwards from the centre. If the transport area is traversed by especially cheap lines of transportation, e.g., railroads and canals, combined transports result (rail and lorry) and the isovectures can be distorted. Once the isovectures have been demarcated, they serve for the construction of isodapanes. They are drawn for the transport of that quantity of goods which is required for the production and sale of 1 unit of finished product.

1.9.1.1.4. As an illustration of the second method, if A, B and C are raw material sites of which 3, 2 and 0.5 tons respectively are needed to produce 1 ton of finished product, and if D, E and F are markets consuming 80%, 15% and 5% of the total output, then the weights used will be in the ratio 3:2:0.5:0.8:0.15:0.05 for A to F respectively.

1.9.1.1.5. Fig. 4 is a sketch showing the construction of an isodapane from isovectures.

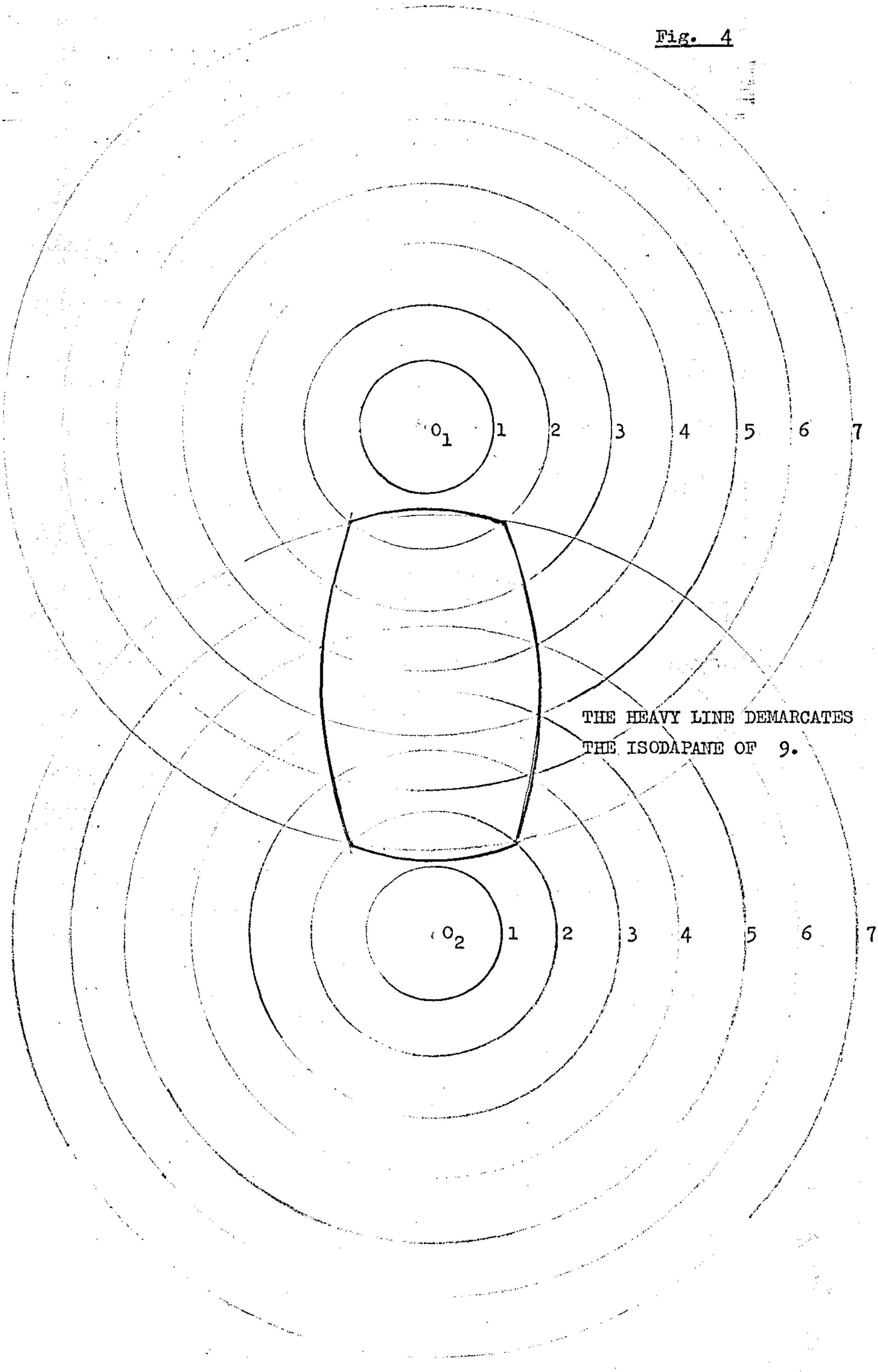
1.9.1.2. <u>Labour costs</u>. Weber defines a Labour co-efficient as the ratio between labour cost per ton of product and the total weight of all transported goods necessary for processing it. If the labour coefficient is high, processing tends to move to an area where transportation costs may be greater.

1.9.1.3. <u>Agglomeration Factors</u>. The significance of this factor may be the influence on location of the proximity or otherwise to auxiliary industries, services, communications facilities, etc.

1.9.2. Hoover(41) makes the follwing comments upon the choice exercised by producers in selecting locations for their plant.

i) they attempt to maximise earnings which are built up

Fig. 4



O_1
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THE HEAVY LINE DEMARCATES
THE ISODAPANE OF 9.

from the combined use of the factors of production.

ii) Regularity and security of earnings is important.

iii) the expected trend of earnings is also relevant.

iv) proper evaluation of the stability, security and future prospects of a venture may be under-rated.

1.9.2.1. He divides the activities of a productive organisation into 3 categories,

a) Procurement (of raw materials)

b) Processing

c) Distribution

From the standpoint of distribution a producer should determine how location can affect demand, since proximity to a market (particularly in relation to competitors) can significantly affect level of demand.

1.9.2.2. Hoover devotes much attention to the influence of various external factors such as industrial zoning, transportation facilities, as well as internal factors such as processing cost differentials, upon industrial location.

1.9.2.3. His work extends the thinking of earlier writers in this field. His detailed examination of their work, and his analysis of transfer costs and their influence upon location is excellent.

1.9.3. Greenhut[58] deviated from previous thinking on the subject by stating that optimum distribution of location was not based solely on considerations of cost. He stated that demand and elasticity of demand also had an effect on location. "Location decisions then appear to be based not only on the centripetal force of minimum cost attraction but also on the centrifugal force of demand elasticities".[59]

1.9.4. Isard's[60] work in the field of regional science has also been significant. He deals with regions which are not homogeneous - various areas have varying characteristics. He studies three types of decisions, namely, location, scale of operations, and flow.

1.9.5. The application of these theories in the field of petroleum distribution is a subject that is too deviant from the subject of this study. They are concerned with the location of the manufacturing plant, the oil refinery in this case. However there are certain aspects that can be included in this analysis which deals with the intermediate storage point, which can be likened to an originating point which is to be located within the 'catchment area' of each depot. Aspinall (62) states that goods tend to be drawn towards the point of final consumption at a rate established by the ultimate consumer. Following upon this, depots tend to move towards the areas of maximum demand. They also tend to be located in such a fashion that the lines of demarcation of adjacent depot areas are on the watershed of delivered prices - it costs the same delivered from either depot. The theories about labour, etc., are not significant as the requirements of skilled labour are very low.

WAREHOUSING

1.10. Since the main interest of this type of study is the structure of the network of warehouses/depots, a few general comments of relevance to warehousing would be appropriate at this stage.

The meaning of the term "warehousing" has been vague and undefined. It is generally used to embrace, rather loosely, the functions of receiving, storage and despatch. These same functions may be carried out at places other than warehouses and this adds to the ambiguity about functions of warehouses. An addition to the generally accepted meaning would be that the above functions comprise warehousing when they are carried out either spatially or functionally separated from the manufacturing process. This extends the definition to "the functions of receiving, storing handling and despatch of goods between the time they are produced until the time they are needed". Here again is an ambiguity. The "time they are needed" could mean either the receipt of the goods by the final consumer or their handling by someone at an earlier stage in the distribution chain, i.e., a wholesaler or a retailer. We can therefore further amend the above definition to read "the functions of storage, handling and despatch of goods between the time they are produced and the time they are required in bulk or in smaller lots suitable sized for the next link in the distribution chain". It is implied in this definition that warehousing is an activity that is carried out by the manufacturing function and that it ends with the transfer of goods to the selling function. We have now run into another area of doubt - is warehousing a part of the manufacturing function? Jenkins (17) is quite definite in his answer to this question. He states that warehousing is a clear and distinct profession that will play an expanding role as a vital sector of the economy. The final definition of warehousing would then be" the separate functions of receiving, storage, handling and despatch of goods between the time of manufacture and the time they are required in bulk or in smaller lots suitably sized for the selling function".

THE BENEFITS OF WAREHOUSING

1.10.1. Warehousing is an expanding field. Its importance has been growing over the past few decades and is likely to grow at an even faster rate over the next few. Its uses to an organisation are many.

1.10.1.1. It permits longer production runs. In general, longer runs mean lower unit production costs. Set-up costs which can sometimes be very high can be spread over a larger quantity of goods. Automated equipment can also be justified more easily if long runs are possible. A warehouse can play an important role in absorbing the high volume of product put out after a long run.

1.10.1.2. A warehouse, by its ability to receive and store goods provides a buffer between the continuous rate of production of a factory and the intermittent, sometimes unpredictable demand of the market. It is a reservoir which absorbs the goods produced in long runs and sends out smaller shipments to customers as and when required.

1.10.1.3. An important economic reason for the existence of warehouses, particularly those located close to areas of high demand, is the opportunity for savings in freight costs. The factory produces goods in large quantities and ships them in bulk to the warehouse. Customers' requirements are moved in much smaller lots either because their total requirements may be small, or they may be making frequent purchases in order to reduce capital tied up in stocks awaiting consumption. Bulk transport to the warehouse is done by the cheapest available method of transport, consistent with the volumes involved; while the smaller shipments to customers are carried out using the more expensive methods. Therefore the interpolation of a warehouse between a factory and its customers enables goods to be moved cheaply in bulk and then broken down into the costlier small shipments close to the customers. If the warehouse did not exist, the expensive small scale transport would be required for all movements of goods, with resultant increases in cost.

1.10.1.4. The presence of warehouses close to the consumers will reduce lead time. This enables the customer to reduce his own inventories because replenishment of stocks is much speedier. The converse also applies, that the firm has to carry at its warehouses much larger stocks, but this is deemed to be a part of the service offered to the public.

1.10.1.5. Customers find the existence of a local warehouse very convenient. The element of customer service cannot be quantified, but it is something that cannot be overlooked.

FUNCTIONS PERFORMED IN WAREHOUSING

1.10.2. Warehousing spans a broad scope of activities, related to some extent to the nature of a company's business. Some firms need little or no warehousing. e.g., a machine tool manufacturer almost invariably builds equipment to special order, which is not stored but shipped direct to the customer. One the other hand, a firm dealing in consumer goods like shoes or radio sets invariably requires warehouses in its system. There may be other firms whose principal business may be warehousing. e.g., a distributor exists on the margin he can make between the amount he pays for goods and the amount he receives from their sale. His main function is to make goods available easily, and warehousing is therefore the principal aspect of his business.

An analysis of the activities involved in warehousing shows certain functions which are either directly involved with or closely related to it. Jenkins (17) lists 11 functions as follows:-

Function	Directly involved	Closely Related
1. Receiving,storing,shipping	X	
2. Inventory accountability	X	
3. Inventory levels	X	
4. Maintenance,safety,housekeeping	X	
5. Cutting to order and packaging	X	
6. Purchasing,labour relations and Industrial Engineering	X	
7. Transportation	X	
8. Traffic		X
9. Accounting		X
10. Production and Sales		X
11. Inspection and Quality Control		X

Further comments on these functions are made in his book. (17)

Magee (18) lists the essential processing functions that a warehouse may perform:-

1. Receives goods
2. Identifies goods
3. Sorts goods
4. Despatches goods to storage
5. Holds goods

6) Recalls, selects or picks goods

7) Marshals the shipment

8) Dispatches the shipment

These functions are allied to those which Jenkins referred to as "directly involved".

We are concerned with the determination of the best combination of warehouses in a distribution system in terms of their number and location in order that the functions listed above are performed in such a manner that the benefits will accrue not only to the firm but also to the general public.

PETROLEUM DISTRIBUTION SYSTEMS

2. The comments made in the earlier sections dealt with the general problems of all distributive industries. This broad field will now be narrowed down to those systems which handle the distribution of petroleum products, mainly fuels in bulk. The petroleum industry provides excellent examples of complete distribution systems which have been in continuous operation for many decades. The industry had small beginnings and so did its methods of distribution. However, it enjoyed a very rapid rate of growth. Developments in distribution were widespread and, to a certain extent, disorganised, but lack of planning did not prove to be a serious disadvantage because the industry developed so rapidly that growth in any form was acceptable. However, in this day and age, there are increasing pressures to prune costs in all phases of the industry, most of all in those stages where expenditure does not enhance the intrinsic value of the product. Distribution practises have been increasingly subject to economy drives - a change in emphasis from the past where most of the effort was concentrated in effecting economies in production.

2.1. The petroleum industry is one of the rare cases where one industry undertakes the whole sequence of operations from searching for raw material to selling the final products of manufacture. It is usually fully integrated from exploration to marketing. It is difficult to recall other industries where the degree of vertical integration is so complete.

2.1.1. The oil industry also provides almost classical examples of oligopplies and monopolies operating on a national scale. The history of the industry has shown that its natural growth favours the establishment and perpetuation of local oligopolies. There are a few large organisations in each country (a few operate internationally); outsiders cannot readily enter the industry; the degree of competition varies at each phase of the industry, but open warfare is avoided; and what appears to be a united front is presented to the public, particularly regarding price.

2.1.2. A monopoly, on the other hand, is almost certainly the result of state intervention. For some reason or other, the state has obtained control of the industry. In such cases we have the typical conditions of a monopoly - one interest; entry barred to others; and complete control of all aspects of the business.

In our narrow field, the following comments may be relevant when formulating ways and means of rationalising petroleum distribution networks, whether they be operated under oligopolistic or monopolistic conditions.

2.1.3. Most countries have many oil companies/organisations operating in competition with each other. This means that eachcompany has to modify its own network independent of the networks of other companies. We will therefore have several sub-optimisations, but no overall effort to tackle the national network. There are exceptions to this, like the UKOP line in Britain, which will handle products belonging to several oil companies, but it is only financial expediency or the provisions of national legislation (65) which causes this. The UKOP line would have been too much of a commitment for any one company to bear, and the obvious step of forming a consortium was taken. However, development on a smaller scale is undertaken by individual companies after having been considered in separate planning schedules.

In spite of the fact that each company will try to rationalise its own network there will be very little done on a macro scale where a synoptic examination is made of a national network. There will still be duplication of facilities which will be a national loss. Such losses can only be eliminated where one body has the authority to make an overall study of the entire network. In other words, some sort of unified control or monopoly must prevail. Such a concept cannot be entertained in a market of free competition except in periods of emergency, such as wartime conditions, when the national interest overrides all others. Even so, any measures taken at such times are only temporary.

2.1.4. Monopolies do exist in the petroleum industry, but they are few and far between. (The country chosen for the case study - Ceylon - has a monopoly of refining, internal supply and distribution.) Here are instances where the process of rationalisation can move to its logical conclusion. The study is on a national basis and can give an overall optimum. There is, however, one very significant weakness in a monopoly situation. There is no other organisation on which to fall back at any time. An oil company operating under competitive conditions is aware that other companies can not only attack its business, but also complement its efforts by covering up blank areas in its network. A monopolist has to cover each and every area by itself, knowing all the time that any oversight or ommission will have serious consequences on the community. This means that his safety margin has to be much wider and he has to pay for added security by having a more complex network.

2.2. A distribution system designed to handle petroleum products is comparatively simple. Figs. 5 and 6 show the structure of a petroleum system and a more complex one which handles canned fruit.

Petroleum distribution is the penultimate link in the long chain of activities that spans the industry. Its function is to ensure that all products are available at places where the consumer can draw his requirements at times and in quantities convenient to him. Jones (32) has listed the following functions of distribution as applicable to the food industry:-

1. Transportation
2. Materials Handling
3. Warehousing
4. Inventory Control
5. Production Planning
6. Administration

With the exception of Production Planning, they are all relevant to the field of petroleum distribution.

The arrangement that is acceptable to one type of consumer may not suit others. For instance, the motorist is willing and able to travel some distance to obtain special fuels for his car. But the petrol station must not be too far away from his residence or place of work. He does not care to go far out of his way merely to get petrol. At the other extreme we have the consumer (in countries like India and Ceylon) who uses kerosene (paraffin) in small quantities for illumination and/or cooking. His daily requirement may be less than ½ gallon. He neither wishes nor expects to go out looking for kerosene. He demands that the kerosene be brought to him, to his doorstep. This means that these countries have very complex distribution systems for kerosene. There are also customers who require such large quantities of product that special arrangements, such as pipelines, have to be made to supply them.

2.2.1. We have thus, on the one hand, a large number of consumers (petrol stations are treated as consumers) scattered all over the country and having varying patterns of demand over the full range of products. On the other hand are the comparatively few sources of petroleum products from which these customers have to be supplied. The sources may be refineries or ocean terminals. In between the main source/s and the customers are the facilities which comprise the distribution network.

2.3. A refinery is geared to a continuous process of separating, treating and finishing products in bulk from crude oil. Just as much as its input is continuous so should be the rate of draw-off of finished products. The supply of the intermittent needs of the customers can upset the smooth flow of operations within the refinery. Therefore all work involved in supplying individual customers is removed from the refinery and centred around a separate storage depot one of whose functions becomes that of insulating the refinery from intermittent external demand. The depot may, in some cases, be adjacent to the refinery itself.

2.3.1. In the present context of improving an existing network to minimise total costs, we could consider that the only fixed elements of the network are those at either end i.e., the refineries and the customers. The location of the refinery is governed only partly by the pattern of internal demand. Other factors, such as the existence of deepwater harbours, supply of fresh water, or even area development are conditional in locating refineries. Customers are of necessity fixed at locations to their convenience.

We therefore consider only the intermediate depots as being variable. We will concentrate on improving total distribution costs by manipulating these depots.

2.4. The channels of communication and distribution link the refinery with its customers. The refinery should be producing (in the ideal case) just sufficient quantities of products to satisfy the total demand of its market. These products will have to move to all parts of the country. How can they move?

By a) Pipelines

b) Coastal tankers

c) Inland waterway, by barge

d) Rail

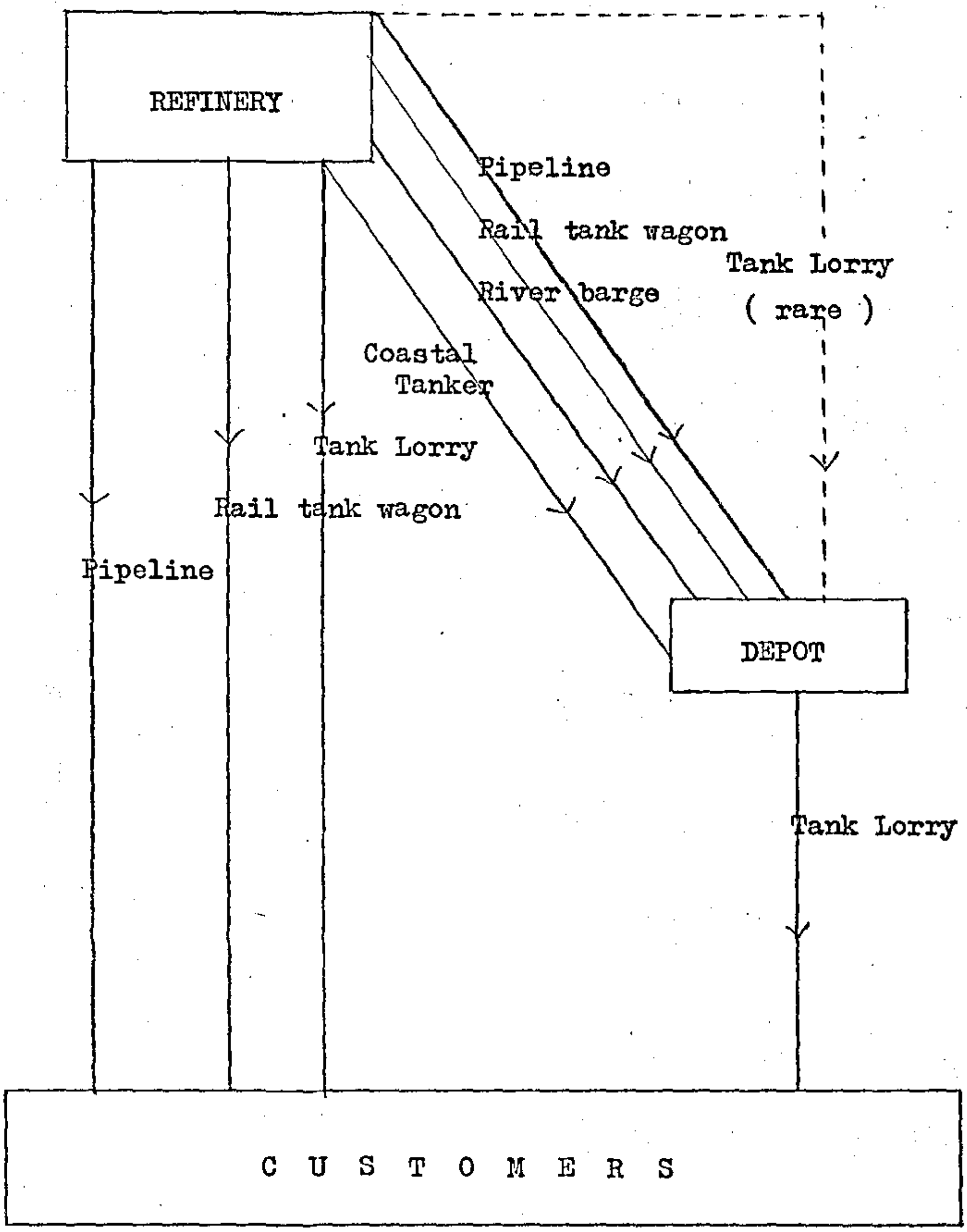
e) Road

Fig. 7 shows all these methods of transport.

2.4.1. <u>Pipelines</u>. The use of pipelines for product transportation was initiated in the U.S.A., which claims the longest product line in the world. Development of product lines in other parts of the world has been somewhat slower. The newest one is the British UKOP line, about 240 miles long, linking in two sections the refineries on the Thames Estuary and Mersey-side with the industrial Midlands.

Pipelines are a unique form of transport in that there

Fig. 7


REFINERY
Pipeline
Rail tank wagon
River barge
Coastal
Tanker
Tank Lorry
(rare)
Tank Lorry
Rail tank wagon
Pipeline
DEPOT
Tank Lorry
C U S T O M E R S

is no return journey involved. The product is held in a container, the pipeline, but the latter does not move. It is the product that moves. This feature enables 100 % utilisation of a line with no waste of time and effort in hauling back an empty container. At the same time the cost of operating a pipeline is closely influenced by its throughput. Unit cost increases very rapidly when throughput falls below optimum capacity. This is due to the very high fixed cost in pipeline operation. Hubbard (47) has clearly illustrated this point in his book dealing with comparative costs of product transport. A pipeline can be quite economical in its use of fuel and manpower, and can be almost fully automated. It is also eminently suited for on-line computer control.

2.4.1.1. The disadvantages of pipelines are considerable. They cost a lot of money to build. In addition to the cost of materials, the securing of way-leaves, rights of way, etc., can be very time-consuming. Once installed, they cannot be moved. In addition a pipeline can handle only a limited range of products at a time. The use of multiple product lines has increased rapidly in recent years, but even now there is a small amount of contamination at the interfaces. High viscosity products such as fuel oil are very awkward to handle in a pipeline. It has to be heated and thinned out before pumping and the line itself has to be insulated if its length is of any significance. What was claimed to be the longest fuel oil line in the world is the Esso line from Fawley to London - 64 miles or so of heavily insulated line.

2.4.1.2. Pipelines are used to supply product to high volume customers or to storage depots.

2.4.2. <u>Coastal Tankers</u>. They are generally used to supply depots or terminals and can be up to about 18,000 tons deadweight. They are comparatively cheap to operate, even though they may be much more expensive than their larger ocean-going counterparts. A single vessel can carry many products on the same trip in compartmented tanks and there are no overwhelming difficulties in handling fuel oils.

2.4.2.1. Coastal tankers are used to supply products to harbours which are too shallow or too congested to handle larger vessels. Owing to the benefits of economies of scale, the biggest possible vessels are (or should be) used for each run.

2.4.3. Inland waterway Barges. The size of the parcel is decreasing and unit costs keep rising. The principles of operation of river barges are the same as those for coastal tankers, except that one can have "trains" of barges plying on the larger rivers. The serious limitation is, of course, the lack of suitable inland waterways. Britain has very few, but the Low Countries are fortunate in having complex networks of canals. The capacity of a barge can vary from about 250 tons to about 7500 tons for the giant pusher trains that ply on the Mississippi and the Rhine. With decrease in size comes decrease in flexibility. A single barge generally carries only one product. They are used mainly to supply products to inland depots from refineries or ocean terminals.

2.4.3.1. The advantages of water carriers are many.

1) they have relatively low costs per ton mile provided loading/unloading is not too costly.

11) they can haul product over long distances, and

111) they can handle comparatively large tonnages.

2.4.3.2. The disadvantages are

1) they are much slower than other forms of transport,

11) special terminal facilities are required, and handling costs may become excessive,

111) they are generally limited to handling goods of low value/weight ratio,

1V) some water carriers assume less liability for loss and/or damage, and

V) they can be seasonal in certain areas.

2.4.4. Rail Tank Wagons. The size of the parcel decreases further. The older tank wagons used by British Rail carried between 4000 and 8000 gallons.

The newest 100 ton wagons can carry about 20,000 gallons. Since there is a better network of railway lines than canals, rail tank wagons have a greater spread of deliveries.

2.4.4.1. The operation of tank wagons has been greatly influenced by the introduction of "block" or "liner" trains. Formerly, tank wagons were treated like other goods wagons - they were loaded, shunted and handled singly. In a block train several wagons remain permanently coupled together and are loaded, moved and unloaded as a unit. The considerable expense of installing additional facilities to handle these composite units has been completely offset by savings in the form of greater utilisation and faster turn-around of wagons. The use of block trains is very popular and it now is exceptional for single wagons to be used.

Rail wagons are generally used to supply product to bulk depots or high volume customers.

2.4.4.2. The advantages of rail tank wagons are

1) they are quite flexible in range of product (fuel oils may require heated wagons for long journeys)

11) they are very economical carriers of goods on intermediate or long hauls

111) they are not unduly affected by the weather

1V) they are quite fast, and

V) an interconnected system of railways provides high flexibility of movement, especially without unloading.

2.4.4.3. Their disadvantages are

1) they are generally uneconomical on short hauls

11) they can sometimes take longer than trucks on long hauls since handling time can be high, and

111) they are generally not feasible for less-than-full load lots.

2.4.5. <u>Road Tank Lorries.</u> The road tank is the smallest and most expensive vehicle for product transportation. However, it performs a vital function in that it serves the majority of consumers who, without it, would not have a practical means of obtaining their requirements. Road tankers make up for their expense by their almost unlimited flexibility of operations. They can go almost anywhere and can handle drops of even 1/8th. of their capacity. They can carry several products at a time (in compartmented tanks), and can serve several customers on the one trip.

2.4.5.1. The extent of utilisation of tank lorries is governed by factors such as their (comparative) high capital and operation costs, manpower requirements and statutory limitations on working hours, distance of travel, etc. In addition, the average size of drop and the number of customers served on a single trip can affect overall costs.

2.4.5.2. Road tankers vary in size from about 1500 gallons to the present practical maximum of 6300 gallons. (the present statutory maximum is 6600 gallons, but design problems set the lower limit). The larger vehicles can also be used for bridging, i.e., supplying a depot rather than a customer.

2.4.5.3. The advantages of road tankers are

1) they can handle goods of high value/weight ratio

11) they are most effective on short hauls

111) trucks give door to door service. There is no handling involved during the course of the journey

1V) delivery is quick, and

V) "difficult" products such as fuel oils present no problem. Continuous heating can be arranged easily.

2.4.5.4. The disadvantages are

1) their manpower requirements are high

11) they operate in single units (as compared with the multi-unit block trains), and

111) costs can he quite high, especially on long hauls.

2.4.6. Yet another method of moving product is in 45-gallon drums on package lorries. This method is almost extinct in Britain but is still popular in countries where either the demand is low or the roads are unsuitable for tank lorries. Costs are very high because the containers deteriorate very rapidly and have to be replaced often. In addition, lorry costs can be high because the vehicle may not be carrying its rated load capacity. This method of transport is so unimportant that it is not considered in the present study. The only note that need be made is that facilities to fill containers may be desirable at terminals/depots if customers continue to use this method of transport.

2.5. RELATIVE COSTS OF METHODS OF DISTRIBUTION

The field of petroleum distribution is an important area for potential savings. Activities in this field do not affect the intrinsic value of the product, except that spatial (or temporal) movement may make it more desirable and attainable to the consumer. Severe competition in wooing customers has resulted in a high level of investment in facilities. Every effort is made to keep down not only initial capital costs but also the recurrent operating/maintenance costs of these assets. While general distribution practice seems to be similar in all oil companies, the one point on which little or no information is available is that of detailed costs. The objective student has no access to actual costs. Such costs may not only give away valuable secrets, but may also provide critics with a potential weapon.

2.5.1. The only work on average and relative costs is that published by Hubbard.[47] He has collected information from several sources and carried out a series of analyses to establish ranges of specific and relative costs. He is the first to state that his results are in no way typical either of a method of transport or of a particular country; but, all the same his work is valuable in giving a useful idea of comparative costs. The numerous graphs and tables which complement his article are useful for this purpose. They illustrate very well the points made earlier regarding the relationship between parcel size and cost, as well as quantity and distance, and cost.

2.5.2. The data used in the case study is real data obtained from historical records. They are fully in conformity with the trends described by Hubbard.

THE PROBLEM

3. The problem is to analyse a distribution system and determine how it has to be altered to achieve minimisation of total distribution cost, consistent with efficient service. Alternatively, it may be desired to design a new network to achieve the same end.

3.1. It is clear that such an analysis has to be preceded by the determination of a series of costs, requirements, and other pieces of relevant information. If an existing network is being studied, historical records would provide the bulk of the data. The data have to be checked and adjusted, where necessary, to make them compatible for the study. A grass roots situation requires more extensive research, particularly if suitable data is not readily available.

3.2. With this background, one has to devise an acceptable basis of forecasting not only future demand, but also other factors, which may influence the study. For instance, a change in general policy might negate the results of a study which could have taken it into account but did not. Future costs too have to be estimated. It is possible that they may not change significantly from present levels, but here too, any foreseeable changes should be taken into account.

3.3. A suitable analytical technique could then be used to determine the detailed structure of the optimal network, and how best to adjust the existing network to form the optimal pattern. If a drastic change is necessary, one must be certain that the benefits of the change justify the investment required to effect it. An acceptable technique of investment appraisal would fit in here. An appraisal of the quantifiable aspects of the change would be easier than evaluating other implications/consequences. For instance, changes in purchasing habits, business contacts or even deeper seated social or political changes.

3.4. If, on the other hand, the exercise demonstrates that no change is necessary in the existing network, that, by chance, the development of the system has produced an optimal network, then what could well have been a tricky problem has been eliminated. Efforts can then be concentrated on other aspects of the business, with the knowledge that there is a sound framework on which to base future growth.

3.5. A specific case is tackled in this project. It is centred in Ceylon, and all data has been obtained from there. All costs are expressed in Ceylon Rupees and cents. The sterling equivalent is £ 1 to Rs. 14.30 cents. It is intended to present this project to the Ceylon Petroleum Corporation as a concrete proposal for reorganising the existing network for the distribution of petroleum products in that country.

THE GENERAL BACKGROUND

4. Basically, we are concerned with the problem of reducing, preferably to an absolute minimum, or else to some point very close to it, the total cost of distributing a commodity from one (or a few) central source to many hundreds or thousands of customers. It is convenient to group them together to form a few hundred centres of demand, on a geographical basis. These centres of demand would be located at varying distances and in different directions from the source/s.

4.1. Take a very simple case - 1 source and 3 centres of demand. Let them be called S_1, C_1, C_2 and C_3 respectively. Let R_1, R_2 and R_3 be the respective requirements at these three centres and let t_1, t_2 and t_3 be the costs of transferring one unit of products from the source to the 3 centres of demand. We now have to minimise the total cost T, where

$$T = R_1t_1 + R_2t_2 + R_3t_3$$

In such a case the only way we can reduce T is by reducing t_1, t_2 and t_3, since the values of R_i cannot be altered. Taking these costs t_i, we find that they are based upon a cost per unit distance and fixed distances d_1, d_2 and d_3. We are now down to the only variable in the system, i.e., cost per unit distance. Life would be extremely easy if cost remains constant with distance, and t_1, t_2 and t_3 vary linearly with distance, thereby costing twice as much to transport one unit of product over 50 miles as over 25 miles. Unfortunately this is not so. Further breakdown of the transport cost per unit per unit distance reveals that while several cost constituents are in fact proportional to distance, others either do not vary at all, or else change in steps which are only roughly related to change in distance. For example, within the limits of accuracy that we are working, fuel cost for a lorry will be proportional to distance; so will cost of tyres. A cost that does not very with distance will be that of loading and unloading its cargo. Costs that vary in steps will include salaries/wages, overtime, shift allowances and meal subsidies.

These factors together result in a transport cost per unit distance which, while increasing with distance, does so at a varying rate of change, i.e., $\frac{dCost}{dd_i}$ varies with d_i.

Fig. 8 shows a linear change in cost; Fig. 9 shows a cost that does not change with distance, while Fig.10 shows a cost which changes in steps. Fig.11 shows the total cost, the sum of the above 3 costs, while Fig.12 shows the relationship between total cost per unit distance and distance.

4.1.1. There are two ways of simulating the relationship depicted in Fig. 11. The first is to assume that the curve is a continuous smooth curve and derive, by the method of least squares, the expression that fits it best. The second is to carry out a process of piecewise linearisation, and to obtain a series of sub-expressions which will produce the same result. This is possible because each segment of the curve is itself a straight line. Fig. 13 shows the smooth curve which was obtained by the least squares method. The approximations are clear.

4.1.2. In view of the closer representation of the relationship by piecewise linearisation, this technique has been selected to make the mathematical model more realistic. There is however, one serious disadvantage in piecewise linearisation. A smooth curve can sometimes be extrapolated if actual data is not available, whereas piecewise treatment cannot cope with extrapolation. One has therefore to ensure that the raw data is comprehensive enough to enable the full range of variability to be covered.

4.1.3. A series of expressions can be built up of the form

$y_1 = m_1 x_1 + c_1$

$y_2 = m_2 x_2 + c_2$, etc., where m_1 and m_2 vary with ranges of x_1 and x_2. The use of these expressions requires the selective choice of m_i, the basis being the value of x. This sort of operation is eminently suited for use on electronic computers, e.g., the conditional or logical IF statement in FORTRAN IV can be used.

Fig. 8

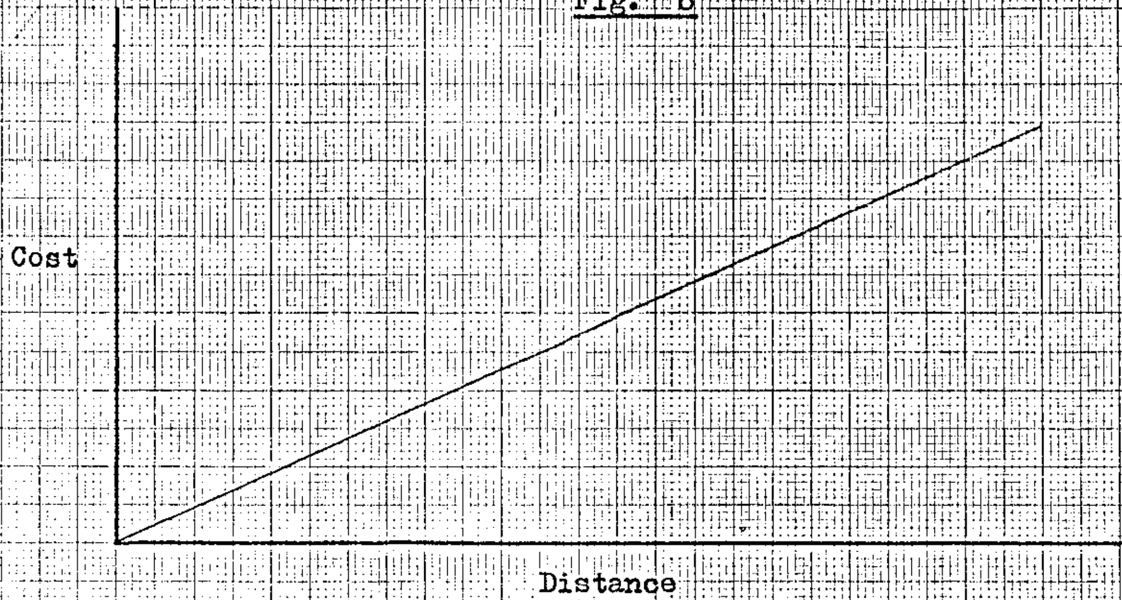


Fig. 9

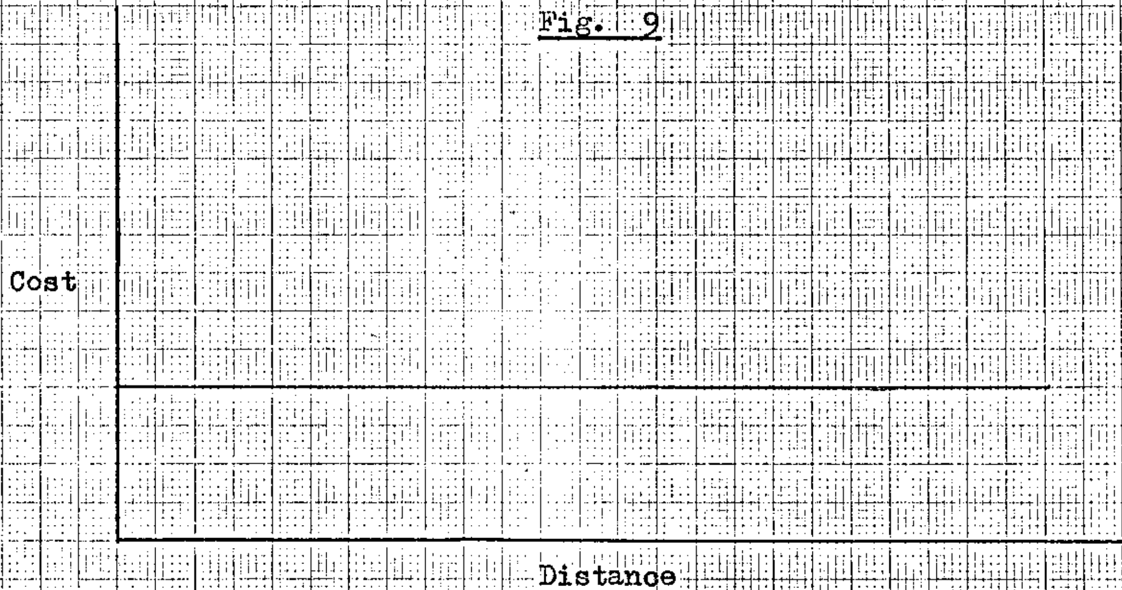


Fig. 10

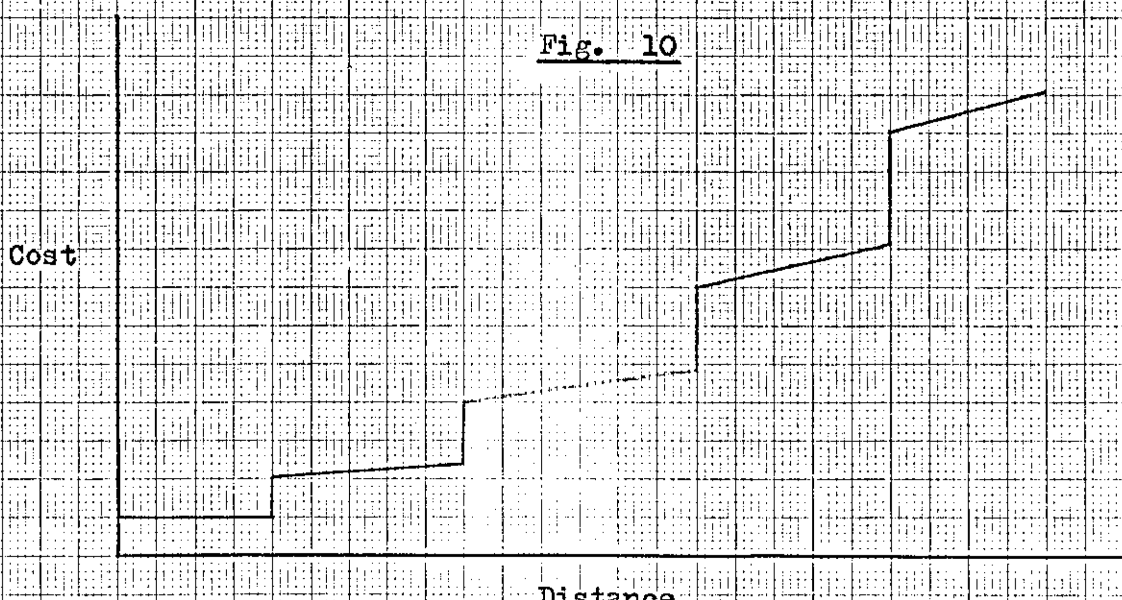


Fig. 11

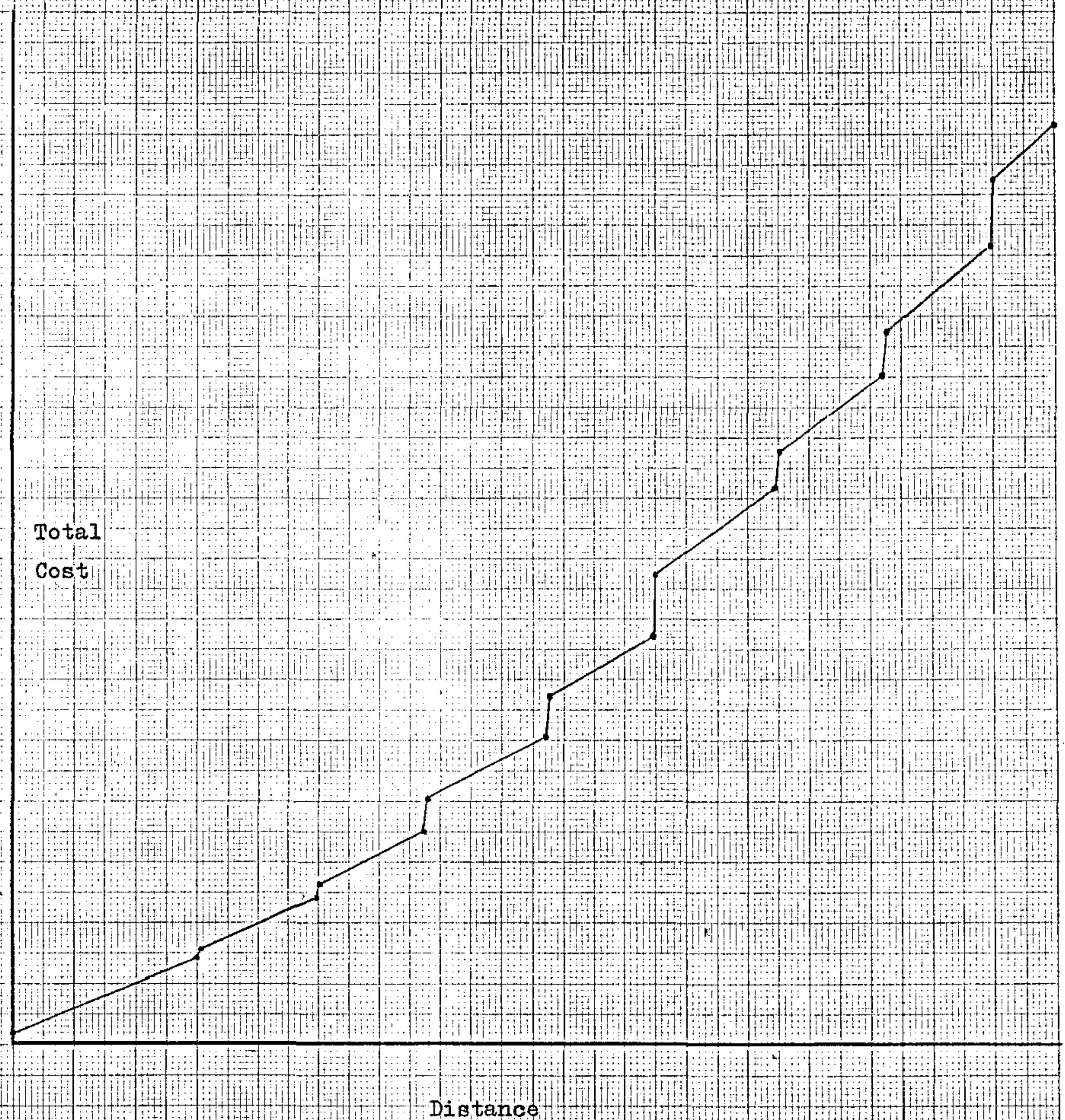


Fig. 12

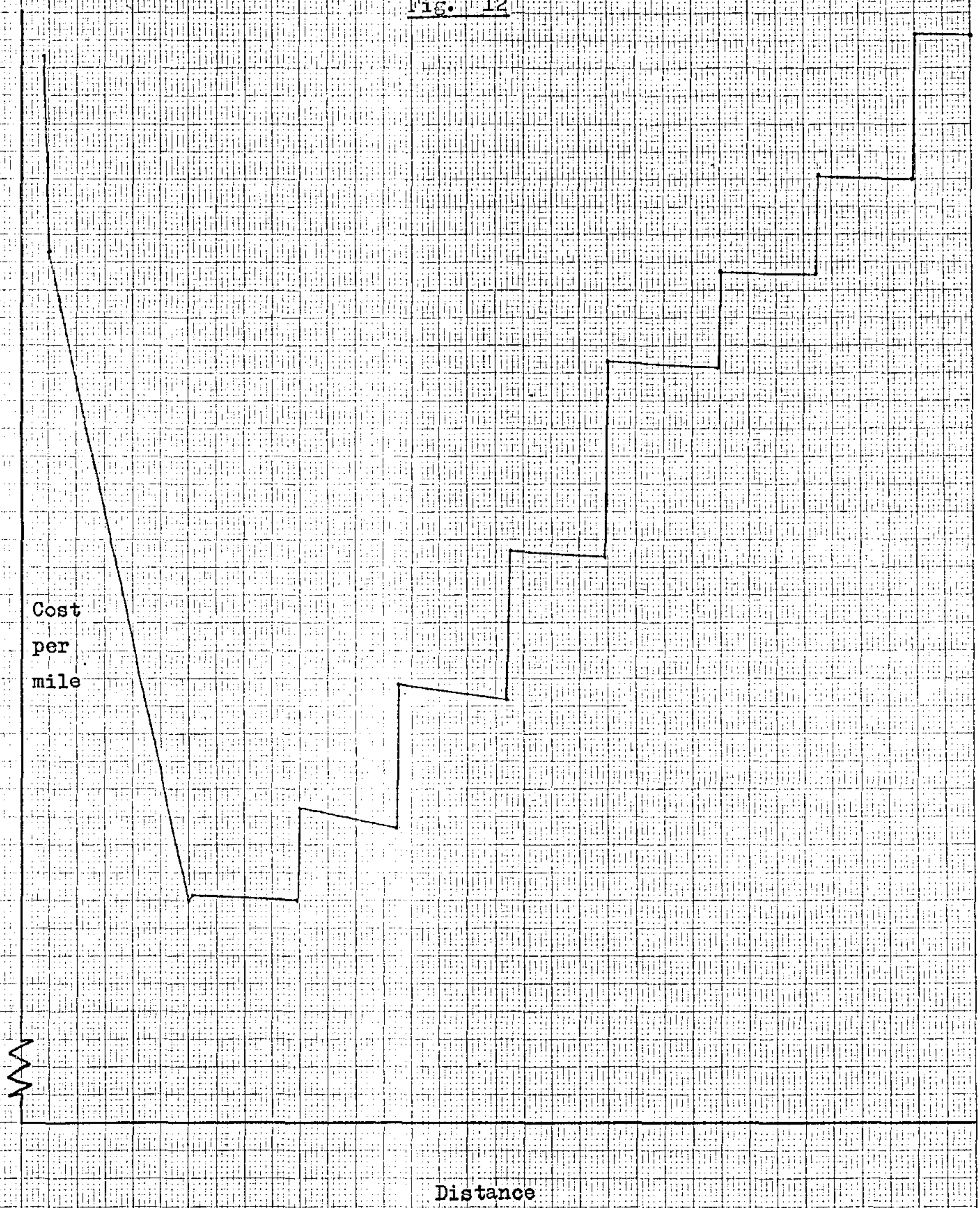
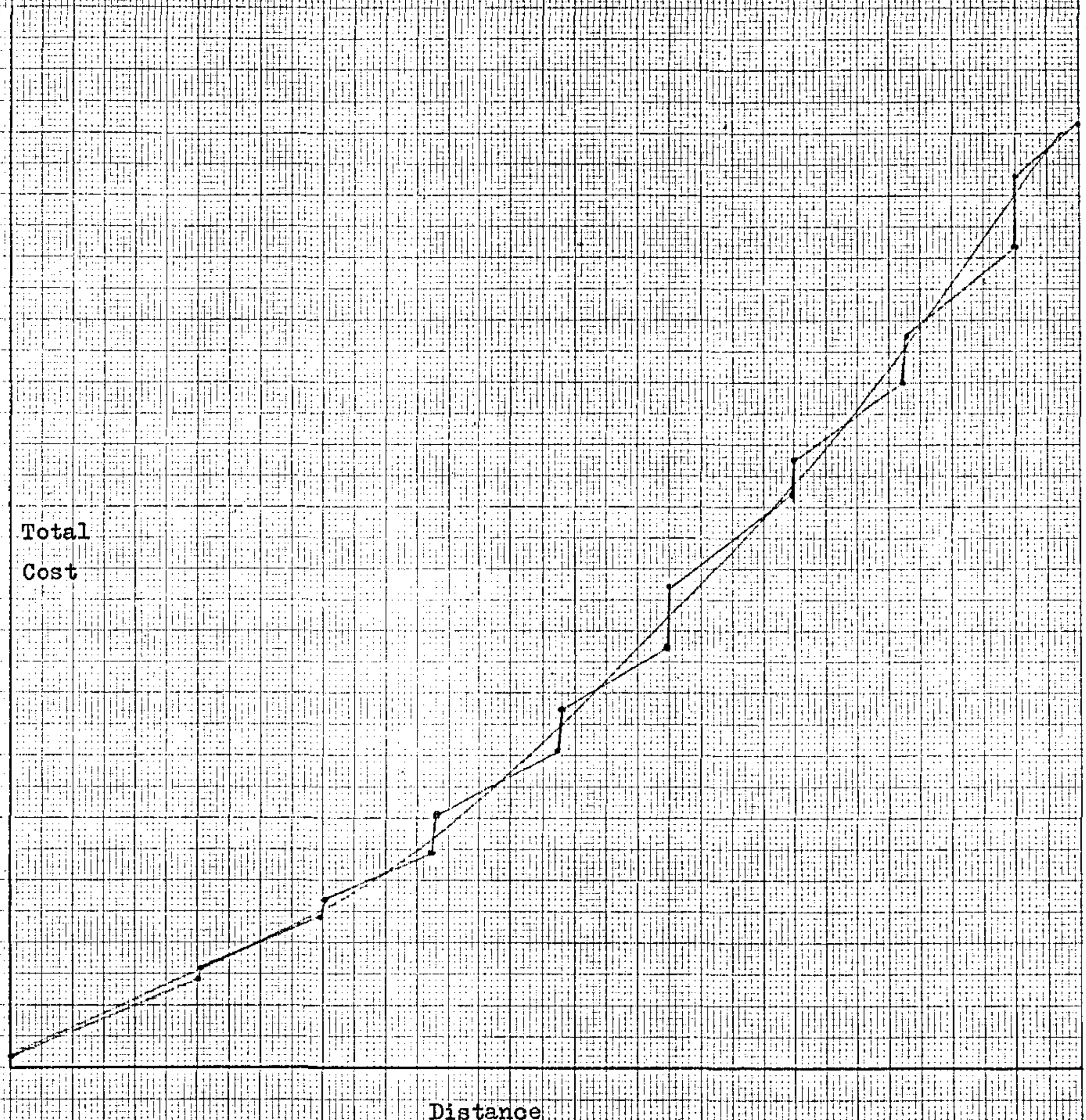


Fig. 13



4.1.4. Fig. 14 gives the logic diagram for the calculation of total costfor our simple case. The sequence of calculations is very simple and straightforward. The value of r_i will determine, for instance, the number of trips that a lorry will have to make to complete delivery.

It is clear that even the simplest case has certain problems. Here it is that of simulating the manner in which unit transport cost changes with distance. This same problem persists throughout the study and I have used the process of piecewise linearisation to tackle it.

4.2. We have already seen that the only variable in the system was the transport cost per unit distance. Among the steps that may be taken to reduce this cost are the following:-

4.2.1. Change the method of transport. We may have reached the point where the throughput warrants a change to a cheaper method of transport, e.g., the movement of feedstock naphthas in rail tank wagons might give way to pipeline transport. The condition is that there is a cheaper and feasible method of transport.

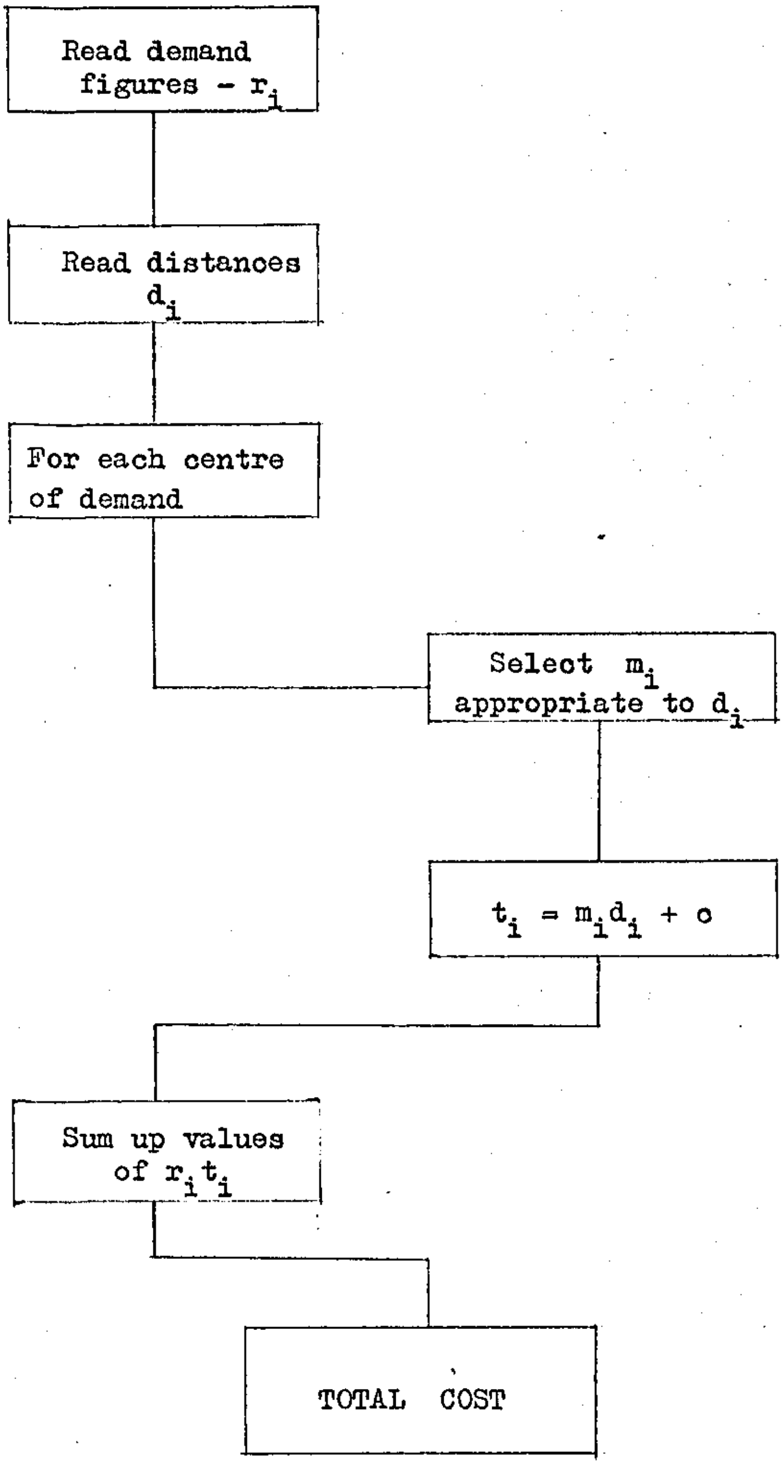
4.2.2. Develop the existing method of transport. The practical limits to vehicle capacity may permit larger vehicles to be used. Costs can then be spread over a larger volume. A new design might result in lower costs, giving the same result.

4.2.3. Reduce loading/unloading costs. The use of specialised equipment may allow reductions in these costs. They normally do not change with distance, but can still affect unit costs significantly.

4.2.4. Reduce multiple deliveries. A vehicle which has to call at several locations to completely discharge its contents builds up costs on two accounts, standing time in discharging, and operating with part load after the first delivery. It may be sometimes possible to persuade customers to take full load deliveries and thereby reduce costs of this type.

4.2.5. Route vehicles properly. If multiple deliveries cannot be avoided, savings can still be effected by planning the routes taken by

Fig. 14


Read demand figures - r_i
Read distances d_i
For each centre of demand
Select m_i appropriate to d_i
$t_i = m_i d_i + c$
Sum up values of $r_i t_i$
TOTAL COST

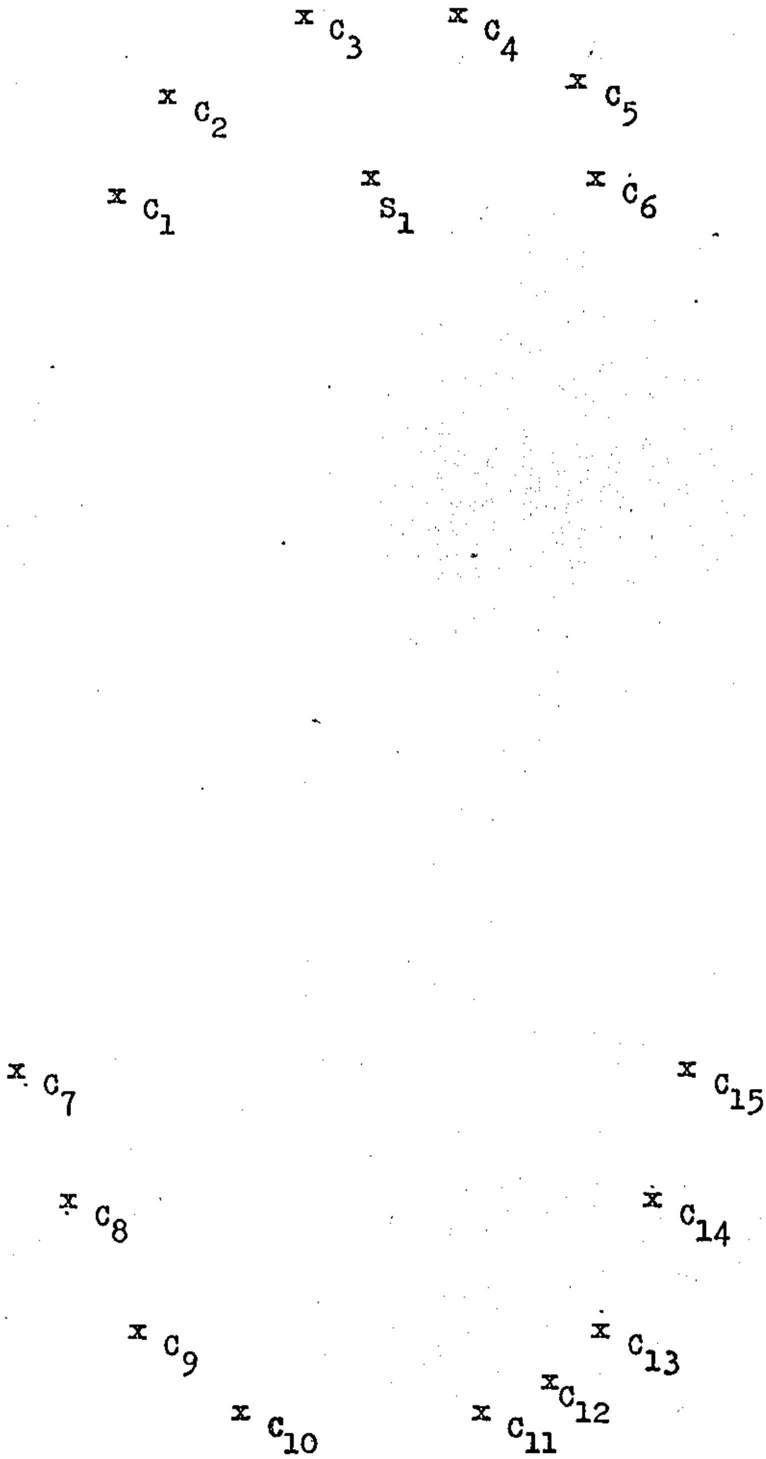
vehicles on their rounds. Most oil companies place great emphasis on vehicle routing, as considerable amounts can be saved by correct routing procedures.

4.2.6. We see from this simple case that one's effort must be directed towards administrative improvements as well as the use of modern equipment to achieve reductions in transport costs. We have used very little equipment, only the loading facilities at the source and the vehicles, but even these can be potential sources of savings.

4.3. Having narrowed down our perspective to the petroleum industry, we progress to a more complicated case. We deal with many more customers, still being served from one main source, but we now have 2 different methods of transportation. In addition to the tank lorry which is used for only small parcels, we have the use of rail tank wagons which can move larger parcels over greater distances. We can then use tank wagons to move product in bulk to a point close to the centres of consumption, break bulk there, and use the more expensive tank lorries to make the smaller deliveries to the customers. Fig 15 depicts the new situation. The significant change is the creation of an intermediate storage point where product is stored after receipt in bulk and prior to despatch in smaller lots.

Reference to Fig.15 shows that customers (or centres of demand) C_1 to C_6 are supplied direct from S_1 because it is the closest source. Customers C_7 to C_{15} are located in such a manner that they could be supplied from the new depot D_1. Large parcels are moved from S_1 to D_1 by rail, at a much lower rate than by road. We realise that the further D_1 is away from S_1, the greater is the saving in transport costs. This is due to two reasons, one being that the unit transport cost by road increases with distance, while the other is that the same cost by rail either stays stable or decreases with distance. Both reasons add to the advantage of using rail tank wagons for the first leg.

Fig. 15


x C_3
x C_4
x C_2
x C_5
x C_1
x S_1
x C_6
x C_7
x C_{15}
x C_8
x C_{14}
x C_9
x C_{13}
x C_{12}
x C_{10}
x C_{11}

It pays us therefore to locate D_1 as close as possible to the customers C_7 to C_{15}, thus increasing the distance over which the cheaper method of transport is used, and reducing the distance over which the more expensive tank lorries are used.

4.3.1. Let us postulate 2 possible sites for the depot, D_1 and D_2. Fig. 16 illustrates the set-up. Let us also say that t_{17}, t_{18}, t_{19}, t_{110}, t_{111},.....t_{115} be the cost of supplying one unit of product from D_1 to C_7 to C_{15}; and that t_{27}, t_{28}, t_{29}, t_{210}, t_{211},......t_{215} are the costs of supplying C_7 to C_{15} from D_2. Let T_1 and T_2 be the cost of moving a unit of product from S_1 to D_1 and D_2 respectively. Finally, let R be the sum of R_7, R_8, ... R_{15}, which are the individual requirements of C_7 to C_{15}.

The costs of the alternatives are

i) Using D_1 $T = RT_1 + R_7t_{17} + R_8t_{18} + \ldots\ldots + R_{15}t_{115}$

ii) Using D_2 $T = RT_2 + R_7t_{27} + R_8t_{28} + \ldots\ldots + R_{15}t_{215}$

We have to choose the lower of the two. The variable factor here is the location of the depot. We have to site D in such a place that a) product is moved in bulk over the largest possible distance from S_1 (have D as far away as possible from S_1), and

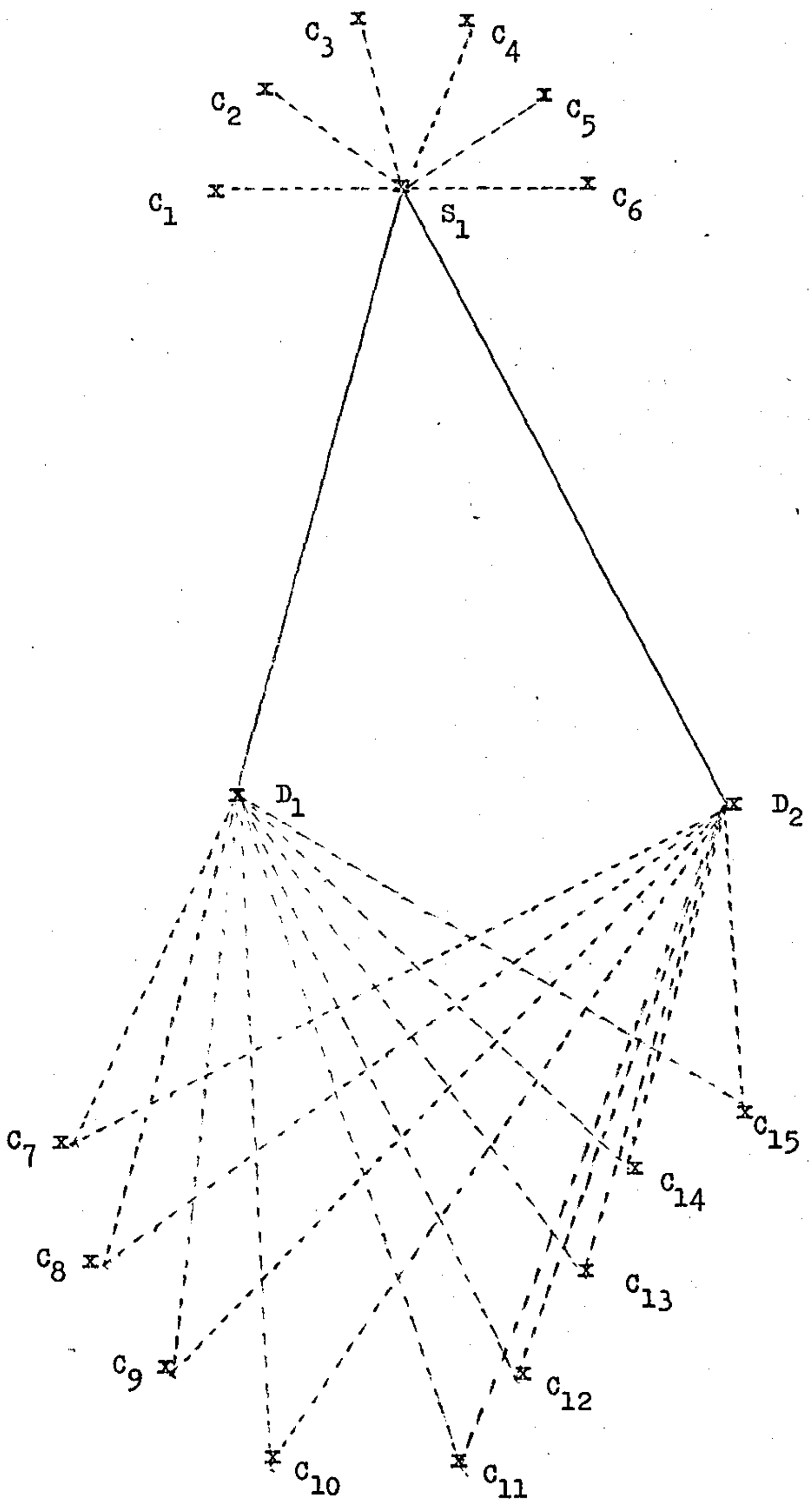
b) product is moved in small lots over the least possible distance from D (have D as close as possible to the location of C_7 to C_{15}.)

4.3.2. We now have a new cost which is not related directly to transportation. This is the cost of establishing and operating the new depot. We have to adjust the location and size of D so that its cost is more than offset by the savings in bulk t ransport. Further benefits that may be difficult to quantify are

a) convenience to customers. Their direct supply point is much closer to them - they can order easily and are assured of a smaller lead time for deliveries. This means that they can operate with lower stock levels and save on inventory costs.

b) improvement in service. This is mainly caused by the proximity

Fig. 16



of the several customers to the depot, and due to the consequent reductions in lead time.

c) removal of routine distribution functions from the central source. This is particularly important in the oil industry. Refining is a continuous process while demand is irregular. Buffer storage is required to balance production and offtake. Part of this storage is provided at the refinery itself, but the other part could be at the depots. We then have only refining operations at one point and distribution operations at the others.

d) strategic reasons. Considerable stocks of products are maintained near the centres of demand to allow for emergencies, such as when long distance communications are interrupted by the weather.

The distribution cost now becomes

$DC + RT + R_7t_7 + R_8t_8 + \ldots\ldots R_{15}t_{15}$, where DC represents the additional cost of the depot (including the cost of holding stocks there) and RT is the cost of bulk transport from the main source to it.

4.4. In the general case, we can have more than one main source S_1, S_2, etc., several hundred centres of demand, $C_1, C_2, \ldots . C_{500}$, and a large number of depots, either existing or proposed, D_1, D_2, etc. In this type of analysis the only difference between an existing depot and a proposed one is that actual costs can be obtained for the former, while estimates have to be made for the latter.

In the theoretical case, one has to assume that each and every centre of demand can be supplied either direct from each source or from each of the depots, both existing and proposed. This increases the number of possible routes to a very large number, and the algorithm employed has to select those routes which together add up to the lowest total cost. e.g., if there are 2 main sources, 100 depots and 750 centres of demand, each such centre will have 102 possible sources, and there will be 76500 feasible routes in the system. The best 102 have to be selected.

4.4.1. Fig. 17 illustrates the network referred to above. It is clear that most of the routes are not desirable, for obvious reasons. e.g., C_1 will be supplied from S_1 rather than from S_2 or D_1 or D_2.

4.4.2. However, the choice of which route is undesirable should be made, not by the operator, but by the algorithm itself. It is only then that the pure logic of the technique can become effective. One must, perforce, set up the problem almost blindly, and let it 'sort itself out'.

4.5. When considering a problem of this sort, what immediately comes to mind is the use of modern Operational Research techniques. The Transportation method (63) or the generalised Linear Programming algorithm (66) would seem to be applicable. There are, however, certain aspects of the problem which are not conducive to the use of these techniques.

4.5.1. Taking the Transportation method first, a typical application is described in the example given below.

"A company has 4 warehouses W_1, W_2, W_3 and W_4. It is required to deliver a product from these warehouses to 3 customers C_1, C_2 and C_3. The warehouse stocks and customer requirements are

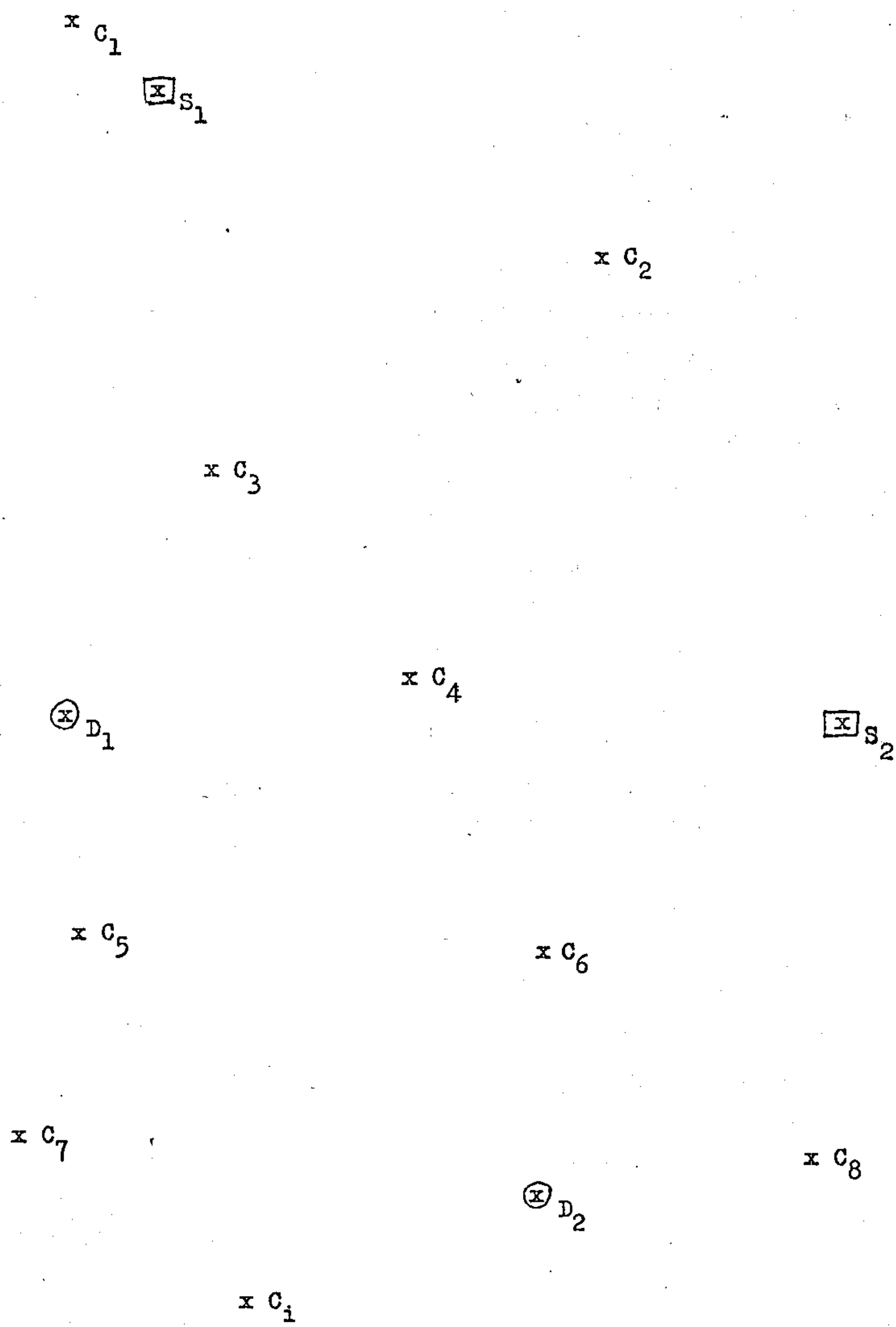
W_1	-	12	C_1	-	17
W_2	-	13	C_2	-	16
W_3	-	11	C_3	-	20
W_4	-	17			53
		53			

The cost of transporting one unit of product from each warehouse to each customer is expressed below.

	W_1	W_2	W_3	W_4
C_1	5	6	9	1
C_2	3	7	4	2
C_3	6	7	2	3

Using the technique described by Makower and Williamson (19) we arrive at two optimal solutions, as shown below.

Fig. 17



	W_1	W_2	W_3	W_4
C_1	-	-	-	17
C_2	12	4	-	-
C_3	-	9	11	-

	W_1	W_2	W_3	W_4
C_1	-	4	-	13
C_2	12	-	-	4
C_3	-	9	11	-

The total cost is 166 in both cases."

The problem and its solutions are quite straightforward. The customers' requirements added up to the total warehouse stock, and every warehouse was emptied in satisfying all customers.

4.5.2. The difficulty has arisen in that each customer has to draw his requirements from two warehouses (except in the first solution, which is degenerate). This is because the individual requirements are as large as some of the warehouse stocks. If the warehouses were all very large and each one could satisfy all the requirements of all the customers, we will come up with the following solution.

	W_1	W_2	W_3	W_4
C_1	-	-	-	17
C_2	-	-	-	16
C_3	-	-	20	-

Total cost is 89.

We have here a better situation where each of the customers draws his requirements from only one warehouse, and only 2 of the 4 warehouses are used at all. This demonstrates an additional use of the transportation technique. It can be set up to produce not only an optimal routing pattern, but also, in certain cases, an optimal warehouse location pattern. This technique could easily have been used for the problem under review if it had produced a complete solution. The difficulty lies in that this method considers only marginal or incremental costs. It pays no attention to fixed costs, and this is very important in a warehouse selection exercise.

4.5.3. The solution does not take into account the possibility that warehouse W_4 which supplies 2 of the 3 customers could have a fixed cost of, say, 50 for the time period under consideration, while warehouse W_1 which is not utilised may have a fixed cost of only 20. The cost figures used in the calculation are the marginal variable costs, those which are directly proportional to throughput. When completing the cost picture by incorporating fixed costs, warehouse W_4 could become infeasible and a further study is necessary to reach an optimal total cost. However, the transportation technique cannot proceed beyond the optimum it has now reached, since any further changes in the basis will only increase transportation cost. But this is what we require, namely, to make a change in the basis, and introduce another warehouse into the basis at the expense of one which has already been selected for the optimal basis. We are moving away from an optimum and thereby completely negating the value of what is otherwise a powerful optimisation technique. The transportation cannot therefore be used to tackle the problem under consideration.

4.6. This same weakness arises in the application of the generalised linear programming approach. The above problem can be expressed as follows:-

Let x_{11} be the amount sent from warehouse W_1 to customer C_1

x_{12} - do - W_2 -do- C_1

⋮

x_{34} - do - W_4 -do- C_3

Minimise $z = 5x_{11} + 6x_{12} + 9x_{13} + x_{14} + 3x_{21} + 7x_{22} + 4x_{23} + 2x_{24} + 6x_{31} + 7x_{32} + 2x_{33} + 3x_{34}$

Subject to $x_{11}, x_{12}, \ldots\ldots\ldots\ldots x_{33}, x_{34} \geqslant 0$

and

$$\left.\begin{aligned} x_{11} + x_{12} + x_{13} + x_{14} &= 17 \\ x_{21} + x_{22} + x_{23} + x_{24} &= 16 \\ x_{31} + x_{32} + x_{33} + x_{44} &= 20 \end{aligned}\right\} \text{Customers' requirements}$$

and

$$\left.\begin{array}{l} x_{11} + x_{21} + x_{31} \leqslant 100 \\ x_{12} + x_{22} + x_{32} \leqslant 100 \\ x_{13} + x_{23} + x_{33} \leqslant 100 \end{array}\right\} \text{Warehouse capacities (large warehouses)}$$

$$x_{14} + x_{24} + x_{34} \leqslant 100$$

Here too we will arrive at the same solution which will select the warehouses to be used and how much they will supply to each customer. The earlier difficulty regarding fixed costs arises and this weakness still cannot be overcome easily. This technique too is deemed unsuitable for our problem.

4.6.1. The problem now resolves itself to one where due weightage has to be given to the fixed costs of each depot, and provision for this has to be incorporated into the algorithm. It cannot be left to be added later as this might defeat the purpose of the above techniques. Even if provision is made for the incorporation of fixed costs in a specialised linear programming algorithm,(42) the problem becomes immense. e.g., the number of variables required for the problem set out in section 4.5.1. would be over 76,500, and the number of equations would exceed 850. Feldman, Lehrer and Ray(45) state in a footnote that "theoretically any warehouse location problem with piecewise linear warehousing cost curves can be given a fixed cost formulation. A warehouse can be associated with each linear segment, the fixed cost being determined by extending the segment until it intersects the cost axis. The difficulty with this approach is computational. If each warehouse has a cost curve describable by five linear segments, then there would be five times as many warehouses in the fixed cost formulation".

4.6.2. Due to the above reasons, problems of this nature have been tackled by other methods, involving the use of Analogue techniques and by Heuristic methods.

ANALOGUE TECHNIQUES

4.7. Mechanical models have been used a great deal in the location of single plants and warehouses. Reference has already been made (35) to the location of manufacturing plant. An early effort on the location of a central garage is that of Keefer.[20] He suggested a method for locating a central garage at which overhauls and major repairs could be carried out on a fleet of trucks. These trucks were leased daily to a number of customers on long term mileage contracts which required their availability at several locations each morning and their return to the base garage each evening. The advantages of a central garage were reduction of idle mileage to a minimum and the consolidation of personnel.

4.7.1. The spatial location of the several sub-garages (which the company was seeking to replace with one central garage) and the customers was marked with pin-holes on a sheet of corrugated board with the aid of a superimposed map of the area. The number of vehicles required was noted against customer location. Small weights (bb shot) were pressed into the board at each of the points representing customer locations, the number used being in proportional to the number required. The centre of gravity of the whole system was determined by balancing the shot-laden board on the end of a pencil.

The theory behind this method of solution was the "resultant of forces" from which follows that any series of weights on the same plane could be reduced to a single equivalent force and balanced by a counter-force applied to the centre of gravity of the system. Consideration was given in this study to the effect of distance, direction and magnitude of each centre of demand. A correction was also made for the weight and centre of gravity of the corrugated board itself since only the effect of the pattern of BB shot was required.

4.7.2. This method assumes that there is a linear relationship between transport cost and distance. It also pays no account to actual distance since the use of the map will only consider straight line or "crow-fly" distances. It was also used to locate a single source, rather than several depots, which is the purpose of this exercise. It was also assumed that the cost of the garage itself could be ignored.

4.8. Bruce (21) has also described the centre of gravity method as commonly used to locate a single distribution point. He proceeds further to demonstrate certain inaccuracies of the method. The theory is basic. Fig. 18 depicts a simple situation. 4 points A, B, C and D each have a demand of 100 units. Their location is plotted on a graph with the following co-ordinates, A(5,5), B(10,5), C(5,10), and D(10,10). The determination of the x - co-ordinate of the centre of gravity requires the following steps:-

a) Multiply the x - co-ordinate of each point by the demand at that point,

b) sum the products so obtained, and

c) divide the sum by the total demand

$$\text{i.e.,} \quad \frac{D_i x_i}{D_i}$$

$$\therefore \text{ the x - co-ordinate} = \frac{5.100 + 5.100 + 10.100 + 10.100}{100 + 100 + 100 + 100}$$

$$= \frac{3000}{400} = 7.5$$

Similarly the y - co-ordinate of the centre of gravity will be 7.5 .

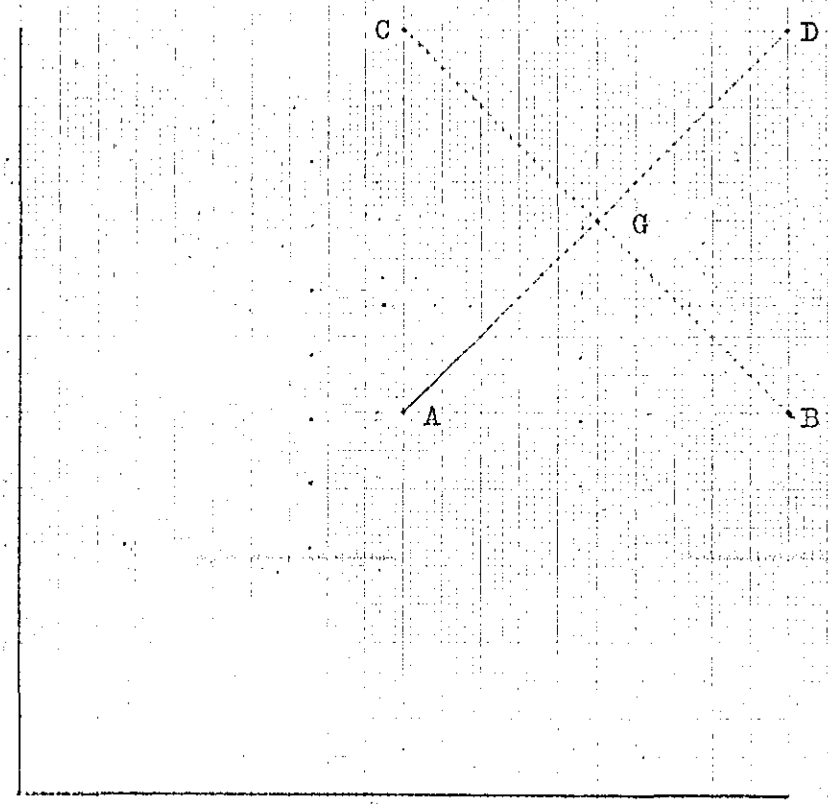
The centre of gravity F has co-ordinates (7.5,7.5) and is at the centre of the square formed by the four points. This is obviously correct.

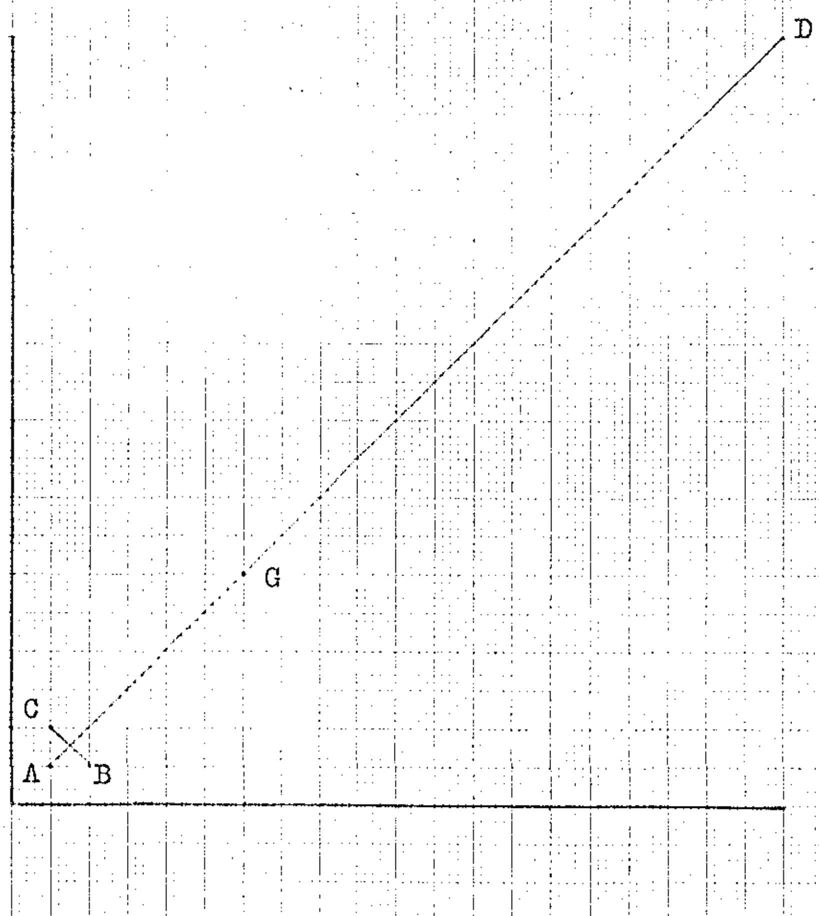
4.8.1. However this method does not hold good for all cases. If point D was moved from (10,10) to (100,100), and A,B and C were left unchanged, the position of the centre of gravity moves to a point closer to D. Its co-ordinates turn out to be,

$$x = y = \frac{5.100 + 5.100 + 10.100 + 100.100}{100 + 100 + 100 + 100} = \frac{12000}{400} = 30$$

G therefore moves to the point (30,30).

Fig. 18





Is this the best location to supply A, B, C and D from, so that the cost of doing so, a function of the total distance travelled, is minimised?

Using Pythagoras' theorem, the distance travelled works out to

$$\sqrt{25^2 + 25^2} + 2\left\{\sqrt{25^2 + 20^2}\right\} + \sqrt{70^2 + 70^2} = 198.4$$

4.8.2. Bruce asserts that the minimum distance will be travelled only when the 'depot' is situated at the point of intersection of the two straight lines which connect the two pairs of points (selecting them so that the two lines cross).

When D was at (10,10), the point of intersection is shown in Fig. 18. It is (7.5,7.5), the same point as the original centre of gravity. When D was moved to (100,100), the point of intersection remains at (7.5,7.5), while the centre of gravity moved to (30,30). If we located the depot at (7.5,7.5), the distance travelled turns out to be

$$3\left\{\sqrt{2.5^2 + 2.5^2}\right\} + \sqrt{92.5^2 + 92.5^2} = 141.5$$

which is seen to be much less than the 198.4 resulting from the use of the centre of gravity.

The proof is simple. It is based on the theorem that the sum of two sides of a triangle is greater than the third side.

4.8.3. The technique recommended by Bruce for the location of a single depot uses the principle set out above. He plots the centres of demand on a graph and then manipulates the position of two straight lines at right angles to each other so that the demands on each side of either line are approximately equal. The ideal centre is then the point of intersection of the two lines. The method is described fully in reference (21).

The resultant location is not necessarily the best nor is it unique. It helps however in narrowing the choice of locations. Its advantages lie in that there are no lengthy calculations involving distances.

4.9. Burstall, Leaver and Sussams[22] have used a technique based on Losch's[35] mechanical model. Their problem was to locate a "best partner" factory for a factory of known location. They mounted a map on a board and drilled holes through points representing sources of raw materials and centres of demand. A thread was passed through each hole and the ends above the table were joined in a knot. To each of the other ends was attached a weight proportional to the demand at that centre. For raw materials a different scale of weights was used to differentiate between the freight rate for raw materials and finished goods.

The knot was shaken slightly to overcome friction and it moved to the place where transport costs were least. It was demonstrated that frictional forces did not invalidate results.

The machine was found to be accurate enough for practical purposes but had the following limitations:-

i) a linear relationship was implied between distances and transport costs.

ii) actual distances could not be represented.

iii) natural hazards or delays were ignored.

However, it was cheap to operate and gave results quite quickly. The results obtained from the use of this machine were incorporated in a computer program designed to calculate costs, etc., for a series of alternative combinations.

4.10. The methods described above deal with the problem of locating one supply point within a market area in order to minimise transportation cost. They are simple to operate and have produced reasonable results. However, the real life problems are much more complicated. A big difference is made when the problem requires the location of several supply points again to minimise total transportation cost.

4.11. Brink and de Cani[23] have described an analogue solution to the problem of locating several supply points. The analogue computer that was used was designed and built by Bernard, and evolved from a crude prototype discussed in a report on an U. S. Air Force contract. (24) This computer utilises electrical potentials on points in a plane. The plane is moved so that iso-cost curves are traceable through the measurement of electrical current.

4.11.1. Brink and de Cani make several assumptions before attempting a solution. They are -

1) Costs, both in time and in shipping costs, can be measured and computed.

2) In the field of actual cost, only shipping cost is considered. Other costs are ignored.

3) The number of distribution centres is less than the number of customer locations.

4) Shipping cost is directly proportional to the number of units shipped.

They precede their analogue solution by setting out the problem in mathematical terms. They use a matrix approach and minimise the total cost function by differentiation. The details of the calculation are set out in their article (23).

4.11.2. The procedure commences by arbitrarily locating distribution points which could be judiciously chosen according to the pattern of customer demand. The location can then be altered during the computation in order to achieve a minimum transportation cost. When iterations produce no reduction in cost, an optimum has been achieved. It is stated that the optimum achieved in this way is not necessarily unique.

The article under reference also gives details of the analogue computer and the principles on which it operates. It also describes how a two centre case can be tackled, and uses an example involving the location of a bar to serve the members of the faculty of the University of Pennsylvania, to demonstrate both the technique and the results obtained.

4.11.3. The weaknesses of this technique lie in that it does not take into consideration certain very important factors in distribution analysis. The first is that this method ignores all costs other than actual shipping costs. For instance, the fixed cost of the distribution centre/s, and the cost of supplying the distribution centre are both ignored. This is evident from the statement that is made in the text, namely, " transport costs could be reduced to zero by putting a distribution centre at each customer location." It is clear that there is a serious weakness in the technique if it cannot consider rejection of such a possibility immediately,merely because the advantages of zero transport cost would be more than offset by the fixed cost of the distribution centres and the fragmented cost of supplying each of these centres.

4.11.4. Secondly it is implied that unit transport cost is linear with distance. This point has been mentioned earlier and its importance emphasised. In the discussion on this and other allied papers that non-linear effects and special limitations could be allowed for, at least approximately, by appropriate adjustments of the mechanical analogue machines. In his summary Dantzig stated that while analogue machines were useful for the solution of special types of linear programming problems, digital computers would be required for the general types, in order to ensure speed and accuracy.

HEURISTIC METHODS

(28)

4.12. Baumol and Wolfe demonstrate the application of the transportation method in warehouse location, but state that important non-linearities may preclude the success of this method. However, they suggest a method which would produce a local "optimum" and a solution that probably cannot be improved except by prohibitively expensive computing for a large scale problem. This method uses the Transportation technique and preselected warehouse sites.

They describe the problems that could arise due to non-linearities and the concavity of the cost relationship, and show their iterative procedure seeks to overcome them.

4.12.1. While agreeing that this is a distinct advance, it must be noted that they have still not paid any attention to the fixed costs of the warehouse/s. The transportation method operates on marginal costs, and when one has determined the transportation cost in the final iteration, one has to add thereto the fixed costs of the warehouses. This could produce a result that may not necessarily be an overall optimum, and the technique used does not help in determining what has to be done in order to reach a "best" solution. In addition they tackle the case where there is either only one product or a composite product. No indication is made of how a multiple product problem can be handled.

4.13. Maranzana[25] tackles the problem of location of supply points by incorporating in his analysis the use of Bellman's algorithm[26] (which finds the shortest path between any two points of a network) and a routine for the determination of the "centre of gravity of a set of weighted nodes". His technique involves the arbitrary selection of a certain number - m - of sources (or depots) and the division of the network into groups of destinations which will be supplied by these sources. This is done by allocating each destination to its "nearest" source. Next, the centre of gravity of each set of destinations is determined and the original sources are replaced by these points. This process is repeated until the sources do not change, i.e.,when the source is also the centre of gravity of each set of destinations. This process of allocation and re-allocation in conjunction with the source for the "nearest" source is claimed to reduce path length to a minimum. It is implied that cost is a function of path length.

4.13.1. This same series of steps is repeated for different values of m, i.e., a different number of depots is selected for each trial, and one can finally determine that number of depots which brings about the minimisation of path length.

It appears that the final solution obtained by Maranzana's technique is not guaranteed to be optimal. He states, however, that with a computer it is feasible to carry out this exercise on a number of different initial selections so that one may be assured of arriving at a good solution, even though it may not be optimal. He demonstrates non-optimal convergence with a small scale problem involving 9 destinations and 2 depots. The initial selection of 2 depots affects the final solution. He also shows how a non-unique centre of gravity can produce final solutions which are significantly different from each other. Maranzana has displayed the results of a 3-source problem in Italy involving anetwork of 40 cities.

4.13.2. A criticism of this method is that it depends upon the selection of the centre of gravity to minimise total distance involved. This point was dealt with earlier (section 4.8.2.), when it was shown that, in certain cases, the centre of gravity was not the best location for a distribution centre. No attention has been paid to the fixed costs of the depots, or of the cost of supplying the depots in the first instance. A further criticism is the strong dependence of this method upon repeated trials with different numbers of depots, to determine the "best" solution.

4.14. Cooper (27) adopts a purely mathematical approach in tackling the problem. He deals with certain restricted problems that may arise in industry, where certain locations are fixed by external considerations, and where costs are either indeterminable or are subject to wide fluctuations. He assumes that there are no restrictions on source capacity and that unit shipping costs are independent of throughput. His paper examines the problem of simultaneous source determination; indicates the magnitude of the computational problems involved and suggests general approaches that may be used in practice.

4.14.1. He postulates that for m sources the capital, depreciation and operating costs, C, would be a function of m - ($C = g_1(m)$ ....(1)), and that the minimum cost of supply from these m sources, D, would be another function of M - ($D = g_2(m)$...........(2)), when the m sources are optimally located. The total cost E would be given by

$$E = C + D = g_1(m) + g_2(m) \qquad \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

The minimum cost solution is obtained when

$\frac{dE}{dm} = dg_1(m)/dm + dg_2(m)/dm = 0$, and solving for m gives the number of sources for the final solution.

He states that relationship (1) can be obtained by fitting existing data into an empirical equation. The problem lies in the determination of relationship (2).

4.14.2. He then proceeds to do so. He first describes a rather lengthy method involving differentiation of several cost expressions and the subsequent solution of several equations to determine the Cartesian co-ordinates of the m sources. He states that the amount of computation involved could be very considerable and even very prohibitive.

He then describes a modified iterative procedure whereby the amount of computation is reduced. He has used an IBM 704 computer to produce "excellent results".

He demonstrates his technique with several examples which confirm that here too there is no guarantee of optimality. He suggests that once a solution has been obtained, the optimum could be reached by solving the extremal equations.

4.14.3. This method too leans heavily upon the use of co-ordinates for he location of the sources and the subsequent calculation of transport costs. Actual distances are not used. In fact, Cooper mentions Euclidean distances, which involve 2 assumptions. The first is that crow fly distance is correct, and the second is that cost is proportional to distance. Both assumptions can introduce serious errors into the results.

A further weakness is that one has to first determine a value for m, the number of sources, and then proceed to reach a minimum, not only varying the locations of the m depots, but also varying the value of m itself.

One feature of this technique is that the sources could finally be located at a point which is not a centre of demand. This may or may not be significant, but it may be desirable to locate a source at at centre of demand.

4.15. Griffiths[(29)] has used an analytical approach to determine the best location for a depot. He deals with the case where the requirement is for a transit depot which is the second link in a distribution chain. Manufactured goods are moved from the factory to a main distribution centre, and then to a transit depot, before they are finally delivered to consumers.

He concentrates his attention upon costs incurred in the last lap, from the transit depot to customers, and deals with costs associated with i) number of vehicles and drivers

ii) mileages run by the vehicles.

He states that the most important contribution to delivery cost is the number of vehicles required, under the various restrictions of customers' convenience, legal working hours or even arbitrary company rules. He decides to minimise the total vehicle-hours required to make all deliveries.

4.15.1. He uses regression analysis to determine coefficients in an expression of the form $T = aM + bN + cV$, where T is the total vehicle working time, M is the distance covered, N is the number of stops, and V is the volume handled. The coefficients are a - the inverse of average vehicle speed, b - the time associated with a single stop, and c - the time required to unload a single unit.

The values obtained after an analysis of an area in the

Home Counties are

average vehicle speed - 16 m.p.h.

Time per drop - 4.2 minutes

Unloading time per unit - 0.2 minutes

4.15.2. He then looks further at the term aM, and formulates a technique adapted to determine a value which would be a route-independent measure of mileage which would be a function only of the relative locations of demands and depot and not upon the routing pattern adopted.

4.15.3. He postulates that a reasonable function of the total mileage run on a delivery round would be the sum of the straight line distances of each town from the depot. This is in contrast to the use of inter-town distances to represent mileage per round, since inter-town distances are dependent upon the route taken.

The expression given earlier now becomes

$T = a_1 \sum_{i=1}^{j} D_i + b_1 N + c_1 V$, where j is the number of towns on the round and D_i is the straight line distance of each town from the depot.

The values of a_1, b_1 and c_1 vary from those obtained earlier.

a_1 = 0.84 mins. per straight-line mile

b_1 = 4.6 minutes per drop

c_1 = 0.2 minutes per unit

4.15.4. This technique was used to determine the location of one depot. It seems to be unable to cope with the location of several depots simultaneously. It also makes certain assumptions regarding costs and distances which may not be entirely justified. Finally, this method approaches the problem from the angle of vehicle hours only. It does not consider depot operating costs, capital costs, which may upset the results obtained. It also concentrates on the situation where a vehicle makes several drops on the same trip. This situation is one which oil comapnies wish to draw away from, and it is felt that too much prominence should not be given to it.

4.16. Webb[39] looks further into Griffiths'[29] straight line distance method. The main objective of his work was to compare the results of locating depots at points of minimal moment sum (the sum of delivery quantities multiplied by the distance of the corresponding delivery from the depot) with locating depots at the point of minimal planned distance with regard to organisations requiring multiple-delivery journeys from their vehicles. He gives some of the facts governing transport costs as -

a) Vehicle costs/ton capacity per mile decrease rapidly as the vehicle capacity and distance increase.

b) The cost of fuel and tyres, i.e. direct costs of distance actually travelled is a small proportion of total costs.

c) The major component of the cost of operating a vehicle is the fixed cost.

He assumes that the route-mileage of distances is a better measure of variable cost than the moment sums.

He describes the data and methodology that he has used and claims a high correlation between moment sums and planned distance, with certain reservations.

4.16.1. In his final paragraphs he comments on certain shortcomings of his method. An important one is that the data would be too meagre to draw any general conclusions on the method. He concludes by stating that the methods of calculation (of depot location) based on cost functions which use the data of each order separately or accumulatively, as does the moment sum, tend to be misleading.

4.17. Lawrence and Pengilly[40] have used an iterative heuristic technique which sets out depot locations after considering the effect of delayed delivery time due to congestion, the presence of natural hazards and the possibility of infeasible depot locations.

The costs that were to be minimised were:-

a) the cost of moving the product to the areas of demand from the depots.

b) the operating costs of the depots.

c) the rental costs of the depots.

d) the cost of moving the product from the factories to the depots (trunking costs). Congestion was dealt with by increasing the actual distance. A similar device dealt with infeasible depot sites.

4.17.1. The technique centred around the calculation of total costs for each iteration. An approximation was used in calculating the operating cost of each depot, but this was found to be only a small error which was ultimately wiped out at the final iteration.

4.17.2. The data required for the program is extensive and the optimisation has been carried out on an IBM 1130 computer. The results are not guaranteed to be optimal, and the starting solution biases the final answer. It is claimed, however, that repeated runs using widely different starting points should throw up an answer that would not be too far from the absolute optimum.

This method makes use of several basic assumptions which would affect the final solution. They are:-

1) the demand is assumed to be divisible into several grids (in this case squares with sides 6.215 miles long)

2) the distance covered within each grid is the same.

3) a general factor μ converts "crow fly" miles into road miles. This factor need not be correct for all grids.

4) it assumes a standard delivery cost per ton mile.

The most important weakness is that the number of depots is determined before commencing the calculation. The process of cost reduction entails the need for several runs on the computer based upon different numbers of depots. There is no self-adjusting feature which makes the choice of the number of depots an integral part of the algorithm employed.

4.17.3. This method is, however, an advance on earlier work because it brings in costs of the depots themselves and it makes provision for delays due to congestion and for infeasible journeys due to natural hazards.

(42)
4.18. Keuhn and Hamburger have also adopted a heuristic approach in their method of locating warehouses. They claim the following advantages for their method -

1) it provides considerable flexibility in the specification (modelling) of the problem.

2) it can handle large scale problems - several hundred potential warehouse sites and several thousand customer location.

3) it is economical of computer time.

They also claim that the results obtained have been better than those obtained by the alternative methods they have considered.

The problem is stated to be - the determination of the spatial distribution of warehouses which will be most profitable by equating the marginal cost of warehouse operation with savings in transportation cost and incremental profits resulting from quick delivery.

4.18.1. Their program has 2 parts - the main program and the Bump-and-Shift routine. The former locates warehouses one at a time until no more can be added without increasing total costs - while the latter attempts to modify solutions obtained earlier by evaluating the effects of dropping warehouses or shifting them from one location to another.

4.18.2. The main program consists of 3 sections, the first of which screens potential warehouse locations to eliminate the necessity of searching over wide areas of clearly infeasible territory. There is the risk that a desirable site may be overlooked in this initial process of elimination, but they can be specifically included as alternatives. The second section finds the warehouse that can bring the greatest savings, while the third further reduces the search for the best warehouse by restricting the choice to only a few - a number set beforehand as an intermediate buffer.

4.18.3. The writers set out their problem in mathematical terms and have demonstrated the technique with 12 sample problems. In 3 of the 12 problems, subsequent investigation showed marginal improvements over the solutions found by this program. The improvements were of the order of only 0.5% and this clearly demonstrates the soundness of this heuristic technique.

4.18.4. As an appendix, Keuhn and Hamburger make a comparative study of the alternative methods of solving the warehouse location problem. They agree that, in theory, a modified linear programming approach could be used, but state that in actual practice the size and the degree of non-linearity preclude the use of the L.P. algorithm. Their comments on the Baumol-Wolfe (28) approach are focussed mainly on the lack of provision for handling fixed costs. They also comment on the Average Cost method used by Balinski and Mills. (43) Here too the linear programming transportation model is used, but costs are described by piecewise linearisation rather than by the concave function used by Baumol and Wolfe. Fixed costs can be incorporated. The simulation approach adopted by Shycon and Maffei (44) is also mentioned. The use of computed air miles is undesirable - and one has to decide beforehand the number of warehouses that is desired.

4.18.5. Of the methods described earlier, the Keuhn-Hamburger method seems to be the most comprehensive. It considers all relevant factors including, of course, fixed costs. It also considers a re-evaluation of the warehouses selected in order to drop certain warehouses which are no longer profitable. i.e. the savings that they could effect by supplying certain demand areas have been wiped out because, those demand areas have been re-allocated to other warehouses. (this is carried out in the Bump-and-Shift Routine)

In the course of the calculation, any warehouse whose addition does not reduce total distribution costs is eliminated from further analysis in the main program. This step is claimed to reduce the number of warehouses that will be considered in subsequent iterations by as much as 90%

4.18.6. Keuhn and Hamburger have not described how the first selection of warehouses is made. It appears that their technique is applicable only to the re-evaluation of an existing network of warehouses. Even so, step 2 in the flow diagram incorporated in their article, which reads " Determine and place in the buffer the N potential warehouse sites which, considering only their local demand would produce the greatest cost savings if supplied by local warehouses rather than by the warehouses currently servicing them" is not clear. It seems that a study is made of the areas supplied by each existing warehouse - in which case the number of iterations seems to be limited beforehand. This doubt is not erased by the restriction placed on the algorithm by fixing at N the number of warehouses that will be considered in each iteration. This point emerges in one of the sample problem where a desirable warehouse site has not been considered merely because it was not included in the N locations set in the buffer. The effect of making N = M, i.e., place all potential warehouse sites in the buffer so that they could all be considered in each iteration has not been mentioned - however, it is stated that computing time increases approximately linearly with the size of the buffer. Therefore, a balance has to be struck between the expense of computer time and the risk that a desirable location is not considered due to restriction in the size of the buffer.

4.18.7. The Bump-and-Shift routine is exercised only at the end of the main program. This means that all potential warehouse sites are evaluated and there emerges a final basis which consits only of those sites which could offer savings over the existing network (or is it supposed to be the theoretical network determined up to that stage by the algorithm?). No attention is paid to the fact that savings could be duplicated i.e., more than one potential site will get credit for savings affected by the supply of products to the <u>same demand area</u>. It is only in the Bump section of the Bump-and-Shift routine that this is checked. If this check could be done concurrent with or immediately after each iteration in the main program, there would be advantages in dropping unprofitable depots early rather than keeping them in the basis until the final checks are made. This angle is given prominence in the method of analysis that is proposed by this work.

4.18.8. The writers mention that multiple product systems could be handled by their routine - but do not describe how this is done. The sample problems deal with only one product and it is stated that the shift routine described in the article cannot be applied directly to multiple product systems. A modification was being planned but its complete effectiveness was not established.

Mention is also made of the possibility of altering the routine of the program to handle a "drop" approach rather than an "add" one - i.e., we assume that all potential warehouses are operating and drop those that are not profitable or cause losses.

The sample programs had the following parameters:-

1) 50 areas of demand.
2) 24 potential warehouse sites (all were at centres of demand)
3) 5 warehouses in the buffer.
4) 3 combinations of factories.
5) 4 levels of warehouse fixed costs.

4.18.9. The time taken for these 12 problems in the main program stage totalled 72 minutes on an IBM - 650 computer with RAMAC disc storage. Each problem required 2 minutes set-up time and 30 seconds per warehouse located. The writers claim that computation time increases at a much slower rate with increase in problem size than is the case with the specialised linear programming algorithms designed to handle fixed cost elements.

4.18.10. The Bump-and-Shift routine required a further one hour on the IBM - 650. However, it is claimed that an efficient computer would have taken only about 10 - 15 minutes to perform this operation - and similar savings would be enjoyed for the main program as well.

4.19. Feldman, Lehrer and Ray (45) have described a computer code which they have developed based upon extensions of the work done by Keuhn and Hamburger (42). They have considered the non convexities caused by the economies of scale associated with the cost of opening and operating extra facilities (warehouses) in a distribution network. They have considered single-product problems involving many factories. They have assumed that the warehousing cost functions for each depot are continuous and concave. This fact and the lack of constraint on warehouse capacity has endowed a useful property, namely, in the final solution no demand centre will receive product from more than one warehouse. A further modification introduced by these workers is the provision for different regional warehousing costs. They have also developed further the "drop" routine suggested by Keuhn and Hamburger. This routine is that warehouses would be dropped from the basis rather than added to it.

4.19.1. The code was tested on a problem with 4 factories, 49 warehouse sites and 200 customer locations in the United States. Transportation cost was assumed to be linear with distance.

4.19.2. The solutions obtained were quite close to the optimal, about 1% less for the drop solution, but about 3% greater for the add solution. Another run using a different cost curve for the warehousing function produced solutions which were within 0.2% of each other, the optimal solution coinciding exactly with the add solution.

These workers have developed the Keuhn-Hamburger approach of heuristic analysis, but have still not made provision for

a) non-linearity of transportation cost

b) continuous checking for profitability of individual warehouses, and

c) complete flexibility in allocation of customers to warehouses.

4.19.3. The last point is clearly illustrated in one of the test cases solved by this technique. A warehouse was placed at Omaha to supply North Platte, Nebraska, even though Omaha itself was supplied from Milwaukee. The reason for this is that Milwaukee was not one of the suppliers nearest to North Platte and was therefore not considered to be a feasible supplier to it. This has been caused by a sub-routine in the code which restricts consideration of supply only to those customers which form the Local Customer Set (LCS) of each warehouse, i.e., closest on a pure transportation cost basis. No justification is claimed for the use of local demand, but it is said to perform as well computationally as any other measures suggested.

4.19.4. The sample problems have been tried on an IBM 7094 computer. The time taken for the problems formulated and solved by Keuhn and Hamburger was under 1 minute each. Subsequent work on a more realistic problem, involving 25 potential warehouse sites and 150 customers, was completed in 2 to 3 minutes. No time estimate has been given for the solution of the larger problem using 4 factories, 49 warehouse sites and 200 customers.

4.20. Reference must be made to an article by Manty (46) which describes the determination of an optimal network of depots for the supply of various petroleum products over an area about half the size of Belgium. The objective was to work out the number of depots, their location, the facilities to be installed and the area covered by each such depot, to minimise total costs, i.e., supply costs (to depots) and distribution costs (depots to customers).

4.20.1. He has set out the total cost function in a simple formula and used an iterative approach to minimise it. His subject takes into account 4 products and presumably one central source. He uses historical data to determine distribution costs which are (i) independent of distance and (ii) proportional to it. He uses the least cost method of transport in calculating these costs. Supply costs were so variable (becuase of geographical discontinuities) that a grid of costs was used in place of a mathematical expression. Depot fixed costs were determined by regression analysis, and demand was estimated for 10, 15 and 25 years ahead.

4.20.2. The search procedure started with the determination of the number of depots to be utilised and to look for optima in each number reckoned. There was no specific method described to select the depots in each trial, and it is assumed that systematic selections were made to take in all possible combinations of depots. A simple cost differential method was used to select the marginal depot that would increase the network from (n) to (n + 1) depots. Iso-cost lines were drawn up after each change in depot location in order to determine depot distribution areas.

4.20.3. When an optimum had been detected (several near optima were found) the necessary adjustments were made to deal with other petroleum products, and to determine the facilities required at each depot.

4.20.4. The whole study seems to have been done manually and has taken about 12 to 13 man months, plus some clerical help.

4.20.5. Manty's approach comes nearest to the method proposed in this summary. He has recognised that practical conditions can sometimes preclude the use of mathematical relationships in setting up a model of industry. He has used an elementary approach and based his specific arguments upon actual costs. He has used a mathematical expression where he feels it will closely resemble the real life situation, e.g., in calculating transport costs from depot to customer, but has used a data grid to determine depot supply cost. In increasing the number of depots in the basis from (n) to (n + 1), he has used the same assumption as Keuhn and Hamburger (42), namely, that the best (n) depots will be contained in the best (n + 1). Wanty has also adapted his study so that the number of depots is a parameter that can be segregated and changed from iteration to iteration in the search for the optimum. Wanty implies that he does reach the optimum. This may be due to the fact that his method seems to consider all possible combinations of depots in each basis. Wanty has not stated the dimensions of his problem, but even though the study took many man months, it seems highly unlikely that he has tried out every possible combination. He has mentioned that the search was in the supply cost grid, but he has also mentioned total cost graphs, which implies that he has carried out the rest of the calculations (depot costs, etc) as well. He states however that the most important single factor was the unit supply cost.

4.20.6. Wanty's method seems to be too long drawn out, particularly if the belief that he tried all possible combinations of depots is correct. It is a moot point whether in doing so, the improvement obtained by the determination of the absolute optimum is significantly different from the near-optima obtained by other methods (especially when a heuristic search too <u>may</u> reach the optimum.)

4.20.7. The belief also shared by Keuhn and Hamburger that the best (n) depots will be contained in the best (n + 1) may not be necessarily correct. It appears to be a weakness of the technique if it cannot cope with a situation that does not behave in this manner. This restriction may be too severe.

4.20.8. Wanty's provision for distribution costs which are both dependent on and independent of distance is a distinct improvement over other methods described earlier, most of which assumed linearity of distribution cost with distance. He does not state how he has made provision for costs which were independent of distance, but the fact that he has used the least cost method transport seems to indicate that he has used a grid in this case as well.

4.21. Smykay[(48)] has recently published an account of an operational simulation program for the solution of the general purpose Physical Distribution problem. It is called the Michigan State University Distribution program. It is claimed to assist in the determination of a wide variety of distribution management decisions including sales forecasting, market planning and plant location.

4.21.1. The MSU system is based upon a rational description of the market, e.g., as being a grid of blocks, the U.S.A. being divided into more than 300,000 blocks, each 3 miles by 4 miles. Each block is assessed on the basis of certain information including sales data by customer and product, and is identified by a 6-digit number. The data also includes information about method, source and cost of supply, and other relevant statistics.

4.21.2. An important feature of the program is a set of decisions made by management about the basis on which the problem is to be approached, e.g., minimum cost, maximum profit, etc. In the case of the warehouse location problem, management has to choose, initially, a set of feasible warehouse sites. The computer simulation program then commences making distribution assignments to achieve lowest total cost. The computer starts with all feasible sites (n) and prints out a list of customers who would be served at lowest cost from point. It then drops every distribution point in sequence, one at atime, and calculates the cost of supply from (n - 1) sites. There will be (n - 1) such calculations. The process is repeated for combinations of (n - 2), (n - 3), etc., sites until all possible combinations are exhausted. Finally, the computer program compares the results of all combinations and selects the lowest cost configuration.

4.21.3. The structure of the program contains provision for making a generalised study of fixed and operating costs, delivery cost,etc.

4.21.4. Smykay's work seems to have formalised the efforts of Wanty (described earlier). He has converted Wanty's approach into a computer program and added several useful features such as the determination of basic cost figures on a dynamic basis.

4.21.5. However, it is still not free of certain weaknesses that have been detected earlier. For instance, Smykay still talks in terms of the market being divided into grids with distances between them being measured by triangulations. He does make provision for converting crow-fly miles into actual road distances - but adopts a common conversion factor for all distances. He also depends upon a mathematical regression for the calculation of transportation costs - which then gives an equation to convert hypothetical costs to actual costs. The most serious weakness seems to be the large number of trials that have to be made before the best solution is obtained. e g., for a problem involving 40 likely warehouse sites the number of trials is $(1+{}^{40}C_{39}+{}^{40}C_{38}+\ldots\ldots+{}^{40}C_{2}+40)$ - an enourmous number indeed. In actual practice it is certain that the total cost hits a minimum long before this number is reached, but one would be unable to determine beforehand exactly how many trials are required.

4.21.6. The value of the MSU program seems to lie in its ability to handle other problems of physical distribution, such as sales forecasting, market planning, etc.

THE NEW PROCEDURE

5. The logic employed in the new procedure is refreshing in its simplicity. The only mathematical techniques used are addition, multiplication, subtraction and division. Only first order relationships have been used, but the introduction of higher orders is easy. The medium which is used to evaluate the performance of the technique is that of cost, which is universally understood and accepted. Certain other techniques use indirect media such as (minimisation of) path length or vehicle utilisation. Their weakness is that the conversion of these units into cost tends to be oversimplified, particularly in connection with the non-linearities described earlier. By expressing everything in terms of cost, the solution of the problem is much simplified, with due regard still being paid to the difficulties which were overlooked earlier.

5.1.1. The sequence of the calculations has been expressed in the form of a computer program, which is in several stages. It first calculates the cost of the present distribution system. Using this as a reference level, it commences a systematic search for improved patterns. Initially the model uses only the central source, with no depots at all, and calculates the cost of supply. Thereafter it introduces depots, one at a time, into the basis. Any gross saving realised by the introduction of a depot into the basis is reduced by the fixed cost of this depot, and if there is a positive nett saving, the depot remains within the basis. The next (see section 5.9.) depot is then tested in the same manner and retained in the basis if it too can show a positive nett saving. Concurrently a check (see section 5.6.) is carried out on each depot already in the basis to ensure that its presence always brings in a positive saving. If, at any stage, a depot shows a negative saving (in other words, a loss) it is immediately dropped from the basis. Such an event can take place when destinations originally assigned to a particular depot are re-allocated to another because the latter can supply them at a lower cost than the former. The total savings shown by the former are reduced by this transfer but its fixed cost does not change very much. (see section 6.2.5. for description of cost build-up). If a sufficient number of demand centres is re-allocated away from a depot, its fixed cost will exceed the savings it can show. When this happens, the depot is dropped from the basis. Its removal sets a special sub-routine (section 5.6.3.) into action to readjust the main program.

5.1.2. A prominent feature of the program is the extensive use of indicators. As would be expected, there are many instances in the flow of logic where subsequent calculations depend upon whether or not certain conditions prevail at that stage. The alternatives have been represented numerically by the use of indicators such as H, MM, MD, etc. The value carried by H, either -2, -1, 0 or 2 determines which course is followed by the flow of calculations. It is felt that the use of these indicators has contributed significantly both to the simplicity of the logic and to the speed of computation.

5.2. The computer program has been written in FORTRAN IV, for use on the ICT 1905 configuration installed at the Computer Centre of the Loughborough University of Technology. (Appendix "A" gives details of the computer). The program consists of a Master segment (length - 3220) called "Distribution Cost Analysis" and 2 library sub-routines UTDL and UTD2 which provide access to off-line magnetic disc storage. The core space requirement of the master segment, semi-compiled sub-routines and raw and intermediate data is 21312 and further storage is required for 2 large data grids of costs and savings. Since the internal core storage of the computer is inadequate to hold the 2 grids, an easy access backing store was required. Magnetic discs were selected because of their rapid random access time.

5.2.1. INPUT The input for the program consists of the parameters which describe the size of the problem, and several blocks of data as follows:-

5.2.2. Parameters of problem and basic cost data.

The number of centres of demand, the likely sites for the depots by number, the number of existing depots, the operating cost of the central source and the basic cost of road vehicles are first fed in. The first three values are dimensions which control the rest of the program.

5.2.3. Transport Cost Data Grid

The next item of input is a grid of transport costs. The dimensions of the grid is determined by the number of centres of demand and the number of likely sources of supply. These parameters have been set out in section 5.2.2. above. Each element in the grid is the cost of supply to a centre of demand either direct from the central source or from the central source via one of the depots. Fig. 19 is a reproduction of a part of the grid. The cost elements have been calculated external to this program. Section 5.3. describes how this was done.

The cost grid is passed on to the magnetic disc storage for easy access.

5.2.4. Centres of Demand and their requirements

The names of the centres of demand which together cover the whole market area, and their total requirements are then fed in. Section 6.3.1. describes how the information for the case study was prepared.

5.2.5. Sources of supply

The names of the central source and the depots comprise the next input. These sources are arranged in a particular order, the central source coming first, followed by the existing depots, and finally the proposed depots, arranged in sequential order away from the central

Fig. 19

REPRESENTATION OF PART OF TRANSPORT COST DATA GRID

Each column represents a source of supply, i.e., Kolonnawa is the first column, Matara (a depot) is the second, Kotagala (a depot) is the third, and so on.

Each row represents a centre of demand, i.e., Adalachchenai is the first, Agalawatte is the second, and Agrapatana is the third, and so on.

Each element represents the total cost of supplying the centre of demand from the source. These costs, together with the fixed costs, account for all the costs of distribution.

0.4594	0.4493	0.3946	0.2137	0.3045
0.0933	0.1472	0.1767	0.2552	0.0968
0.1934	0.0739	0.1361	0.1804	0.3289
0.1750	0.0528	0.0831	0.2529	0.2750
0.0986	0.2096	0.3920	0.3764	0.1021
0.4594	0.4282	0.3764	0.3476	0.2997
0.1582	0.1379	0.1435	0.1679	0.1345
0.1545	0.1635	0.1926	0.1008	0.2087
0.1539	0.2503	0.0968	0.1197	0.1269
0.5140	0.1509	0.2658	0.2367	0.5478
0.1582	0.1361	0.1029	0.1987	0.0985
0.0792	0.1305	0.0986	0.2003	0.1486
0.2693	0.4978	0.1786	0.1999	0.1609
0.0810	0.1638	0.0647	0.1768	0.1279
0.2387	0.5140	0.1983	0.2587	0.5432
0.1675	0.0599	0.2234	0.0987	0.1275
0.1074	0.1190	0.1166	0.1543	0.2196
0.2067	0.1619	0.2378	0.1987	0.2118
0.2348	0.2781	0.3654	0.1998	0.2763
0.0739	0.1398	0.1186	0.2044	0.4041

source. Section 5.9. describes how the order of depots was decided.

5.2.6. Fixed Costs

The next input will be the fixed cost of the central source and the existing depots. (see section 6.3.3.1.). These figures are arranged in the same order as are the depots in section 5.2.5. above.

5.2.7. Variable Operating Costs

The next input consists of the variable operating cost of the central source and the existing depots. These are followed by estimates of the variable costs of the proposed depots. (see section 6.2.7.4. for further details.) These costs too are arranged as in section 5.2.5. above.

5.2.8. Rail freight costs

Rail transport costs comprise the next input. These costs cover haulage from the central source to the existing and proposed depots. Section 6.3.5. gives further details.

5.2.9. Present sources of supply

A series of code figures is then fed in indicating which source presently supplies each centre of demand. These figures are arranged in the same order as are the centres in section 5.2.4. above. This information is required to calculate the cost of the present system of distribution.

5.2.10. Limitations of depot capacity

There is the possibility that some of the existing or proposed depots may have some constraint which sets a maximum to the amount of product that it can handle during a particular time period. If such cases exist, the last item of input makes provision for consideration of this constraint. The maximum is modified to make it compatible with monthly demand and fed in for each such depot. If no constraint exists, a value of 0 (zero) is fed in. Section 5.8. describes the sub-routine which comes into operation to deal with these limitations.

5.3. Section 5.2.3., Transport Cost Data Grid, requires some clarification at this point. As mentioned earlier the elements of the grid are costs of supplying each demand centre from each source. These costs have been obtained after a separate exercise which has taken into account the following components:-

5.3.1. the unit operating cost of the central source. (see section 6.3.3.2.) The centres of demand are fed either direct from the central source or from a depot which is in turn supplied from the central source. Therefore, the central source is common to all routes and is included in the computation of every element in the cost grid.

5.3.2. cost of transporting product (in bulk) from the central source to the depot (see section 6.3.5.7.). Deliveries direct from the central source to the customer will have a zero contribution on this account.

5.3.3. the unit operating cost of each depot (see sections 6.3.3.2. and 6.2.7.4.). Here too direct deliveries will have a zero contribution.

5.3.4. the cost of the final leg of transportation by road. This cost is obtained using the distance from the central source to the demand centre (in the case of direct deliveries), or from the depot to the demand centre (where a depot figures in the distribution chain).(67) The distances used in the case study are actual road mileages and not approximations made by assuming crow-fly journeys.

5.3.4.1. The other factor that is considered is the cost per unit distance of road transport. Reference was made earlier to non-linearities of transport cost. Section 6.3.4.4. describes how this problem was tackled in this study.

5.3.4.2. Transport cost, as expressed by T would then be

T = Operating cost of central source + trunking cost to depot (where applicable) + depot operating cost (where applicable) + road haulage cost from central source/depot to the centre of demand.

Appendix "B" describes the exercise which produced the elements of the transport cost grid.

THE PRELIMINARIES

5.4. Once the input has been fed in, the first stage of the computer program calculates the cost of the present distribution system. This consists of three constituents:-

a) the fixed costs of the central source and the existing depots,

b) the operating costs incurred at these same points, including delivery costs, and

c) the costs incurred when customers pick up their requirements on their own.

The determination of the first element is simple. The calculation of the same costs has been done earlier and have been fed in earlier (see section 5.2.6.). The second constituent is determined after putting together 3 pieces of primary data. They are the quantity delivered, the cost of delivery and the source of supply. All three are items of input, as per sections 5.2.4., 5.2.3., and 5.2.9. above. The cost of collections by customers is determined by putting together the quantities collected (section 5.2.4.), the source of collections (section 5.2.9.) and the costs incurred in making product available at these sources. e.g., collections from the central source involve only its operating cost; while collections drawn from depots incur source operating costs, cost of transport from the source to the depot concerned, and the operating cost of the depot. All this information has been fed in earlier.

These three constituents are added together to give the total cost of the present distribution system. (This total cost is the base figure against which the performance of the optimisation program is judged. Regular comparisons are made between the costs generated by successive iterations and this base cost.) At this stage the program prints out a series of tables which set out the input data and costs of the present system of distribution.

THE MAIN PROGRAM

5.5. The objective of this program is to bring about a re-organisation of the existing distributive network so as to improve on the base cost obtained earlier (section 5.4.). This section of the program sets up procedures for a systematic search for different combinations of depots which together with the central source will reduce overall distribution costs. The study is confined only to direct transport costs and to notional fixed and operating costs. No attention will be paid to the study of each depot. This can be done as a separate exercise after this program has produced its solution.

5.5.1. As the first feasible solution, I have taken what appears to be the obvious first step in such an analysis. I have assumed that there are no depots at all and that all customers will be served direct from the central source. (This compares with the initial feasible basis in the simplex method of solving linear programming problems). The cost grid (described in section 5.3.) has been set up with this approach in mind, and it is a simple calculation which produces the total cost of supplying all destinations from the central source. The elements in the first column of the grid are multiplied by the corresponding demand figures to give the total variable cost. To this add on the fixed cost of the central source and the cost of collections and the total is the hypothetical cost of supplying all centres of demand from the central source.

5.5.1.1. In the majority of cases, this cost willbe higher than the base cost of the present system, and negative values appear as both absolute and percentage improvements over the base cost. It is only a very remote possibility that the initial basis will show any improvement over the base cost. Such an event will take place only in a very small market in which illogical and unnecessary development has taken place. It is inconceivable that the oil industry anywhere in the world could be guilty of such a sin.

5.5.2. The initial feasible solution serves four important functions. They are

5.5.2.1. It eliminates the unlikely possibility that the existing network has been grossly overdeveloped.

5.5.2.2. It sets up a base figure of unit delivery cost (named 'S') to each destination, in this case the per unit cost of supply from the central source. It is this cost that provides a pivot for the introduction of new depots into the basis.

5.5.2.3. It gives initial values to the indicators (named 'LA') which identify the source from which each individual demand centre is supplied. There are as many indicators as there are demand centres. The values of LA are subscripted. All values of LA are set at this stage at 1, since this is the distinctive number of the central source.

5.5.2.4. It also gives a value to the indicator called 'KD', which shows the status of each depot in the program. The initial feasible solution enables KD(1) (the KD value corresponding to source 1) to take the value 1. Section 5.5.6.3. for details of other values of KD(i).

5.5.3. Having passed through the initial phase of the main program the algorithm is now set to increase the basis, i.e., to bring in more depots. Having selected the next depot to take up (see section 5.9.) the procedure is to compare delivery costs from this new depot with the present base cost (generated in section 5.5.2.2. above). The cost grid has been set in such a way as to enable quick comparisons to be made.

5.5.4. Costs are compared for each centre of demand. If the new depot can supply the first centre (i.e., the first row in the grid) at a cost lower than the central source, then there will be a saving in transferring the first centre to the first depot. The potential saving is the difference in transport costs multiplied by the volume required at the first centre. Similar calculations are made for every other centre.

A summation is then made of the total gross savings that are possible by the introduction of the new depot into the basis.

5.5.5. The test of whether the new depot remains in the basis or not is carried out by comparing the total potential savings with its fixed cost. If the savings exceed the fixed cost, there is a nett gain in retaining the depot in the basis. If, on the other hand, the fixed cost exceeds the potential saving, the depot is not kept in the basis, but is retained for reconsideration at a later stage, if necessary.

5.5.6. Let us assume that the first depot did, in fact, show a positive nett saving and was retained in the basis. The program then diverts a little from the main stream of calculations and sets up certain indicators as follows:-

5.5.6.1. The source indicators (LA) take new values where necessary. If the first demand centre is diverted to the new depot while the second centre continues to be supplied from the source, LA(1) takes a value of 2 (which is the distinctive number of the first depot), while LA(2) remains at 1.

5.5.6.2. The base delivery cost figures (S) which were set up earlier are now altered to reflect the change in the delivery pattern. S(1) will now take the value of the cost of delivery to the first centre from the new depot (it will be lower figure than before, because supply is cheaper from the first depot than from the central source), while S(2) remains at its former value, since the central source continues to supply this centre.

5.5.6.3. The value of KD for the first depot - KD(2) also becomes 1.

The indicator KD can take one of several values. They are

5.5.6.3.1. KD(i) = 0. When this is so, the depot has still not been considered for the basis. All depots have this value at the start of the program.

5.5.6.3.2. KD(i) = 1. The depot has now been considered, and having shown a positive nett saving, has been retained in the basis.

5.5.6.3.3. KD(i) = 2. The depot has been in the basis but is to be dropped because the demand centres assigned to it do not have any effective requirements. This provision has been made to cope with a situation where a demand is only expected in the future or is for another product or type of product. In such an event the depot is not retained in the basis because fixed costs will be incurred with only the expectation of future demand, and this would be wasteful at the present time. The inclusion of this depot can be taken up later at the appropriate time.

5.5.6.3.4. KD(i) = 3. The depot has been in the basis but is being dropped because its contribution to savings has changed from positive to negative. So many of the centres originally allocated to this depot have been shifted elsewhere, that the savings position has been inverted.

KD values of 2 or 3 assist in the evaluation of the summary, which takes place at the end of each iteration, and shows the structure of the current network. At the end of the summary, the value is changed from either 2 or 3 to 4.

5.5.6.3.5. KD(i) = 4. The depot has been considered, but is not in the basis. It has either shown a negative value for nett savings in the first place (in which case it would never have entered the basis) or it has been dropped from the basis for some reason or other. Depots with KD values of 4 are always eligible for reconsideration.

5.5.6.3.6. KD(i) = 5. This value can be assigned to a depot if it is to be specifically excluded from consideration at any stage in the program. Originally, the provision was made for completeness, but later work has shown that it can be of positive value to even a routine problem. This aspect is discussed further in section 5.7. which describes the sensitivity analysis procedure.

5.5.7. A print out is also obtained summarising the status quo as follows:-

5.5.7.1. the volume of demand, source of supply, cost per unit and the total distribution cost for each centre of demand.

5.5.7.2. the throughput allocated at this stage of the program to the depot in question.

5.5.7.3. the fixed cost of the depot. If it is an existing depot the fixed cost is known. If it is proposed, the fixed cost is calculated according to the formula described in section 6.2.8.

5.5.7.4. the variable cost of supplying the demand centres allocated to the depot.

5.5.7.5. the gross saving realisable by the introduction of the depot into the basis.

5.5.7.6. the nett saving of the depot, i.e., the gross saving minus the fixed cost.

5.5.7.7. A summary of all the depots (and the central source) in the basis, giving their present throughput, fixed cost and variable cost for each depot.

5.5.7.8. the total fixed cost of the entire network up to this stage, i.e., a summation of the fixed costs listed in section 5.5.7.7.

5.5.7.9. the variable cost of the entire network up to this stage, i.e., the sum of variable costs of all the points listed in section 5.5.7.7. above.

5.5.7.10. the total cost of collections (see section 5.4.)

5.5.7.11. the total overall cost, i.e., the sum of total fixed costs, total variable costs and the costs of collections. This total should be less than the corresponding figure in the previous iteration.

5.5.7.12. the total saving realised by the inclusion of the depot in the basis. It is usually equal to the value described in section 5.5.7.6., but this can change if the iteration caused a depot to drop out of the basis. It can even have a negative value, but this is always corrected subsequently.

5.5.7.13. the improvement (absolute) in cost over the existing system. This is usually negative at first, but will become positive if the algorithm is successful in improving upon the present system.

5.5.7.14. the above improvement expressed as a percentage.

5.5.8. This is the end of the first iteration. The same procedure is followed for the next depot. Its supply cost is compared with the present base delivery cost, which could be for supply from either the central source or from another depot. The same comparison as above is made and if the new depot shows a positive nett saving, it too enters the basis, and the requisite changes are made in the S and LA values. KD(3) also gets its appropriate value and after certain checks (see section 5.6.) are made, the status quo is again summarised. The iterative procedure carries on until all depots have been considered.

5.6. CHECKS

Each iteration contains a check to ensure that every depot in the basis is productive. i.e., it makes a positive contribution towards the savings realised by the improvement program. The check is on whether the nett savings of each depot are negative, zero or positive. If the depot has a negative nett saving, it is contrary to the main stream of the program and must be dropped. If the depot has a zero value for nett savings, its presence in the basis, while not being unprofitable financially, does not make any definite contribution in the desired direction. On the other hand, its presence may load some unquantifiable factors such as planning and supervision time and record-keeping. It may, of course, add to customers' convenience to have this depot in operation. All in all, its presence in the basis may be debatable. The decision as to whether it is permitted to remain in the basis can be made in the light of general circumstances. The computer program requires only very minor alterations. (In the case study, I have decided that such a depot should not remain in the basis and the program has been adjusted accordingly). A positive nett value is desirable and the depot remains in the basis. The program can also be adjusted to handle a minimum value of positive savings, which will ensure that a realistic pass mark is observed. Values of savings smaller than this will be treated as if they were negative.

5.6.1. The nett savings figure is obtained by deducting the fixed cost of each depot from the gross savings realisable by its introduction. Gross savings arise when the depot can supply demand centers at a cost lower then the previous base delivery cost. e.g., let us assume that the central source S supplies demand centres C_1, C_2; and that the first depot D_1 supplies C_3, C_4, C_5, C_6, C_7 and C_8. Let us assume that the gross savings of D_1 were GS_1 and that its nett savings were GS_1-FC_1 (where FC_1 was the fixed cost of D_1). NS_1 would have been positive, otherwise D_1 would not have entered the basis. GS_1 has been built up of the savings contributions on account of C_3, C_4, C_5, C_6, C_7 and C_8.

5.6.2. Let us now consider the introduction of depot D_2 into the basis. A comparison of delivery costs may show that C_3, C_5 and C_7 could be supplied cheaper from D_2 rather than the present supplier D_1. If the total savings on account of these three centres exceeds FC_2 (the fixed cost of D_2), then the second depot enters the basis because NS_2 is positive. At the same time D_1 would lose supply to C_3, C_5 and C_7. (It is also likely that centres may be allocated away from the central source, but its feasibility is never questioned because it <u>has</u> to be present in the basis at all times). This means that GS_1 and therefore NS_1 would be affected. GS_1 would now consist of the savings contributions of only C_4, C_6 and C_8. The fixed cost FC_1 may or may not change. If it is an existing depot, the fixed cost will not change. If it is a proposed depot, the estimate of FC_1 will change according to the formula derived in section 6.2.8. The expression which changes the value of NS_1 is

new NS_1 = old NS_1 - savings contributions from C_3, C_5 and C_7 + whatever adjustment is necessary to the fixed cost, the theoretical value being obtained from the use of the abovementioned formula.

5.6.3. We now look at the new value of NS_1. If it remains positive the depot D_1 is still productive and remains in the basis. The case with zero savings has been discussed earlier (sect. 5.6.). If NS_1 becomes negative, we have an undesirable situation where a depot which came legitimately into the basis, continues to supply certain centres of demand, but does so at a loss. This cannot be allowed - and the depot is dropped forthwith from the basis. (It will, however, be available for reconsideration in future iterations even though its performance has not been successful at this stage. Provision for reconsideration has been incorporated in the program in order to cope with the possibility of subsequent re-shuffling of demand centres that may enable this same depot to become "profitable" again) When this depot is dropped from the basis, some adjustment has to be made regarding those demand centres that it was still "supplying". It would complicate programming immensely if a search were made at this stage to determine the next best source of supply - there is an equal chance that this next best source is either already in the basis, or it has been considered and rejected, or it is still to be considered. In order to cope with all possible eventualities, the device that is adopted is to revert supplies to all their demand centres to the central source. At the same time an indicator (IR) is activated so that, when all iterations in the main program have been completed, i.e., all depots have been considered, the program loops back and takes up <u>all</u> the depots for re-consideration. This loop ensures positively that the demand centre will in fact be assigned to the next best source which will then be kept in the basis, provided, of course, that <u>its</u> nett savings position is favourable. The reversion of supply to the central source may increase the total cost of distribution - since we are taking a retrograde step - but such an event is only temporary. The indicator IR causes the program to loop and the inbuilt provision for cost reduction ensures that ground lost is caught up again.

5.6.4. The check described above has proved its value over several runs of the test problem. A run without this check gave a result where more than 2 depots remained in the basis even though they were unprofitable. This is because they entered the basis initially as profitable depots - but re-allocation of their demand centres reversed the position. In fact, it is only a check like that described above, that will ensure that such reversals are detected and rectified.

5.7. SENSITIVITY ANALYSIS

A sensitivity analysis forms an integral part of the new technique. It has been designed with two primary objectives:-

a) It performs the usual function of demonstrating the effect of making changes in the final basis.

b) It provides a mechanism whereby the operator may be able to bring about further improvements to the final solution obtained by the main program. Since the proposed technique is heuristic, the final solution cannot be guaranteed to be optimal. The sensitivity analysis could point out areas of further search which may bring a non-optimal solution closer to the absolute optimum.

5.7.1. The routine is also iterative. It commences with the final solution obtained by the main program - which displays the number and identity of the depots chosen and the allocation of demand centres to these depots. An assessment is now made of the effect on the final cost of dropping one at a time, the selected depots from the final basis. The effect is also determined of forcing non-selected depots into the basis. The mechanism of these operations is simple. For the first, the relevant depot is specifically excluded from consideration by setting its KD indicator at 5 (see Section 5.5.6.3.). Concurrently, all demand centres allocated to it are reverted for supply from the central source - and the main program routine (described in Section 5.5.) is repeated. The main program does not start from scratch (i.e., with all demand centres being supplied from the central source). It continues from the pattern reached in the final iteration with the only change being in the source of supply of those centres which were allocated to the depot in question. This short cut saves computing time. The main program (repeated) now brings the amended problem to a new final basis - and determine the change between this basis and the former final basis. In the majority of cases, the amended final basis operates at a higher cost. The difference is the extra cost that would be incurred if the basic depot was dropped. If, on the other hand, the amended set-up costs less than the original basis, the sensitivity analysis has produced a bonus. It has detected an opportunity of improving upon the final solution obtained earlier. In such an event the earlier program has not reached the optimum (not unexpected since it is a heuristic program) and a clue is obtained as to how it can be approached. The exclusion of this depot will improve the solution.

5.7.2. If only one such depot is detected by the analysis, no further work is necessary. The amended final basis is displayed as the result. If, however, there are many such depots, a re-run of the program is required (after specifically excluding all these depots) as the analysis can only cope with one depot at a time and the collective effect of dropping several depots is not the sum of their individual depots.

5.7.3. The second alternative consists of forcing non-selected depots into the basis. Each such depot is examined to determine whether there are any centres of demand which could be supplied from it at a cost lower than that from the assigned source of supply. If there are no such centres the effect of forcing this depot into the basis is to incur an extra expenditure equivalent to its fixed cost. If, however, there are centres which could be supplied cheaper from this depot, the total potential saving in so doing is determined. This saving is deducted from the fixed cost of the depot and the balance is the extra cost of forcing this depot into the basis. The fixed cost will always be higher than the potential saving. If it wasn't the depot would have been included in the first instance. The reduction of potential savings from the fixed cost takes into account the effect on fixed costs of other depots of the hypothetical transfer to the new depot of certain centres of demand.

5.7.4. The value of this sensitivity analysis is clear. The effect of making changes, either way, in the basis is expressed in the form of extra cost, and a decision regarding possible changes can be made with a full knowledge of its consequences.

SPECIAL FEATURES

5.8. In addition to the checks and sensitivity analysis described above, the new technique incorporates provision whereby an additional constraint can be considered. The constraint concerns a possibility that certain depots may, for some reason or other, have a maximum throughput set upon them by external factors. (see section 5.2.10.) Lack of space, inadequate transport facilities, or legal restrictions may be some of these factors. A ceiling to throughput is a serious handicap and provision is made in the program to give the best results within this constraint.

5.8.1. The maximum is determined separately and is fed in as an item of input. When the usual test of feasibility of a depot is made - are the nett savings positive? - a check is made to determine whether the throughput so allocated exceeds the maximum throughput (if any). If the maximum has been exceeded, a special sub-routine comes into operation. This sub-routine first arranges demand centres assigned to the depot in decreasing order of magnitude of the savings that they can contribute if supplied from this depot. An allocation is then made which while keeping the throughput within its maximum consists of these centres which contribute the savings to the depot. Having done so, a further check is made on the feasibility of the depot - do the savings realisable by the new selection of centres of demand still exceed the fixed cost of the depot? If so, the depot enters the basis, with a throughput that is within the constraint. If not, the depot does not enter the basis at this stage, since its constrained throughput does not produce adequate savings to justify its entry. However it remains available for reconsideration at a later stage if necessary.

5.8.2. Adequate cross checks have been incorporated in the program to ensure that the maximum throughput is not exceeded, and that every effort is made to operate such depots as close as possible to the throughput ceiling so that savings too can be maximised.

SELECTION OF DEPOTS FOR CONSIDERATION IN BASIS

5.9. The procedure described above envisages the introduction, one by one, of all feasible depots into the basis. The initial basis consists of only the central source. Depots are brought in thereafter. The question arises now about the order in which they are taken up. This question can be best answered by describing how I have tackled the case study.

5.9.1. The case study deals with 1 central source, 13 existing depots, 72 proposed depots and 613 centres of demand. I have arranged the depots (85 in all) in the following sequence after the central source:-

a) the 13 existing depots. The order in which the 13 are arranged is that in which they appear in the records of the Ceylon Petroleum Corporation. I do not believe that there is any significance in their arrangement and I extend this belief to the order in which they are taken up in the program. The main reason for this assumption is that these depots are fairly uniformly scattered throughout the country and are, to a certain extent, independent of each other.

5.9.2. There are three reasons for taking the existing depots first. They are:-

5.9.2.1. I am hoping to reduce the need for altering the existing pattern of depots to a minimum by giving the program every chance to keep them in the basis. When all demand centres are "exposed" to the existing depots first, there is a greater chance that they would remain attached to their present sources. Once these depots are in the basis, they can be eliminated only if a sufficient number of demand centres is withdrawn from them. My method does not ensure that all existing depots will remain in the basis - it merely gives them every opportunity of doing so.

5.9.2.2. By reducing the amount of alterations to the existing pattern, I am hoping to keep down the requirements of fresh capital that will be needed for the construction of new depots. This is in deference to the universal shortage of capital in all parts of the industry.

5.9.2.3. I am depending on the fact that the oil companies would have carried out some sort of analysis of distribution patterns and costs before constructing these depots at their present locations.

5.9.3. It is the method of arranging the balance 72 depots that is important. My first intention was to devise some sort of priority basis for selection. I assumed that the biggest centre of demand would, by virtue of its high volume, show potential for the greatest saving in cost. I therefore arranged all demand centres in decreasing order of volume of throughput. Then, for the biggest volume centre, I found the depot that could show it the greatest saving in transport cost, and considered it first of all for the basis. The next depotto be taken showed the greatest saving for the second highest volume centre, and so forth. It was found however, that there was no guarantee that every depot would be considered. e.g., if a certain depot could not be the cheapest supplier to any centre, it was never considered. In addition there was the fact the depots were considered more than once; since there would be 613 iterations involving only 85 depots. On an average, each depot was taken up about 8 times. This was very wasteful in computing effort. Furthermore this method meant that there were at least 613 iterations, most of them being repeated many times over.

5.9.4. Before rejecting this method, I repeated the run with the centres of demand taken in increasing order of throughput, a reversal of the above order. The result obtained showed considerable variation from that obtained earlier, and confirmed my belief that I was following a wrong approach.

5.9.5. I then changed the system of depot selection to taking each and every depot in the basis. As stated earlier the first few that were considered were the existing ones. The rest of the sites were also located on railway lines radiating away from the central source. Each railway line was taken up separately, and the depots on it were taken up in the order that one would meet them when travelling away from the central source. One would therefore use the same rationale as was used in the main program. The earlier depots started off with high throughputs since they covered the whole "catchment area" of the line, but this throughput was whittled away when depots further down the line were taken up. This meant that all depots but the last one on the line started off big and lost their volume to the depots coming after them. Each depot was therefore given the best opportunity to remain in the basis, and if they did drop out, it was due entirely to the "competitive" position, and not due to bias on my part.

5.9.6. By bringing about this change, I detected several areas of improvement.

5.9.6.1. I made sure that every depot was considered for the basis.

5.9.6.2. I cut down the number of iterations from 613 to 85. (In most examples, the ratio of demand centres to warehouse sites would be of the same order.)

5.9.6.3. There was a logical sequence in which depots were considered.

5.9.6.4. The consideration/rejection of depots was done by the algorithm and was not influenced by any bias on the part of the operator.

5.9.7. I have incorporated this system in the program.

THE COMPUTER PROGRAM

5.10. The computer program, written in FORTRAN IV is listed in the following pages. The statements have been numbered for easy identification. This section is devoted to a quick run-through of the program, with a brief explanation of the flow of logic.

Statements

10 - 45	This is the program description segment. It gives a number to the program (GPO3) and indicates the input and output media.
50	gives the title to the program - Distribution Cost Analysis
55 - 70	sets the dimensions of the subscripted variables used
75 - 85	Data statement describing alternative legends
90 - 100	determines and prints out the Starting time
105	sets the space requirement on the magnetic disc(UTD1)
110 - 125	sets parameters of problem - IC = number of centres of demand; ID = number of depots; JB = number of existing sources. Also feeds in basic cost data - AX and AY are coefficients in the expression E = P x AX + AY, which calculates the fixed cost of proposed depots; CK is the operating cost of the central source; RR is the basic cost per gallon mile of road tank lorries; and IG is a parameter (IG = IC x ID) which influences storage/retrieval of data from the magnetic disc.
130 - 180	reads in (from magnetic tape) the transport cost data grid (D) and transfers it to the magnetic disc; also reads in names of the centres of demand (DN) and their requirements (S, SI, X and TB being Standard Gallons (A), Standard Gallons (B), Kolonnawa Gallons (A) and Kolonnawa Gallons (B) respectively); the names of the depots (DP);

Statements

	the fixed costs of the existing depots (E); depot operating costs (TT); trunking costs to depots (TX); cost of supplying each centre from the central source (Y); maximum throughput of depots (LX); and the present source of supply to each centre of demand (IS).
190 - 195	calculates the fixed cost of the present network.
240 - 525	calculates the cost of the present distribution system and prints out all details of the present set up.
530 - 625	prints out list of depots (existing and proposed), and ex depot costs.
650 - 750	calculates and prints out cost of supplying all centres of demand from the central source.
770 - 900	sets up certain preliminary conditions for the iterations of the main program which commences from statement 790. Statement 775 is the one which specifically excludes depot numbers 12, 26, 40 and 43 from the basis. See section 6.4.2.4. for reasons.
965 - 1015	checks on the possibilities of savings for the depot being considered. Each centre of demand is taken up separately.
1040 - 1165	checks on the profitability of each depot already in the basis. If a depot becomes unprofitable, it is dropped from the basis, and the centres allocated to it are reverted for supply from Kolonnawa. Statement 1125 activates a loop which repeats the whole cycle of operations to ensure that centres of demand are assigned to the lowest cost source.
1170 - 1275	summarises and retains the throughputs and costs of all depots (and the central source) in the basis.
1280 - 1335	checks on the profitability of the new depot.
1375 - 1400	investigates whether the maximum throughput, if any, has

Statements	been exceeded. If so, it sets up a special sub-routine.
1410 - 1470	this segment comes into operation only if the throughput assigned to the depot has exceeded its maximum throughput. It arranges the savings contributions of the centres of demand allocated to it in decreasing order of savings.
1500 - 1630	allocation of demand centres to the depot in decreasing order of magnitude of savings such that the maximum throughput is approached but not exceeded.
1635 - 1710	summary of the balance centres of demand.
1715 - 1805	check on the profitability of the depot with its constrained throughput.
1810 - 2185	summary and print out of present status. All depots in the basis are listed with their present throughputs, fixed costs and variable costs. The new depot's contribution to savings, its throughput, fixed and variable cost; the number of depots in the basis; the fixed and variable cost of the network to date; the savings over the present cost of supply and the percentage savings are also printed.

The iterations of the main program end here. The next iteration starts from statement 790.

2195 - 2525	end of iterations of main program. If the loop in statement 1125 has been activated, the main program is recycled to repeat the whole series of iterations. Once the main program has been completed, the final basis is summarised and printed. In addition to giving costs and throughputs of the whole network, each source is listed separately with the centres allocated to it. This listing permits easy determination of where a particular centre has been allocated.
2530 - 2685	final summary of depots in basis, with throughputs and costs.

Statements

2710 - 2725	provision for identification of depots whose exclusion will improve the solution.
2730 - 2750	provision to alter estimates of demand (if necessary).
2755	provision to exclude sensitivity analysis, if so desired.
2765 - 2780	time check and print out.
2785 - 3070	sensitivity analysis.
3075 - 3085	final time check.
3105	end of segment.

```
RAN COMPILATION BY #XFAT MK 2A    DATE  25/06/69  TIME  07/16/56

LIST(LP)
SEND TO (ED,FORTCOMPAREA.ONE)
PROGRAM(GP03)
INPUT1=CR0
COMPRESS INTEGER
OUTPUT2=LP0
USE4=MT0(COST MATRIX)
TRACE0
END
```

```
 MASTER DISTRIBUTION COST ANALYSIS
 DIMENSION DP(86),E(86),KD(86),TT(86),TX(86),LX(86),RA(86),P(86),RT
1(86),D(613),DN(613),LA(613),S(613),X(613),TB(613),IS(613),Y(613),S
2I(613),ND(613),I0(3),I1(3),I2(3),I3(3),I4(3),I5(3),I6(5),I7(5),I8(
35),LZ(613),SZ(613),NE(86)
 DATA I4(1)/12H   INITIAL  /,I5(1)/12H ADDITIONAL /,I1(1)/12H  INCL
1USION /,I2(1)/12H  RETENTION /,I7(1)/20HENTER THE BASIS       /,I8(1
2)/20HREMAIN IN THE BASIS /
 CALL TIME(T)
 WRITE(2,1)T
 FORMAT(/1X13HSTART TIME = A8/)
 CALL UTD1(110000)
 READ(1,2)AX,AY
 FORMAT(F5.3,F6.1)
 READ(4)IC,ID,JB,IG,OK,RR
 DO 3 I=1,ID
 READ(4)(D(J),J=1,IC)
 CALL UTD2(2,IC*(I-1)+1,IC,D(1))
 DO 4 I=1,IC
 READ(4)DN(I),S(I),SI(I),X(I),TB(I)
 READ(4)(DP(I),I=1,ID)
 READ(4)(E(I),I=1,JB)
 READ(4)(TT(I),I=1,ID)
 READ(4)(TX(I),I=1,ID)
 READ(4)(Y(I),I=1,IC)
 READ(4)(LX(I),I=1,ID)
 READ(4)(IS(I),I=1,IC)
 REWIND 4
 DO 5 I=1,JB
 CT=CT+E(I)
 WRITE(2,6)
 FORMAT(/3X38HSUMMARY OF COUNTRY WIDE DEMAND PATTERN//)
 WRITE(2,7)
 FORMAT(3X5HDESTN4X5HDEPOT2X6HDEL EX1X6HCOL EX1X6HDEL EX1X6HCOL EX,
12(2X5HTOTAL3X5HTOTAL))
 WRITE(2,8)
 FORMAT(19X5HDEPOT3X5HDEPOT3X3HKOL4X3HKOL3X3HDEL3X3HCOL2X6HDEMAND4X
14HCOST//)
 DO 9 I=1,IC
 IF(S(I))10,10,11
 CALL UTD2(1,IC*(IS(I)-1)+I,1,PX)
 GO TO 12
 S(I)=0
 IF(X(I))13,13,14
 CALL UTD2(1,I,1,Q)
 GO TO 15
 X(I)=0
 T2=S(I)*PX
```

```
T3=SI(I)*(OK+TT(IS(I))+TX(IS(I)))
T4=X(I)*Q
T5=TB(I)*OK
T6=T6+T3
T7=T7+T5
W=T2+T3+T4+T5
C1=C1+W
WW=WW+T2+T4
D(I)=S(I)+X(I)
T1=SI(I)+TB(I)
F1=F1+D(I)
F2=F2+T1
V=D(I)+T1
J0=S(I)
J1=SI(I)
J2=X(I)
J3=TB(I)
J4=D(I)
J5=T1
J6=V
WRITE(2,16)DN(I),DP(IS(I)),J0,J1,J2,J3,J4,J5,J6,C1
FORMAT(2(1XA8),1XI6,1XI5,1XI7,1XI6,1XI7,1XI6,1XI7,1XF7.0)
CONTINUE
WRITE(2,17)
FORMAT(//)
WRITE(2,18)F1
FORMAT(3X19HTOTAL DELIVERIES = F11.2/)
WRITE(2,19)F2
FORMAT(3X20HTOTAL COLLECTIONS = F10.2/)
F3=F1+F2
WRITE(2,20)F3
FORMAT(/3X39HTOTAL DEMAND THROUGHOUT THE COUNTRY IS F12.2//)
WRITE(2,21)CT
FORMAT(//3X33HFIXED COST OF EXISTING NETWORK = F11.2/)
WRITE(2,22)WW
FORMAT(//3X36HDELIVERY COST OF EXISTING NETWORK = F11.2/)
CT=CT+C1
T8=T6+T7
WRITE(2,23)T6
FORMAT(/3X34HCOST OF COLLECTIONS FROM DEPOTS = F10.2)
WRITE(2,24)T7
FORMAT(3X42HCOST OF COLLECTIONS FROM CENTRAL SOURCE = F10.2)
WRITE(2,25)T8
FORMAT(/3X32HTOTAL COST OF ALL COLLECTIONS = F11.2//)
WRITE(2,26)C1
FORMAT(//3X36HVARIABLE COST OF EXISTING NETWORK = F11.2/)
WRITE(2,27)CT
FORMAT(///3X33HTOTAL COST OF EXISTING NETWORK = F13.2///)
```

```
      JC=ID-1
      JB=JB-1
      WRITE(2,28)DP(1),JC,JB
3     FORMAT(//2X59HTHIS PROGRAM WILL ARRANGE SUPPLY FROM THE CENTRAL SO
     1URCE - A8/17H AND SOME OF THE I3,52H LIKELY DEPOT LOCATIONS TO RED
     2UCE TOTAL DISTRIBUTION/27H COST. OF THESE, THE FIRST I3,42H DEPOTS
     3 COMPRISE THE EXISTING DISTRIBUTIVE/8H NETWORK)
      JB=JB+1
      WRITE(2,29)JC
)     FORMAT(3X4HTHE I3,29H LIKELY DEPOT LOCATIONS ARE:-//)
      WRITE(2,30)
)     FORMAT(3X5HDEPOT3X14HOPERATING COST3X11HSUPPLY COST3X11HSOURCE COS
     1T3X19HTOTAL COST EX DEPOT0)
      WRITE(2,31)
      FORMAT(25X26HRUPEES PER IMPERIAL GALLON/)
      DO 32 I=2,ID
      TZ=TX(I)+TT(I)+OK
      WRITE(2,33)DP(I),TX(I),TT(I),OK,TZ
      FORMAT(1XA8,7XF6.4,9XF6.4,8XF6.4,11XF6.4)
      WRITE(2,17)
      JC=JB+1
      WRITE(2,34)DP(1)
      FORMAT(3X56HINITIAL DISTRIBUTION PATTERN - ALL DESTINATIONS SUPPLI
     1ED/26H FROM THE CENTRAL SOURCE (A8,1H)/)
      CALL UTD2(1,1,IC,S(1))
      V,W=0
      DO 35 I=1,IC
      W=S(I)*D(I)
      LA(I)=1
      V=V+W
      C=E(1)+V+T8
      WRITE(2,36)DP(1),E(1)
      FORMAT(/3X14HFIXED COST OF A8,4H IS F10.2)
      WRITE(2,37)DP(1),V
      FORMAT(3X49HVARIABLE COST OF SUPPLYING ALL DESTINATIONS FROM A8,4H
     1 IS F13.2/)
      WRITE(2,25)T8
      WRITE(2,38)C
      FORMAT(3X23HINITIAL OVERALL COST = F13.2//)
      C2=CT-C
      WRITE(2,39)C2
      FORMAT(3X42HIMPROVEMENT OVER COST OF PRESENT SYSTEM = F12.2/)
      C3=(100*C2)/CT
      WRITE(2,40)C3
      FORMAT(5X25HPERCENTAGE IMPROVEMENT = F7.2///)
      WRITE(2,41)
      FORMAT(1X53H-----------------------------------------------------)
      C4=C
```

```
  KD(1)=1
  KD(12),KD(26),KD(40),KD(43)=5
2 K=1
  IR=0
5 K=K+1
  IF(K.GT.ID)GO TO 44
  IF(KD(K).GT.4)GO TO 43
  IF(KD(K).EQ.1)GO TO 45
  BK,RK,NG=0
  CALL COPY(12,I0(1),1,I1(1),1)
  CALL COPY(12,I3(1),1,I4(1),1)
  CALL COPY(20,I6(1),1,I7(1),1)
  GO TO 46
5 NG=1
  RK=RA(K)
  BK=AY
  CALL COPY(12,I0(1),1,I2(1),1)
  CALL COPY(12,I3(1),1,I5(1),1)
  CALL COPY(20,I6(1),1,I8(1),1)
5 KD(K)=1
  CALL UTD2(1,(K-1)*IC+1,IC,X(1))
  M=-2
  IA=IC
  MD=0
7 IF(M)48,48,49
3 DO 50 J=1,ID
) RT(J)=RA(J)
  GO TO 51
) WRITE(2,52)DP(K),I6
? FORMAT(/3XA8,12H DEPOT WILL 5A4)
  WRITE(2,53)
3 FORMAT(//3X23HIMPROVED SUPPLY PATTERN/)
  IF(K.EQ.5.AND.NG.EQ.0.AND.KY.EQ.0)WRITE(2,54)
. FORMAT(1X11HDESTINATION2X10HTHROUGHPUT2X6HSOURCE2X15HCOST PER GALL
 1ON2X14HTRANSPORT COST/)
  DO 55 J=1,ID
5 TT(J),TX(J)=0
  GO TO 56
  MM=0
5 V,Q,F,R,A=0
  DO 57 I=1,IA
  IF(MD)58,58,59
3 IR=I
  GO TO 60
) IB=ND(I)
) TB(IB)=0
  IF(MM)61,62,61
? ST(IB)=S(IB)
```

```
1 SX=SI(IB)-X(IB)
  IF(SX)63,63,64
4 IF(M)65,66,65
6 LB=LA(IB)
  IF(LB-1)67,65,67
7 IF(LX(LB).GT.0.AND.KD(LB).EQ.1)LX(LB)=LX(LB)+D(IB)
  IF(LB-JC)68,69,69
8 DI=0
  GO TO 70
9 DI=D(IB)
0 CALL UTD2(1,IG+(LB-1)*IC+IB,1,BT)
  RT(LB)=RT(LB)-BT+DI*AX
1 IF(RT(LB))72,72,65
2 RT(LB)=RA(LB)
  DO 73 II=1,IC
  IF(LB-LA(II))73,74,73
4 IF(LB-JC)75,76,76
5 DI=0
  GO TO 77
6 DI=D(II)
7 CALL UTD2(1,IG+(LB-1)*IC+II,1,BT)
  RT(LB)=RT(LB)-BT+DI*AX
  KD(LB)=3
  IR=IR+1
  LA(II)=1
  S(II)=Y(II)
3 CONTINUE
  WRITE(2,78)DP(LB),DP(1)
8 FORMAT(/2XA8,60H DEPOT WILL DROP OUT OF THE BASIS. ALL DESTINATION
 1S ASSIGNED/22H TO IT WILL REVERT TO A8,18H FOR RE-ALLOCATION/)
  MM=1
  GO TO 56
5 W=D(IB)*X(IB)
  TB(IB)=D(IB)*SX
  V=V+W
  R=R+TB(IB)
  A=A+D(IB)
  IF(M)57,57,79
9 S(IB)=X(IB)
  LA(IB)=K
  IF(K.EQ.5.AND.NG.EQ.0.AND.KY.EQ.0)WRITE(2,80)TB(IB),DN(IB),DP(K)
0 FORMAT(68X5HSAVE F10.2,14H BY SUPPLYING A8,6H FROM A8)
  U=W
  GO TO 81
3 U=D(IB)*S(IB)
  Q=Q+U
  IF(M)57,57,81
1 KK=LA(IB)
```

```
  TT(KK)=TT(KK)+D(IB)
  TX(KK)=TX(KK)+U
  IF(K.EQ.5.AND.NG.EQ.0.AND.KY.EQ.0)WRITE(2,82)DN(IB),D(IB),DP(KK),S
 1(IB),U
2 FORMAT(1XA8,3XF11.2,2XA8,5XF6.4,8XF10.2)
7 CONTINUE
  IF(MD)83,83,84
3 IF(M)85,85,86
5 IF(KY.EQ.0)CALL UTD2(2,IG+(K-1)*IC+1,IC,TB(1))
  DO 87 I=1,ID
7 RA(I)=RT(I)
5 IF(A)88,88,89
) IF(K.LT.JC)GO TO 90
  E(K)=A*AX+AY-BK
) IF(NG)91,91,92
| RA(K)=R-E(K)
  GO TO 93
2 IF(K-JC)94,94,95
4 RA(K)=R+RK
  GO TO 93
5 RA(K)=R-E(K)+RK
5 IF(RA(K))96,96,97
3 IF(NG.EQ.1)GO TO 43
5 KD(K)=4
  GO TO 43
7 IF(M.EQ.-1)GO TO 98
  IF(LX(K))99,100,101
| IF(LX(K)-A)102,100,100
2 EX=A-LX(K)
  WRITE(2,103)A,DP(K),LX(K),EX
3 FORMAT(2X28HTHE GENERATED THROUGHPUT OF F10.2,4H AT A8,30H EXCEEDS
 1 ITS MAXIMUM VALUE OF /1XI10,4H BY F10.2)
  DO 104 L=1,IC
  J=2
  IF(TB(J-1)-TB(J))105,105,106
5 HI=TB(J-1)
  II=J-1
  GO TO 107
5 HI=TB(J)
  II=J
7 J=J+1
  IF(J-IC)108,108,109
3 IF(HI-TB(J))105,107,107
' IS(L)=II
, TB(II)=L-IC
  GO TO 110
) M=M+1
) IF(M.GT.1)GO TO 111
```

```
 M=M+1
 GO TO 47
8 I=1
 J=0
 TH=D(IS(I))
2 IF(LX(K)-TH)113,114,114
4 J=J+1
 ND(J)=IS(I)
 IS(I)=0
5 I=I+1
 IF(I-IC)116,116,117
6 IF(D(IS(I)))117,117,118
8 TH=TH+D(IS(I))
 GO TO 112
3 TH=TH-D(IS(I))
 GO TO 115
7 WRITE(2,119)K,DP(K)
9 FORMAT(//8X39HERROR IN CALCULATIONS FOR DEPOT NUMBER I3,1H(A8,2H).
 1//)
 GO TO 43
7 IF(J)120,120,121
1 WRITE(2,122)DP(K),J
2 FORMAT(3X26HTHE MAXIMUM THROUGHPUT OF A8,30H DEPOT HAS BEEN REACHE
 1D AFTER I3,13H DESTINATIONS/62H (ARRANGED IN DECREASING ORDER OF S
 2AVINGS)ARE SUPPLIED FROM IT/)
 M=M+1
 IA=J
 MD=1
 GO TO 47
4 IF(M)123,123,124
4 DO 125 I=1,IC
 IF(IS(I))125,125,126
6 IB=IS(I)
 TB(IB)=0
 U=D(IB)*S(IB)
 Q=Q+U
 KK=LA(IB)
 TT(KK)=TT(KK)+D(IB)
 TX(KK)=TX(KK)+U
 IF(K.EQ.5.AND.NG.EQ.0.AND.KY.EQ.0)WRITE(2,82)DN(IB),D(IB),DP(KK),S
 1(IB),U
5 CONTINUE
 IF(KY.EQ.0)CALL UTD2(2,IG+(K-1)*IC+1,IC,TB(1))
 DO 127 II=1,ID
7 RA(II)=RT(II)
3 IF(A)120,120,128
3 IF(K.LT.JC)GO TO 129
 E(K)=A*AX+AY-BK
```

```
29 IF(NG)130,130,131
30 RA(K)=R-E(K)
   GO TO 132
31 IF(K-JC)133,134,134
33 RA(K)=R+RK
   GO TO 132
34 RA(K)=R-E(K)+RK
32 IF(RA(K))135,135,136
20 IF(NG.EQ.1)GO TO 43
35 KD(K)=4
   IF(KY)137,137,43
37 WRITE(2,138)A,DP(K)
38 FORMAT(3X30HTHE CONSTRAINED THROUHHPUT OF F10.2,31H IS INSUFFICIEN
  1T YO JUSTIFY THE/14H INCLUSION OF A8,13H IN THE BASIS///)
   WRITE(2,17)
   GO TO 43
36 IF(M)139,139,140
39 M=M+1
   GO TO 47
0  LX(K)=LX(K)-A
1  WRITE(2,141)I3,DP(K),A
1  FORMAT(/3X3A4,14HTHROUGHPUT AT A8,4H IS F11.2/)
   IF(K-JB)142,142,143
2  WRITE(2,144)DP(K),E(K)
4  FORMAT(5X14HFIXED COST OF A8,4H IS F9.2)
   GO TO 145
3  WRITE(2,146)I3,DP(K),E(K)
6  FORMAT(5X11HCALCULATED 3A4,14HFIXED COST OF A8,4H IS F8.2)
5  WRITE(2,147)I3,DP(K),V
7  FORMAT(3X3A4,17HVARIABLE COST OF A8,4H IS F11.2/)
   WRITE(2,148)I3,I0,DP(K),R
8  FORMAT(3X3A4,16HGROSS SAVING BY 3A4,3HOF A8,17H IN THE BASIS IS F1
  111.2)
   WRITE(2,149)I0,DP(K),RA(K)
9  FORMAT(5X31HCONTRIBUTION TO NETT SAVING BY 3A4,3HOF A8,4H IS F9.2/
  1/)
   WRITE(2,150)
0  FORMAT(3X15HDEPOTS IN BASIS//)
   WRITE(2,151)
1  FORMAT(4X5HDEPOT3X18HPRESENT THROUGHPUT3X10HFIXED COST4X13HVARIABL
  1E COST//)
   NY=0
   DO 152 I=1,ID
   J=1
   IF(KD(I)-1)153,154,153
4  IF(I-LA(J))155,156,155
6  IF(TT(I))157,157,158
5  J=J+1
```

```
  IF(J-IC)154,154,153
8 IF(I.LT.JC)GO TO 159
  E(I)=TT(I)*AX+AY
9 F=F+E(I)
  WRITE(2,160)DP(I),TT(I),E(I),TX(I)
0 FORMAT(3XA8,6XF13.2,6XF10.2,4XF11.2)
  GO TO 152
7 KD(I)=2
3 IF(I.GT.(JC-1))E(I)=0
2 CONTINUE
  DO 161 I=1,ID
  IF(KD(I).EQ.2.OR.KD(I).EQ.3)GO TO 162
  GO TO 161
2 WRITE(2,163)DP(I)
3 FORMAT(/3XA8,35H DEPOT HAS DROPPED OUT OF THE BASIS)
  NY=NY+1
  KD(I)=4
1 CONTINUE
  WRITE(2,17)
  IF(K-1)164,164,165
4 N=K
  GO TO 166
5 N=N+1-NY-NG
6 WRITE(2,167)DP(1),N,F
7 FORMAT(3X14HFIXED COST OF A8,5H AND I3,12H DEPOT/S IS F13.2)
  VA=V+Q
  C=F+VA+T8
  WRITE(2,168)DP(1),N,VA
8 FORMAT(3X17HVARIABLE COST OF A8,5H AND I3,12H DEPOT/S IS F13.2)
  WRITE(2,25)T8
  WRITE(2,169)C
9 FORMAT(3X23HREDUCED OVERALL COST = F12.2//)
  C5=C4-C
  WRITE(2,170)I3,I0,DP(K),C5
0 FORMAT(3X3A4,15HNETT SAVING BY 3A4,3HOF A8,17H IN THE BASIS IS F11
 1.2/)
  C2=CT-C
  C3=(100*C2)/CT
  WRITE(2,39)C2
  WRITE(2,40)C3
  WRITE(2,41)
  IF(KY)171,171,43
1 C4=C
  GO TO 43
4 IF(IR)172,172,173
3 WRITE(2,174)IR
4 FORMAT(/3X5HIR = I3/)
  GO TO 42
```

```
2 TO,TF,TS=0
  IF(KY)175,175,176
5 WRITE(2,177)
7 FORMAT(//3X17HEND OF ITERATIONS//)
  WRITE(2,178)
8 FORMAT(3X28HOPTIMAL DISTRIBUTION PATTERN///)
  WRITE(2,54)
  GO TO 179
6 WRITE(2,180)
0 FORMAT(3X30HRESULTANT DISTRIBUTION PATTERN//)
9 DO 181 I=1,IC
  X(I)=S(I)*D(I)
1 TS=TS+X(I)
  IF(KY)182,182,183
2 WRITE(2,184)TS
4 FORMAT(/3X45HSUM OF VARIABLE COSTS TO ALL DESTINATIONS IS F11.2/)
  WRITE(2,185)
5 FORMAT(/3X37HALLOCATION OF DESTINATIONS TO SOURCES//)
  WRITE(2,186)
6 FORMAT(///3X6HSOURCE8X11HDESTINATION4X10HTHROUGHPUT3X15HCOST PER G
 1ALLON3X14HTRANSPORT COST)
3 DO 187 J=JC,ID
7 E(J)=0
  DO 188 J=1,ID
  W,TX(J)=0
  DO 189 I=1,IC
  IF(J-LA(I))189,190,189
0 W=W+D(I)
  IF(KY)191,191,192
1 WRITE(2,193)DP(J),DN(I),D(I),S(I),X(I)
3 FORMAT(1XA8,7XA8,8XF11.2,10XF6.4,8XF11.2)
2 TX(J)=TX(J)+X(I)
9 CONTINUE
  IF(W)188,188,194
4 IF(KY)195,195,196
5 WRITE(2,197)DP(J),W
7 FORMAT(5X20HFINAL THROUGHPUT AT A8,4H IS F11.2)
6 IF(J-JB)198,198,199
8 IF(KY)200,200,201
0 WRITE(2,144)DP(J),E(J)
  GO TO 201
9 E(J)=TT(J)*AX+AY
  IF(KY)202,202,203
2 WRITE(2,204)DP(J),E(J)
4 FORMAT(5X22HREVISED FIXED COST OF A8,4H IS F9.2)
1 IF(KY)205,205,203
5 WRITE(2,206)DP(J),TX(J)
6 FORMAT(5X17HVARIABLE COST OF A8,4H IS F10.2////)
```

```
3 TF=TF+E(J)
8 CONTINUE
  TO=TF+TS+T8
  C2=CT-TO
  C3=(100*C2)/CT
  IF(KY)207,207,208
7 WRITE(2,209)TF
9 FORMAT(//3X58HTOTAL FIXED COST OF CENTRAL SOURCE AND SELECTED DEPO
 1TS IS F11.2)
  WRITE(2,210)TS
0 FORMAT(3X42HTOTAL VARIABLE COST OF OPTIMAL PATTERN IS F11.2)
  WRITE(2,25)T8
  WRITE(2,211)TO
1 FORMAT(///3X41HTOTAL OVERALL COST OF OPTIMAL PATTERN IS F11.2/)
  WRITE(2,39)C2
  WRITE(2,40)C3
  WRITE(2,212)
2 FORMAT(///3X46HFINAL THROUGHPUTS AND COSTS OF SELECTED DEPOTS/)
  WRITE(2,213)
3 FORMAT(3X52H(ZERO THROUGHPUT INDICATES NON-UTILISATION OF DEPOT)/)
  WRITE(2,214)
4 FORMAT(//1X5HDEPOT3X16HFINAL THROUGHPUT3X10HFIXED COST3X13HVARIABL
 1E COST/)
  DO 215 K=1,ID
  N=(K)=KD(K)
  P(K)=RA(K)
  IF(E(K))216,216,217
7 IF(TT(K))218,218,219
8 WRITE(2,220)DP(K),TT(K),E(K),TX(K)
0 FORMAT(1XA8,3(2XF11.2),1X36HTHIS EXISTING DEPOT WILL NOT BE USED)
  GO TO 215
9 IF(K-JB)216,216,221
1 WRITE(2,222)DP(K),TT(K),E(K),TX(K)
2 FORMAT(1XA8,3(2XF11.2),1X18HNEW DEPOT LOCATION)
  GO TO 215
6 WRITE(2,223)DP(K),TT(K),E(K),TX(K)
3 FORMAT(1XA8,3(2XF11.2))
5 CONTINUE
  NP=N-1
  T2=TO
  GO TO 224
8 WRITE(2,225)TF
5 FORMAT(/3X19HTOTAL FIXED COST = F10.2)
  WRITE(2,226)TS
6 FORMAT(3X22HTOTAL VARIABLE COST = F10.2)
  WRITE(2,25)T8
  WRITE(2,227)TO
7 FORMAT(3X21HTOTAL OVERALL COST = F10.2)
```

```
   TY=TO-TZ
   WRITE(2,228)TY
8  FORMAT(/3X22HMINIMUM EXTRA COST IS F10.2//)
   IF(TY)229,229,230
9  WRITE(2,231)DP(IZ),IZ
1  FORMAT(3X39HTHE PROGRAM SHOULD BE RE-RUN EXCLUDING A8,17H DEPOT BY
 1 SETTING/4H KD(I3,12H) EQUAL TO 5///)
   GO TO 230
4  IF(IQ)232,232,233
3  DO 234 I=1,IC
4  D(I)=D(I)*INCRSE
   CONTINUE
   GO TO 42
2  IF(JQ)235,235,236
5  WRITE(2,237)
7  FORMAT(///3X20HSENSITIVITY ANALYSIS//)
   CALL TIME(T)
   WRITE(2,238)T
8  FORMAT(3X7HTIME = A8/)
   KY=1
   DO 239 I=1,IC
   SZ(I)=S(I)
9  LZ(I)=LA(I)
   DO 230 IZ=2,ID
   WRITE(2,41)
   WRITE(2,41)
   IF(NE(IZ).EQ.1)GO TO 240
   CALL UTD2(1,(IZ-1)*IC+1,IC,X(1))
   K,DJ,TB(IZ),TT(IZ)=0
   WRITE(2,242)DP(IZ)
2  FORMAT(//3XA8,66H DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CE
 1NTRES OF DEMAND:-)
   DO 243 J=1,IC
   S(J)=SZ(J)
   SX=S(J)-X(J)
   IF(SX)243,243,244
4  TB(IZ)=TB(IZ)+(SX*D(J))
   K=K+1
   TT(IZ)=TT(IZ)+D(J)
   WRITE(2,245)DN(J),D(J)
5  FORMAT(55XA8,5XF10.2)
   IF(LA(J)-JB)246,246,247
6  DI=0
   GO TO 248
7  DI=D(J)
8  DJ=DJ+DI
3  CONTINUE
   IF(K)249,249,250
```

```
9 WRITE(2,251)
1 FORMAT(55X4HNONE)
0 WRITE(2,252)TB(IZ)
2 FORMAT(3X30HTHE TOTAL POTENTIAL SAVING IS F10.2)
  IF(IZ.LT.JC)GO TO 253
  E(IZ)=TT(IZ)*AX+AY
3 RA(IZ)=E(IZ)-TB(IZ)-DJ*AX
  WRITE(2,254)RA(IZ)
4 FORMAT(/3X51HMINIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS F1
 10.2//)
  GO TO 230
0 WRITE(2,255)DP(IZ)
5 FORMAT(//3X19HEFFECT OF DROPPING A8,27H DEPOT FROM THE FINAL BASIS
 1/)
  N=NP
  DO 256 I=1,ID
  RA(I)=P(I)
6 KD(I)=NE(I)
  KD(IZ)=5
  DO 257 I=1,IC
  IF(LZ(I).EQ.IZ)GO TO 258
  LA(I)=LZ(I)
  S(I)=SZ(I)
  GO TO 257
8 S(I)=Y(I)
  LA(I)=1
7 CONTINUE
  GO TO 42
0 CONTINUE
6 CALL TIME(T)
  WRITE(2,259)T
9 FORMAT(/1X18HCOMPLETION TIME = A8/)
  WRITE(2,260)
0 FORMAT(//3X10HEND OF JOB)
  STOP
  END

OF SEGMENT, LENGTH  3220, NAME  DISTRIBUTIONCOSTANALYSIS
```

FEATURES OF PROPOSED TECHNIQUE

5.11. This technique has been developed empirically from first principles in an attempt to make it easily understood and undertaken. It has been designed with very simple logic and the mathematics used is basic. In spite of its simplicity it contains several features which cover the gaps left by previous work, even though the latter frequently employ much more sophisticated algorithms. This section is devoted to a discussion of how the new procedure overcomes certain shortcomings of earlier work in this field.

5.11.1. Fixed Costs

The incorporation of fixed costs has not been undertaken by several methods listed earlier - Linear programming (section 4.6.), the specialised transportation method (section 4.5.), the centre of gravity methods of Keefer (section 4.7.), Burstall, Leaver and Sussams (section 4.9.), Bruce's manipulation method (section 4.8.), Brink and de Cani's analogue method (section 4.11.), and the heuristic methods of Baumol and Wolfe (section 4.12.) and Griffiths (section 4.15.). These techniques either ignore fixed costs or are unable to cope with them. For instance, linear programming is a very elegant method of cost minimisation (or profit maximisation) in an established operational network. It operates on marginal costs on the assumption that fixed costs are constant throughout the study and therefore need not enter the optimisation process. It is this assumption that makes standard linear programming unsuitable for problems such as the one being undertaken in this study. The idea is to bring about fundamental changes in the network itself, and not merely to re-arrange routings within a fixed network. While admitting the possibility that the optimisation of routings might not change the structure of the network, one must use a technique that could cope with such changes as an integral part of the algorithm.

5.11.1.1. The other methods too show this same weakness in not taking into account the fixed costs of the depots selected for the network. Most of them simply ignore fixed costs. The presumption seems to be that fixed costs will not change much, or, since, they are mostly dealing with single depot systems, that fixed costs are taken to be unchanged during the exercise.

5.11.1.2. The new technique takes fixed and variable costs into consideration, and any depot which drops out of the basis, takes its fixed cost away from the objective function. Keuhn and Hamburger (42) refer to the use of specialised linear programming algorithms designed to handle fixed cost elements but dismiss their use on the grounds of non-linearity and excessive computing time, especially when less time-consuming routines are available.

5.11.2. Consideration of other costs

In addition to the fixed costs of the depots, there are other costs which have to be considered. Certain writers do not include them at all. Brink and de Cani (section 4.11.) have not taken into account the supply cost from the main source to the centre/s of distribution. Griffiths (section 4.15.) considers only delivery costs from transit depots to customers, in a 4-stage problem involving factories, distribution centres, transit depots and customers. He does not consider all the other costs that are built up in the system.

5.11.2.1. It is clear that all costs must enter into consideration. The purpose of the exercise is to minimise total costs, not merely transport costs between depot and customer.

5.11.2.2. All costs have been taken into account in the new method. These costs are generated externally and fed in as input data. The extension of the main program to calculate such costs presents no difficulty whatsoever, but it is felt that they are best done outside this program. For one thing, each run will have to calculate the same costs over and over again. Furthermore, the flexibility of the optimisation procedure is increased greatly if the only alterations required in it from problem to problem are the setting of the parameters governing the size of each problem.

5.11.3. Multiple drop journeys

Griffiths (section 4.15.) has confined his study to multiple drop journeys. This is a vital feature of the problem, the fact that several customers/towns will have to be visited on the single delivery round. His concepts of route-dependent and route-independent measures of mileage are based on this provision.

5.11.3.1. It is agreed that multiple drops are a necessary provision in petroleum deliveries, particularly in Britain. It is however, almost extinct in Ceylon.

5.11.3.2. The new technique does not make specific provision for multiple drops. It is however possible to incorporate this provision for certain centres of demand. Multiple drop journeys are more expensive than single drop trips, and it is possible to estimate how much more the former would cost. This correction factor could then be applied to the volume of demand at those particular centres involved in multiple drops. This is similar to the provision made by Lawrence and Pengilly (section 4.17.) to deal with traffic congestion and infeasible depot sites. The adjustment is only approximate because it assumes that these demand centres require multiple drops all the time, but here too a correction may be made by reducing the extra cost factor which was used to increase the volume of demand.

5.11.4. Traffic congestion/road Hazards

The adjustment made by Lawrence and Pengilly (section 4.17.) to reflect the additional time (and cost) by traffic congestion and natural hazards is to increase the actual mileage by a predetermined factor. Similar provision can be made in the new technique, by adjusting the road mileage when calculating transport costs to demand centres.

5.11.5. Centre of Gravity

The use of "centre of gravity" methods has already been described . It has also been established that the centre of gravity is not necessarily the best place to locate a supply depot, and that the total distance travelled from the centre of gravity to all the nodes is not always the minimum. Since minimisation of path length, and therefore transportation cost, is a vital purpose of this study, such a method is unacceptable as a universal technique.

5.11.5.1. The new method does not consider centre of gravity at all. It only takes into account the actual cost of transporting product from each likely depot to all centres of demand. It can also cope with the location of several depots simultaneously, while the centre of gravity method seems to be able to indicate only one source, or else alternative sources.

5.11.6. Determination of distances

Several techniques described earlier estimate distances by triangulation, the use of co-ordinates or the direct measurement of crow-fly distances. Transportation costs are based on these estimates, which presuppose that there are direct routes linking all nodes by straight lines. This is admittedly not true in practice. Roads, even some of the more modern ones, have a habit of meandering over the countryside and are invariable longer than Euclidean distances. No correction is made for this. Anyway (section 4. 21.) makes an overall adjustment for this, but even this cannot be accurate because the correction factor in only an average.

5.11.6.1. It is felt that this sort of error can and should be overcome. It seems a pity that basic errors should be allowed to cloud one's judgment in such a manner.

5.11.6.2. The new technique does not depend on co-ordinates or triangulation to fix distances. Actual road miles are used, so that errors on this account are minimised, if not eliminated altogether.

5.11.7. <u>Non-linearity of transport costs</u>

Non-linearity of transport costs is an important fact of life. Any analysis that does not recognise this is introducing a very serious element of error into the results. Most authors assume linearity as a matter of convenience, but they point out that it does not exist. But very little has been done to incorporate non-linearities in actual work.

5.11.7.1. The new technique pays attention to non-linearities, but not directly. It uses transport costs that have been calculated externally (see section 5.3.) both on the basis of unit distance as well as per journey.

5.11.7.2. Provision for non-linearity is claimed even though it is not a part of the main program, because the approach adopted in my technique is to work on total variable cost per journey, and non-linearity is recognised and incorporated in the routine which calculates these costs.

5.11.8. <u>Multiple depot systems</u>

Some of the work described earlier has been concerned with the placement of one depot. The present study requires the placement of an unknown number of depots. Therefore a technique which can locate only one depot is inadequate to cope with this problem.

5.11.8.1. The new technique is based upon introduction/rejection of all feasible depots and there is no limitation as regards number of depots that can be selected. Convergence on an optimum is entirely automatic and cannot be influenced by the number of depots located.

5.11.9. <u>Pre-determination of number of depots in basis</u>

The last point leads directly to this one. Some techniques depend upon an external decision regarding the number of depots to be located. The process of optimisation requires repeated runs of the program using different numbers of depots, with a final examination being made to determine the best pattern. In addition to varying the number of depots in each run, most procedures consider several combinations of depots.

5.11.9.1. It is felt that this "interference" reflects a weakness of the technique itself. In addition a lot of time may be wasted in repeated runs.

5.11.9.2. The new technique is self-adjusting. It alters the number of depots in the basis upon considerations of cost alone. It searches for better solutions and in doing so alters the number of depots. In fact, the algorithm is more concerned with the identity of the depots in the basis. The number follows automatically from this.

5.11.10. Use of grids in market demarcation

In certain methods the market has been divided into grids. This demarcation has been made in order to facilitate calculation of distances and therefore costs. Lawrence and Pengilly (section 4.17.) assume that the distance travelled within each grid (6.215 miles square) is constant, while Smykay (section 4.21.) implies that the demand is uniform within each grid section (3 miles by 4 miles).

5.11.10.1. The approximation used in the new technique is to concentrate the volume of demand within a certain area (post office zones have been used in the case study) at its centre. In other words, each town is represented by one customer whose volume of demand is the sum of the volumes of each individual consumer in the area.

5.11.10.2. This approximation has been made for convenience and to reduce computing time. It is quite easy to consider each consumer individually, but doing so would not cause any significant improvement in the result. It would only increase computation time.

5.11.11. Re-evaluation of depots in basis

The evaluation of depots in the basis is an important part of the iterative routine used in the new technique. Keuhn and Hamburger (section 4.18.) have incorporated this same facility in their method. The need for it is clear. A depot is accepted only when it can show some savings in distribution cost. A depot should remain in the basis only as long as it can show savings. The moment it fails to do so, it must be dropped. This decision requires a constant appraisal of each depot as often as possible. Keuhn and Hamburger do this only after their main program is complete, in other words, when it has reached its first "optimum". The new technique evaluates all depots during each iteration. Unprofitable depots are weeded out as and when they are discovered and the whole basis is altered to correct this action. Each iteration of the new technique is therefore completely feasible at all times not only from the practical angle, but also from the cost-effectiveness angle. Keuhn and Hamburger's iterations are not. They can contain unprofitable depots, which are detected only by the Bump-and-Shift routine.

5.11.11.3. An advantage is claimed on this account for the new technique. The process of convergence to the best, if not the optimal, basis is very rapid, because all anomalies are detected and eliminated as soon as they arise. The presence of an anomaly might adversely affect the final basis, particularly when the latter cannot be guaranteed to be optimal.

5.11.12. Complete flexibility of supply arrangements

The new technique has complete flexibility of supply built into it. The flexibility is represented by its ability to arrange supply to every centre of demand from every depot. This has created the need to prepare a data grid which in its original state represented the actual mileage between any two of the above nodes. No provision was made for supply from one warehouse to another or from one customer to another. In the case study the data grid has 613 rows (centres of demand) and 86 columns (possible sources).

5.11.12.1. This flexibility was required by the logic of the method. Since the network was developed from "grass roots", it was necessary to determine in the first instance the cost of supplying all demand centres from the central source only. Thereafter depots were introduced one at a time and each had the "opportunity" of supplying any or all of these centres. This meant that the full grid was required. It is possible to reduce part of the work in preparing the mileage grid by putting arbitrary high mileages for obviously undesirable routes. However actual distances were used for the case study. One by-product of this optimisation process was that it was possible to determine the costs of the routes that were excluded from the basis. In fact, the success of the sensitivity analysis is partly due to this facility.

5.11.12.2. The need for complete flexibility was felt earlier when describing the method of Feldman, Lehrer and Ray (section 4.19.). Warehouses were confined to their local customer sets, and we had the curious situation where a warehouse was situated in one town which was supplied from a warehouse located in another town.

5.11.13. <u>Computation time</u>

The new technique requires little computation time. Earlier work was spread over months (Wenty - section 4.20), weeks (Burstall, Leaver and Sussams - section 4.9.) to hours on the computer. The time taken for my method is less than 15 minutes for the convergence, and a further 20 minutes for the sensitivity analysis, for a 86 x 613 problem. This time includes that taken for a fairly comprehensive print-out of the data and the results. A print-out complete in every detail (i.e., full information regarding centres of demand, their allocated sources of supply, per unit and total costs, for every iteration as well as the sensitivity analysis), will take about 15 minutes longer.

5.11.13.1. The short computing time enables many runs to be undertaken, (if the sensitivity analysis requires it) and the final run can be easily adjusted to give the complete result on the print-out.

5.11.14. <u>Optimality</u>

With the exception of Linear Programming, no other practical technique can guarantee optimality for a large scale problem. One has to balance the additional cost of obtaining an optimal solution against the convenience of getting close to it. The real test is whether the degree of improvement is worth the extra effort, particularly when heuristic methods <u>may</u> (if one is lucky) reach the optimum.

5.11.14.1. In the case study the first run produced an improvement of 4.02% over the cost of the present distribution system. The first sensitivity analysis indicated further improvements, which by the exclusion of three depots gave a result 4.18% better than the present cost. A second sensitivity analysis showed potential for further improvement by shutting out yet another depot. The final result was 4.21% better than the present system, and a third sensitivity analysis showed no further improvement.

THE CASE STUDY

6. The case study pertains to the analysis of the distribution system presently operated by the Ceylon Petroleum Corporation, which is a state owned Corporation created by an Act of Parliament (9) (the Ceylon Petroleum Corporation Act No. 98 of 1961). It has been undertaken with the permission of the Corporation and will be submitted to its Board of Directors as a specific plan for the improvement of its distribution network.

Ceylon, a brief sketch

6.1. Ceylon is a small island, just over 25,000 square miles in extent, lying to the south of India. Its population is now over 12,500,000 and its people are mainly occupied in agriculture. Tea is the main export commodity, followed by rubber and coconut. Its main imports are rice and other essential foodstuffs, industrial machinery, consumer goods and petroleum.

6.1.1. Until 1964, the bulk of Ceylon's requirements of petroleum came from the Persian Gulf. Three international oil companies, Shell, Esso (formerly Stanvac) and Caltex were well established in the country and with the exception of small quantities of lubricants, had a firm grip on the petroleum market.

6.1.2. Ceylon had no refinery and only refined products were imported. All fuels were shipped in bulk and all other products were packed in 45-gallon drums or smaller containers. Ceylon's main oil port is Colombo, the capital. Colombo Harbour has 2 special oil jetties, which are connected by a 5-mile pipeline to the main Oil Storage Installations at Kolonnawa, on the eastern boundary of Colombo City. The three oil companies had storage facilities on contiguous sites within the main Kolonnawa Installation and had, together, a total tank capacity of over 300,000 tons for all fuel products. From Kolonnawa supplies were made to all service stations, kerosene (paraffin) agencies, consumer points, etc., either by road tankers, railway wagons or pipelines, direct or through one of several intermediate storage depots all of which were fed by rail.

6.1.2.1. There was no movement of product from Kolonnawa by inland waterway, nor is any such movement likely in the foreseeable future. The only possibility of trans-shipment by water is by the use of coastal tankers to supply Ceylon's second oil port, Trincomalee, or any other future sub-installation.

6.1.3. In 1964, the Ceylon Petroleum Corporation acquired all those assets of the three oil companies which were used for the inland distribution of all petroleum products. The companies now remain with only an interest in the import and distribution of aviation and marine fuels and lubricants.

6.1.3.1. This step meant that one organisation had to maintain and operate as one network three separate and independent distribution systems which had been run in active competition with each other. This meant that there was triplication of facilities right down the line.

6.1.3.2. It is here that the need is acutely felt for drastic rationalisation. However desirable this may be from a cost angle, due attention has to be paid to the broader social and even political aspects of pruning away redundant facilities and reshaping the balance of the system. It is in this context that this project has been undertaken.

DESCRIPTION OF NETWORK

6.1.4. The hub of Ceylon's petroleum distribution network is the main installation at Kolonnawa, just outside Colombo City. All product consumed in the island has to pass through Kolonnawa after being discharged at Colombo Harbour. (The only exceptions are certain quantities of bunker fuels stored and issued from Bloemendhal Terminal; supplies for a thermal power station which by-pass Kolonnawa, and the small quantities that are discharged at Trincomalee, on Ceylon's North-East coast).

Ceylon's first oil refinery, sited at Hapugaskande, about 9 miles north-east of Colombo, is due to be commissioned in July 1969. Imports would then be switched from refined products to crude oil. However, the inland distribution system would suffer no change and Kolonnawa will continue to be the main supply centre for all products.

6.1.4.1. Kolonnawa Terminal, now almost entirely the property of the Ceylon Petroleum Corporation, is well equipped with modern storage facilities, and road and rail loading equipment. It also houses a lubricating oil blending and packing plant and a candle factory. It has a large maintenance workshop and a modern garage.

6.1.4.2. Fuel products leave Kolonnawa Terminal by road tankers, railway tank wagons, pipelines or packed in drums. The latter means is used mostly by retail dealers who are permitted to pick up their requirements of fuels from the main installation. This is a concession that was granted many years ago mainly to enable road haulers bringing export commodities to Colombo to have a return load on their homeward journeys. This step proved beneficial all round since most haulers were prepared to charge low freight rates for such return loads, and this benefit was often passed on to the consumer. This concession also meant that there was a second avenue of transportation (other than that of oil companies, later the C.P.C.) available for the inland distribution of fuel products.

6.1.4.3. Customers, other than those who pick up their requirements direct from Kolonnawa, are supplied either by road, rail or pipeline. There are only a few large volume customers who fall into the latter category and since their supply arrangements have proved entirely satisfactory, will not be considered in this analysis. This leaves only those customers who are supplied by road or by rail.

6.1.4.4. As in most other countries, rail freight rates in Ceylon are, by and large, lower than road haulage rates, the differences increasing with distance. The difference becomes doubly significant when the distance by road is so great that the driver either has a rest period(during which time the vehicle is idle) or is replaced by another (thus increasing the cost of lorry operations). In addition the railway tariff is such that differential freight rates are charged according to the flash point of the product carried. Thus the rates for gasolines, kerosene/high speed diesel and fuel oils are approximately in the ratio 13:8:7. Since the road haulage rate is constant for all fuels (vehicles are loaded according to volume and not weight - therefore the same rate applies), there is every benefit to transfer haulage of all products and particularly the high flash point materials, to rail wagons. This fact is recognised by arranging transport to all intermediate storage points by rail. The final lap is, as usual, by road.

6.1.4.5. The situation is one in which the bulk of the customers obtain product by rail wagon or road tanker direct from Kolonnawa or by road tanker from one of the depots which is fed by rail from Kolonnawa.

INTERMEDIATE STORAGE POINTS

6.1.5. The depots, in co-ordination with Kolonnawa, perform a vital part in the distribution system. The points that are now operated by the C.P.C. are those that were built and used by the oil companies. Since each company was independent of the other two, there were three systems of these depots. The different market shares and varying policies of the companies resulted in 3 dissimilar networks. The following table sets out the details of these networks.

DEPOT SYSTEMS OPERATED BY THE 3 OIL COMPANIES BEFORE 1962

Company	Depot	Distance from Kolonnawa Rail miles
SHELL	Peradeniya	71.1
	Kotagala	111.3
	Haputale	153.5
	Kurunegala	58.5
	Anuradhapura	126.6
	Kilinochchi	205.0
	Jaffna	245.6
	Galle	72.1
	Matara	98.6
	Batticaloa	217.3
	Ratnapura	64.3
CALTEX	Matara	98.6
	Jaffna	245.6
	Peradeniya Junction	70.5
STANVAC	Jaffna	245.6
	Batticaloa	217.3

The location of these depots is indicated in Map No. 1.

6.1.5.1. Shell had a very large network which was created for 2 main reasons. They were

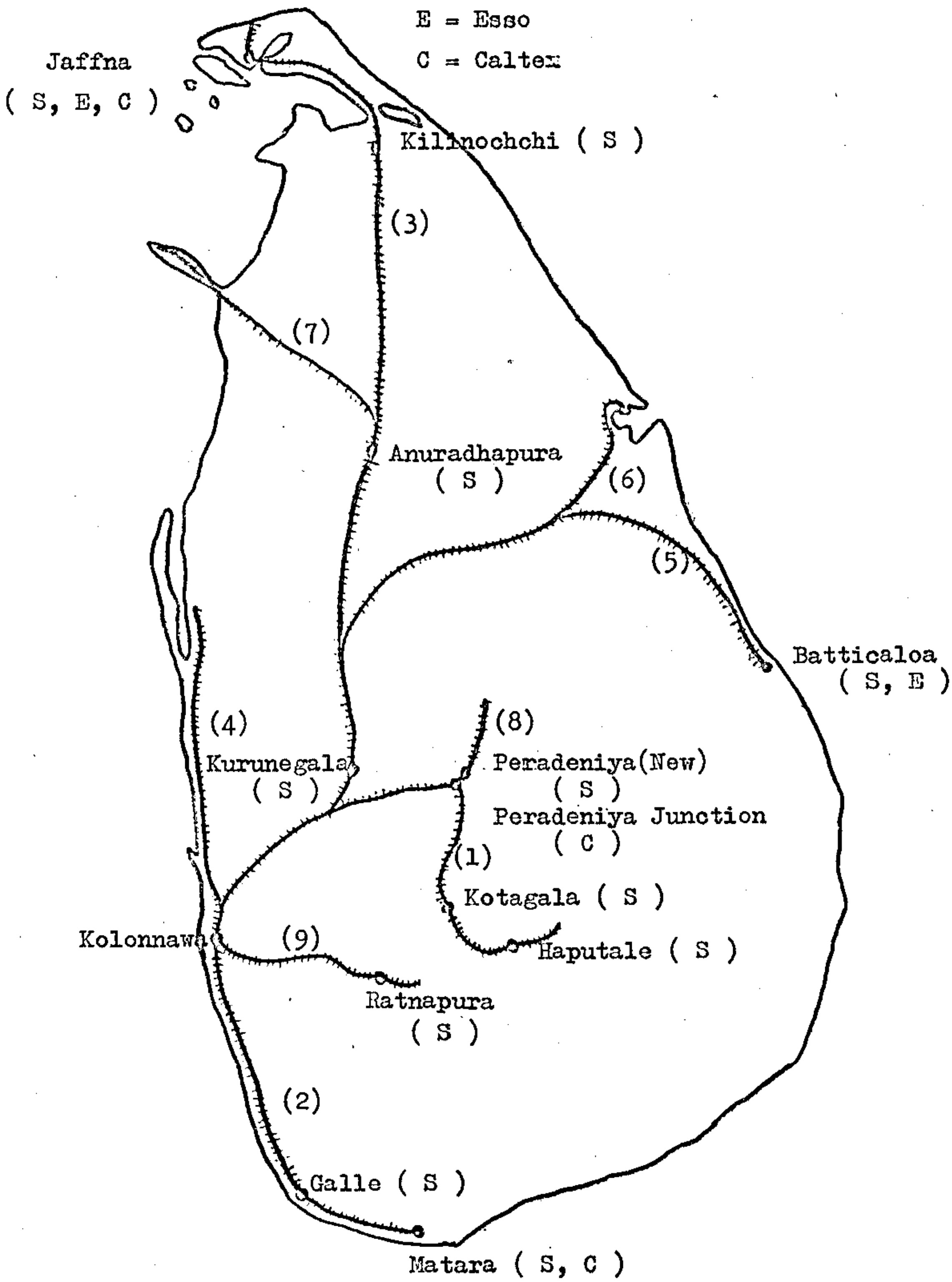
a) Shell's participation in the market was about 55%. (Stanvac had just over 23% while Caltex had about 22%).

b) Shell had foreseen the possibility that the Government would enact legislation to limit the radius of operations of a tank lorry to about

Map No. 1

LOCATION OF OIL COMPANY BULK DEPOTS

S = Shell
E = Esso
C = Caltex



65 miles. Map No. 1 shows the relative positions of their depots.

6.1.5.2. The establishment of 5 Shell depots (Peradeniya, Kotagala, Haputale, Ratnapura and Kurunegala) in the central part of the island was to facilitate the supply of diesel oil and fuel oil to the tea and rubber factories in this area.

6.1.5.3. Stanvac and Caltex preferred to operate with 2 and 3 depots respectively and resorted to long distance road haulage to bridge the other gaps.

6.1.5.4. When the C.P.C. commenced monopoly distribution in the country, they acquired all these depots. One town, Jaffna, had 3 separate oil depots. They were on adjacent sites and were combined to operate as one. In other towns, 2 depots were combined.

6.1.5.5. The following table gives the locations of the depots now operated by the C.P.C. The locations are marked on Map No.2.

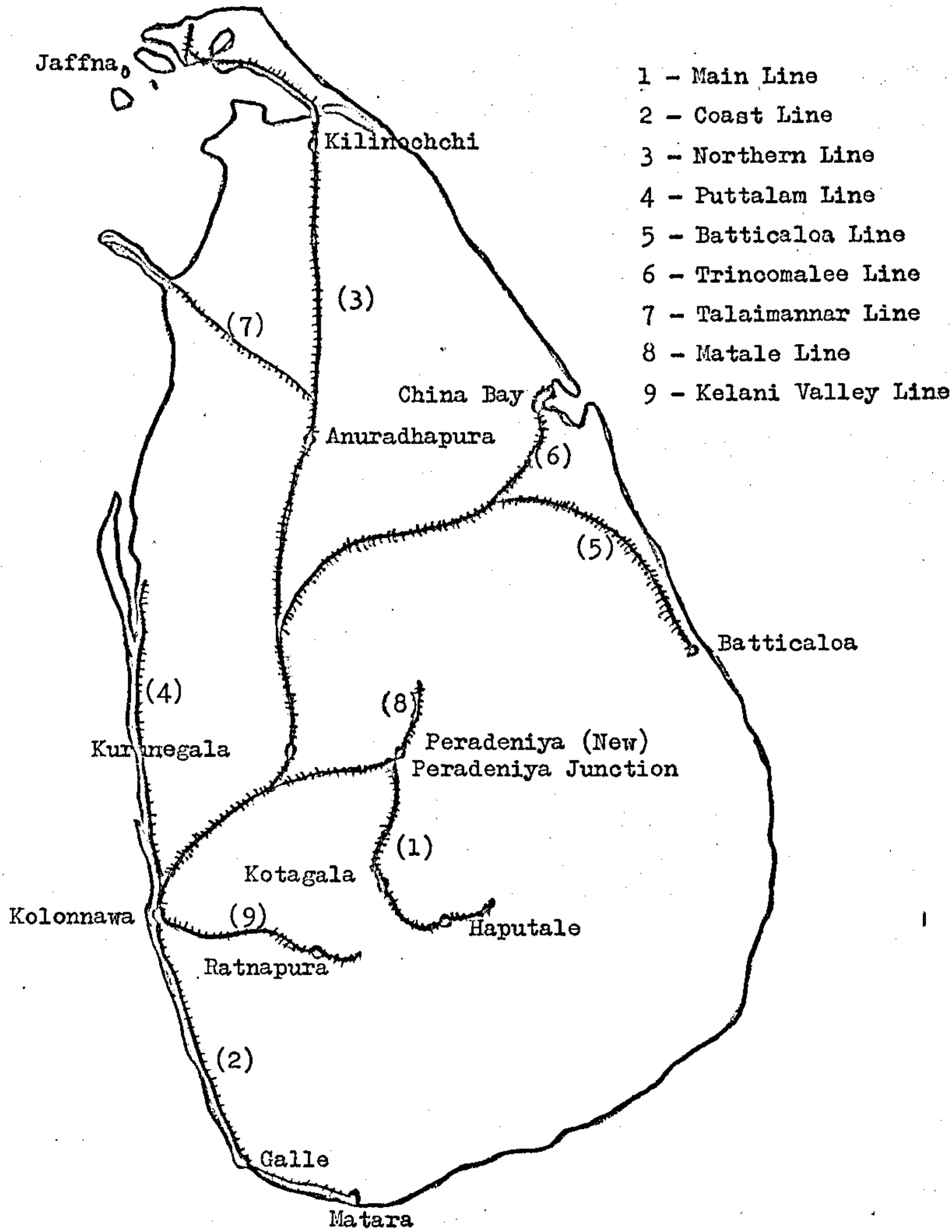
LOCATION OF CEYLON PETROLEUM CORPORATION BULK DEPOTS

Town	Distance from Kolonnawa Rail miles
Peradeniya	71.1
Kotagala	111.3
Haputale	153.5
Kurunegala	58.5
Anuradhapura	126.6
Kilinochchi	205.0
Jaffna	245.6
Galle	72.1
Matara	98.6
Batticaloa	217.3
Ratnapura	64.3
Peradeniya Junction	70.5

6.1.5.6. In addition, several large customers, particularly of kerosene, diesel and fuel oils, are supplied by rail tank wagons. These

Map No. 2

LOCATION OF CEYLON PETROLEUM CORPORATION BULK DEPOTS



customers will not be dealt with in this study because rail is the cheapest feasible method of transport and any alteration in supply arrangements would increase costs. It is most unlikely that their throughput will rise to those levels which would warrant the installation of pipelines, and since water borne transport is impossible due to location, the present means of transport will continue well into the future.

DEMAND PATTERN

6.1.6. Having seen what the distributive network looks like, it is now appropriate to study the pattern of consumption, and therefore, demand.

The C.P.C. has for accounting purposes divided its customers into the following categories:-

1) Petrol Stations
2) Kerosene Agencies
3) Estates
4) Private Industries
5) Government Departments/Corporations
6) International customers
7) Others (unclassified)

PETROL STATIONS

(7)

6.1.6.1. There are about 650 petrol stations now being supplied by the C.P.C. A few marginal outlets that were being maintained purely for prestige reasons by oil companies died a natural death when brand competition was removed.

6.1.6.1.1. These outlets are country-wide and form a very effective network which satisfies all motorists in the country. In fact, there seems to be an excess of outlets, particularly in certain built-up areas, where previous brand competition has resulted in an unnecessary duplication of outlets. However, the C.P.C. was forced to take over all oil company outlets and keep them supplied with products. Compulsory closure brings other problems in its wake, and has, for the moment, been shelved.

6.1.6.1.2. The average petrol station has bulk storage facilities for 2 grades of petrol, high speed diesel (DERV), and kerosene. Some outlets also store diesel fuel, particularly in the estate areas. About 150 petrol stations also offer specialised lubrication facilities.

KEROSENE AGENCIES

6.1.6.2. In addition to the petrol stations offering kerosene for sale, there are about 225 (7) specialised kerosene agencies offering only this product.

6.1.6.2.1. At the moment, kerosene is the most important petroleum fuel in Ceylon. The demand for it is island-wide and this requires a distributive network which is equally spread out. In addition to this there is another important factor, namely, the consumer of kerosene is not mobile. He requires the product for use in his home and demands that it be brought to him rather than going out for it as does a motorist for petrol. This point too means that the network has to be further spread out to ensure that there is a source of kerosene within easy reach of almost every household in the country. This is clearly a difficult task, and the C.P.C. and the kerosene agents have appointed several sub-agents, generally small shop-keepers in every village. These sub-agents are supplied by the agents and they in turn supply the ultimate consumers.

6.1.6.2.2. It is beyond the scope of this study to describe the various means of transportation of kerosene, but mention must be made of the kerosene tank cart. This is essentially a metal drum of 60 to 150 gallons capacity mounted on a wooden or metal chassis. It is fitted with two large wooden wheels with metal tyres, and is drawn by one or two bulls. There are about 2000 tank carts plying in Ceylon and they perform an invaluable task in making kerosene available at each consumer's doorstep.

6.1.6.2.3. The facilities available at the average kerosene agency are a 2000 gallon tank, a pump or other measuring device, and a few tank carts.

ESTATES

(7)

6.1.6.3. There are over 1000 estates in Ceylon consuming a considerable quantity of fuels, mainly diesel oil and fuel oil. Of the main crops, tea and rubber require the largest amounts of fuel for processing. Due to the topography of the island and due to the fact that both tea and rubber grow best in the hilly areas, there is a concentration of tea and rubber estates in the central part of Ceylon. This has localised the areas of demand, and special facilities were installed to cope with this.

6.1.6.3.1. In addition to the 5 bulk depots mentioned earlier, which supply many estates direct, there are several rail-fed dealer operated outlets which supply mainly diesel oil to the estates. The throughput at many of these outlets is considerable, and all supply is at the lowest rate in the railway tariff. These outlets too will not be included in this study.

PRIVATE INDUSTRIES

6.1.6.4. The fourth category of customers covers all types of industry in the private sector. There is a concentration of these industries in and around Colombo and the supply of fuels is no great problem. Most of them are supplied by road tanker, while the smaller consumers pick up their requirements from Kolonnawa Installation. Similar arrangements exist for the industries which are located within the delivery zones of the bulk depots.

GOVERNMENT DEPARTMENTS/CORPORATIONS

6.1.6.5. The next category of consumers in Ceylon covers all

Government departments and Government-sponsored Corporations. These include the Railway, the state passenger transport company, electricity and water departments, cement factories, etc.

The locations of these outfits is scattered throughout the country. The method of supply depends to a large extent on the volume; the larger customers are supplied by pipeline or by rail tank wagon, while the others are supplied in road tankers from Kolonnawa or from one of the bulk depots.

INTERNATIONAL CUSTOMERS

6.1.6.6. This is a very small group of customers. Their requirements, mainly of marine bunkers, are met by the use of a well-equipped bunkering barge in Colombo Harbour, or by direct alongside bunkering at Trincomalee. In both cases fuels are sent to the harbours by pipeline either from Kolonnawa Terminal or from Bloemendhal, or from the China Bay sub-installation.

OTHERS

6.1.6.7. The final category consists of all those customers not included in any of the earlier groups. Their supplies are arranged according to the volume of demand and the point of supply.

DETAILED DESCRIPTION OF THE DEMAND PATTERN FOR PETROLEUM FUELS IN CEYLON

6.1.7. For the purposes of this study, no special attention need be paid to the different categories of customers. All that is required is that one can estimate how much of each fuel is required within each town or other selected area of demand. This would give us a target to aim at, and formulate the problem which is, to transfer that amount of each fuel to each and every area of demand from the central supply point at a minimum overall cost. The degree of variability is introduced by the alternative methods of transport that are available, the differences in the costs of these methods, and the (theoretical) likelihood of locating intermediate bulk depots anywhere in the island.

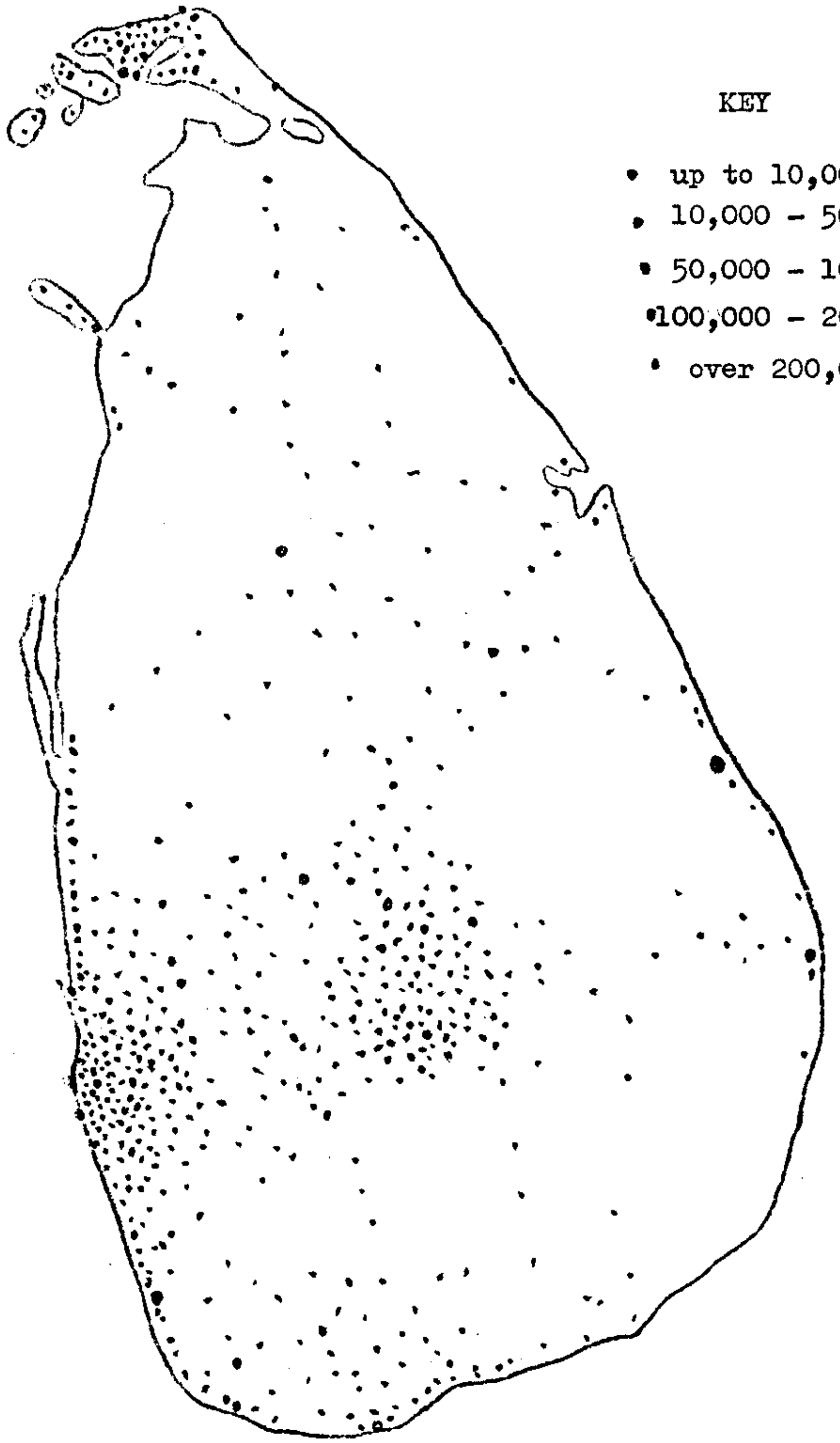
6.1.7.1. The possibilities of the last factor are reduced drastically by postulating that each and every one of these intermediate supply points should be fed from the main supply centre either by rail or by coastal tanker. (Pipelines are not being considered because the likely throughputs over the distances concerned are insufficient to justify their cost). We are thus reduced to the position where a likely bulk depot could be situated only alongside a railway line or near a port. Since the railway network in Ceylon is limited (see Map 1 or 2) 85 such points are being considered ; also, there are only 2 ports other than Colombo where facilities could be installed for reception of coastal tankers (Trincomalee and Galle). Additional ports are being developed but it is too early to consider such sites. Galle is on the railway system and will be considered for this study as a rail fed point, but Trincomalee can be water fed since all facilities exist for this operation.

6.1.7.2. Appendix C is a table which shows the island wide demand pattern for the 6 major fuels as distributed according to the location. The demand shown against each town is the total in that town for all petrol stations, kerosene agencies, estates, industrial plants and government consumers.

6.1.7.3. Map 3 shows, in the form of a colour code, the towns involved and the quantity of demand in each town. It is clear that the bulk (70%) of the total island's demand is concentrated in an arc of 60 miles radius of Colombo. However, it is equally clear that the whole island is dotted with little pockets of demand, each of which must be satisfied to maintain the effectiveness of the island's delivery system. The

Map No. 3

DISTRIBUTION OF CENTRES OF DEMAND IN CEYLON



KEY

- up to 10,000 st. gallons
- 10,000 - 50,000 -do-
- 50,000 - 100,000 -do-
- 100,000 - 200,000 -do-
- over 200,000 -do-

monopoly situation that prevails in Ceylon further accentuates this problem because there is no other supplier that the C.P.C. can fall back on. In a situation of competition, participants can stay out of certain unprofitable areas with the expectation that such areas will be adequately served by their competitors who have different networks and who find some advantage in maintaining these supplies.

6.1.7.4. Closer examination of the Table in Appendix C shows that the products with the widest spread of demand are kerosene and gasoline. This is only to be expected because these products have now become basic necessities of life. High Speed Diesel also enjoys a fair spread of demand, but such demand is mainly in the larger centres of population. Small villages do not use much HSD because they have no vehicles requiring it. The demand for Diesel Oil is almost entirely confined to the Central, North Western, Uva, Sabaragamuwa, Western and Southern Provinces, while Fuel Oil demand is still further narrowed down to the Western and Central Provinces. These features set out certain requirements of the desired distribution network. Arrangements to supply kerosene must predominate while those to supply Fuel Oil need be considered only for a few bulk depots. However, the future cannot be ignored. Due attention must be paid to how demand will be changed or created afresh in the future. The results of such an exercise (Reference 68) indicate that the same sort of demand pattern will continue and no drastic changes are likely. Such change as can be foreseen is small and will not affect any present planning.

DATA OBTAINED FOR CASE STUDY

6.2. I am indebted to numerous colleagues in the Commercial and Finance Divisions of the Ceylon Petroleum Corporation who readily supplied me with actual data and costs.

6.2.1. The information consisted of the following:- (71)

6.2.1.1. A description of the existing distributive network in Ceylon; the locations of the 14 depots, and details of the facilities installed therein. One depot, Bloemendhal, confines its activities to the supply of marine bunkers to ships in Colombo Harbour. Since pipelines supply and draw off product from it, it does not enter this analysis.

6.2.1.2. A list of the important customers of the C.P.C., by (72) name and customer number.

6.2.1.3. The addresses of each of these customers. 613 areas of demand were demarcated to cover the whole island. The boundaries used were post office areas. The list of several thousand customers was therefore reduced to 613, the weightage given to each centre of demand being the sum of the requirements of the individual customers allocated to it. (72)

6.2.1.4. A series of sales figures which established the demand for each of the customers. Data for several months in 1967 were averaged out to give a realistic estimate of monthly demand.

6.2.1.5. Further information regarding the method and source of supply of customers' demand. Sales figures were broken down as follows:-

Product	Customer Number	Source of Supply	Quantity Supplied: Deliveries (CPC lorry)	Collections (Customers' vehicles)	Rail/pipeline

6.2.1.5.1. "Deliveries" cover those quantities which are moved in C.P.C. tank lorries from Kolonnawa or a depot to a customer. In other words, the customer obtains supplies at his own doorstep and the responsibility for transportation rests solely on the Corporation.

6.2.1.5.2. "Collections" represent those quantities which are drawn by the customer in his own containers/vehicles from the loading gantries at Kolonnawa or one of the depots. The responsibility of the Corporation ceases when it makes product available at the gantry and it is the customer's responsibility from then onwards.

6.2.1.5.3. Rail and pipeline deliveries are considered to be outside the scope of this study.

6.2.1.6. Cost figures in respect of Kolonnawa and the bulk depots.(71) These costs were broken down into several headings, which had to be put together again to give fixed and variable costs.

6.2.1.7. Costs of operating the Corporation's fleet of tank lorries.(71)

6.2.1.8. Costs of transporting various fuel products by rail(73) from Kolonnawa to a number of existing rail fed points. These points included all the existing bulk depots and some of the proposed locations.

6.2.1.9. The freight tariff published by the Ceylon Government Railway.(74)

6.2.1.10. Data(73) for conversion of all fuel products into "standard gallons" or "kerosene equivalents".

6.2.2. There are 14 depots in the present network. They are Matara, Kotagala, Haputale, Peradeniya Junction, Batticaloa, Kurunegala, Anuradhapura, Jaffna, Ratnapura, Galle, Kilinochchi, New Peradeniya, China Bay and Bloemendhal. (see Map No. 2). The last has been excluded from our study for the reason given in section 6.2.1.1.

6.2.2.1. Most of the above locations consist of complexes of former oil company depots. e.g., Jaffna consisted of 3 bulk depots; Matara was 2 bulk depots and a dealer point; and Batticaloa was 2 bulk depots.

6.2.2.2. China Bay depot is a part of the enormous oil storage installation (102 tanks of 12,000 tons each - a total of over 1.2 million tons capacity) built by the Royal Navy to serve the British East India Fleet which was based at Trincomalee (China Bay) during and after World

War I. The entire installation was purchased from the Admiralty by the Ceylon Petroleum Corporation in 1964 and a small part of it is being operated as the China Bay depot. Supplies to this depot are made by ocean/coastal tanker and the modified supply costs have been incorporated in the data.

6.2.3. The list of customers was most comprehensive. It gave their names and addresses, as well as customer numbers. In addition to providing useful background information, it served the specific purpose of providing a bridge between customers and centres of demand. Appendix "C" gives details of how this operation was carried out. The list of customers is not reproduced here.

6.2.4. It must be emphasised that the demand figures used in this study are estimates for 1977 based on actuals for 1967. The demand beyond 1977 is more likely to be affected by the broad patterns of economic and industrial development in Ceylon and it may not be prudent to assess such changes at this stage. It is theoretically possible to predict demand as far as say 1987, bit since their reliability would be in doubt, they would not serve any useful purpose now. I have based my forecasts upon a special report[68] on demand for petroleum products in Ceylon prepared in 1968. This states that the total demand would rise at an annual rate of 5.6% over the next decade.

(It has been shown in repeated runs that the estimated demand can show considerable changes without significantly affecting the ultimate solution. Since there is no reason to expect large variations in either the pattern or distribution of demand, it was deemed adequate to work on the basis set out above).

6.2.5. When dealing with the fixed and operating costs of existing depots, I encountered the common problem of making an accurate estimate of these costs. The case study presents unusual complications.

Only a very small proportion (less than 5 %) of the present fixed assets of the Corporation were erected from scratch. The balance was vested in the Corporation by Act of Parliament, which acquired the assets of the oil companies. Once acquisition was completed, the oil companies were invited (11) to claim compensation for the sites they had lost. Claims were received, studied and lengthy negotiations were entered into to reach a compromise that would be acceptable to all parties concerned. The agreement that was finally reached was on the basis that no individual assets would be valued. Lump sums were fixed for each of the three companies, and payment made thereafter.

6.2.5.2. It was then left to the Corporation to decide upon the exact valuation which would be placed against the individual items in its books. Since such a step would have involved long-drawn out and expensive procedures, the Corporation too decided to adopt the "bulk" approach.

6.2.5.3. The total compensation figure was divided arbitrarily to cover storage/handling facilities (including Kolonnawa Terminal and the bulk depots), vehicles (mainly tank lorries), and the other physical assets (mainly land and equipment at petrol stations, etc.).

6.2.5.4. The value thus set for storage facilities was again divided arbitrarily to obtain individual valuations for Kolonnawa and each of the depots. The basis used was the proportions of effective tankage available at these points. Thus, in a total of 100 tons acquired, a depot containing 10 tons was valued at twice the amount set for one containing 5 tons, the former being valued at 10% of the value of all storage/handling facilities.

6.2.5.5. The amounts obtained in this manner were taken to be the cost of each of these depots, and was capitalised accordingly. These values would bear little relationship to original costs of construction written down to the date of acquisition. In the first instance it would not be easy to determine the element of depreciation and regular maintenance would have complicated matters further. They could also not be considered to be replacement costs as present-day construction would be more expensive.

6.2.5.6. These capital costs have been amortised in a straight line over periods of up to 20 years, in a manner deemed by the Corporation to be reasonable. General administration costs, maintenance and the salaries of basic staff have also been included in fixed costs.

6.2.5.7. In the case of operating costs too, we have the difficulty of preparing accurate estimates of operating expenditure for the different activities/locations. While accepting there would be some degree of arbitrariness in the cost allocations made by the Corporation's accountants (which would only be natural), I believe that their figures are adequate for my purpose and have accepted them in toto. However, I take full responsibility for the manner in which I have segregated them to obtain fixed and operating costs.

6.2.5.8. There is one point that must be emphasised here regarding both fixed and operating costs, that is, that I have used cost figures collected in 1967 together with demand figures projected for 1977. There is no doubt at all that costs will change between 1967 and 1977, but the change will be common to all activities/locations. I am assuming, therefore, that it will not be necessary to forecast changes in costs over the decade, and am using 1967 costs throughout the analysis. This does not represent a weakness in the optimisation technique; it is merely a convenient short cut. The approximation means that the absolute solution (in terms of costs) will not be correct, but the other aspect of the solution, namely, the ideal pattern of distribution, would most certainly be so.

6.2.6. I have selected the proposed depot locations on the following considerations:-

6.2.6.1. Each of them is on an existing railway line . Some of the locations, e.g., Hatton, Wattegama, Lunuwila and Badulla, already contain dealer-operated points, fed by rail from Kolonnawa. If such a subject is located by this study, its conversion/expansion into a fully fledged Corporation-operated bulk depot will not be difficult.

6.2.6.2. I have been restricted to railside locations because neither pipelines nor inland waterways are at present feasible for the movement of petroleum fuels in Ceylon.

6.2.6.3. Each of the sites selected is also a demand centre, and will have a "home" throughput which will serve as a stabiliser for the potential depot.

6.2.6.4. The sites are situated at an average about every 8 to 10 miles on the railway lines. The Main Line (linking Badulla and the central highlands with Colombo) is just over 180 miles long and has the following depots, existing and potential:-

Ragama Junction (potential)	9.3	rail miles from Kolonnawa
Gampaha (potential)	16.45	- do -
* Veyangoda (potential)	22.59	- do -
* Mirigama (potential)	30.59	- do -
Alawwa (potential)	40.29	- do -
* Polgahawela Junction (potential)	45.39	- do -
Rambukkana (potential)	52.16	- do -
* Kadugannawa (potential)	65.5	- do -
Peradeniya Junction (Existing)	70.51	- do -
* Gampola (potential)	78.3	- do -
Nawalapitiya (potential)	87.34	- do -
* Watawala (potential)	100.18	- do -
* Hatton (potential)	108.21	- do -
Kotagala (Existing)	111.3	- do -
* Talawakelle (potential)	115.74	- do -
* Watagoda (potential)	120.14	- do -
* Nanu-oya (potential)	128.11	- do -
Ambawela (potential)	137.13	- do -

Haputale (Existing)	153.48 rail miles from Kolonnawa	
* Bandarawela (potential)	160.63	- do -
Demodara (potential)	172.73	- do -
*Haliela (potential)	177.69	- do -
* Badulla (potential)	181.38	- do -

6.2.6.5. The Coast Line, just under 100 miles long, has the following locations:-

Moratuwa (potential)	13.34 rail miles from Kolonnawa	
Panadura (potential)	17.18	- do -
Wadduwa (potential)	21.64	- do -
* Kalutara South (potential)	27.55	- do -
Alutgama (potential)	38.55	- do -
* Ambalangoda (potential)	53.9	- do -
Hikkaduwa (potential)	60.41	- do -
Galle (Existing)	72.15	- do -
Habaraduwa (potential)	78.5	- do -
Weligama (potential)	90.5	- do -
Matara (Existing)	98.63	- do -

6.2.6.6. The Northern Line commences at Polgahawela Junction (on the Main Line) and extends to over 250 miles from Kolonnawa. It has the following points:-

Kurunegala (Existing)	58.54 rail miles from Kolonnawa	
Maho Junction (Potential)	85.42	- do -
Galgamuwa (potential)	98.79	- do -
Anuradhapura (Existing)	126.6	- do -
Madawachchiya Junction (potential)	142.7	- do -
Vavuniya (potential)	157.36	- do -
Mankulam (potential)	185.6	- do -
Kilinochchi (Existing)	205.0	- do -
Elephant Pass (potential)	214.3	- do -

Pallai (potential)	221.78 rail miles from Kolonnawa	
Chavakachcheri (potential)	236.0	- do -
Jaffna (Existing)	245.63	- do -
Chunnakam (potential)	251.53	- do -
Kankesanturai (potential)	256.57	- do -

It will be seen that the distances between adjacent sites are higher than the average on the Main and Coast Lines. This is because the Northern Line passes through relatively undeveloped country and the population, and the demand for petroleum, is spread relatively thin.

6.2.6.7. The Puttalam Line commences at Ragama Junction (on the Main Line) and extends to over 85 miles from Kolonnawa. It has

Ja-ela (potential)	13.5 rail miles from Kolonnawa	
* Negombo (potential)	23.46	- do -
* Lunuwila (potential)	33.2	- do -
* Madampe (potential)	44.15	- do -
Chilaw (potential)	50.58	- do -
Battuluoya (potential)	62.4	- do -
Puttalam (potential)	85.1	- do -

6.2.6.8. The Batticaloa Line starts from Maho Junction (on the Northern Line) and extends to over 215 miles from Kolonnawa. It has

Kekirawa (potential)	116.28 rail miles from Kolonnawa	
Habarana (potential)	129.62	- do -
Galoya Junction (potential)	140.2	- do -
Hingurakgoda (potential)	150.7	- do -
* Polonnaruwa (potential)	161.3	- do -
Welikanda (potential)	177.4	- do -
Valaichchenai (potential)	198.27	- do -
Eravur (potential)	209.39	- do -
Batticaloa (Existing)	217.27	- do -

6.2.6.9. The Trincomalee line commences at Galoya Junction (on the Batticaloa Line) and extends to over 180 miles from Kolonnawa. It has the following locations:-

Kantalai (potential)	158.39 rail miles from Kolonnawa
China Bay (Existing)	179.44 - do -

(but supplies are made by ocean/coastal tanker, not by rail)

* Trincomalee (potential)	183.54 rail miles from Kollonawa

6.2.6.10. The Talaimannar line starts from Madawachchiya Junction (on the Northern line) and extends to over 200 miles from Kolonnawa. It has the following sites:-

Madhu Road (potential)	169.38 rail miles from Kolonnawa
Murunkan (potential)	177.42 - do -
Mannar (potential)	191.77 - do -
Talaimannar (potential)	207.18 - do -

6.2.6.11. The Matale line (supplying the northern part of the central highlands) starts at Peradeniya Junction (on the Main line) and extends to over 90 miles from Kolonnawa. It has the following sites:-

New Peradeniya (Existing)	71.11 rail miles from Kolonnawa
* Kandy (potential)	74.41 - do -
Katugastota (potential)	77.46 - do -
* Wattegama (potential)	82.4 - do -
* Matale (potential)	91.6 - do -

6.2.6.12. Finally, the Kelani Valley line (a narrow guage line, as opposed to the others which are of standard broad guage), which extends from Kolonnawa to a distance of over 85 miles. It has the following sites:-

Pannipitiya (potential)	11.16 rail miles from Kolonnawa
Homagama (potential)	15.7 - do -
Padukka (potential)	22.41 - do -
Avisawella (potential)	37.33 - do -
Eheliyagoda (potential)	46.36 - do -
Kuruwita (potential)	56.68 - do -
Ratnapura (Existing)	64.29 - do -

* Kahawatta (potential)	81.41 rail miles from Kolonnawa
* Opanaike (potential)	85.79 -do-

The facilities available by way of rolling stock, etc., on this line are somewhat limited. This may set a constraint on the feasibility of the sites listed above. The special loop described in section 5.8. has proved its value in handling this type of situation. Appendix "D" contains the result of a run which has been set up excluding all 9 depots (using section 5.5.6.3.6.) on the Kelani Valley line. The difference is clear. Further comments are made on this subject when discussing the results of this study.

6.2.6.13. All the depots mentioned above have been marked on Map No.4. Asterisks (*) have been used to denote those locations which already contain dealer operated railside depots.

6.2.7. In determining operating costs of the proposed depots, it was assumed that they would all be more efficient than the existing ones. They would therefore be assigned lower operating costs.

6.2.7.1. The new depots would be designed with the new circumstances in mind, namely, they would have to serve a monopoly supplier, who would have to tackle the entire distribution effort unaided by competitors.

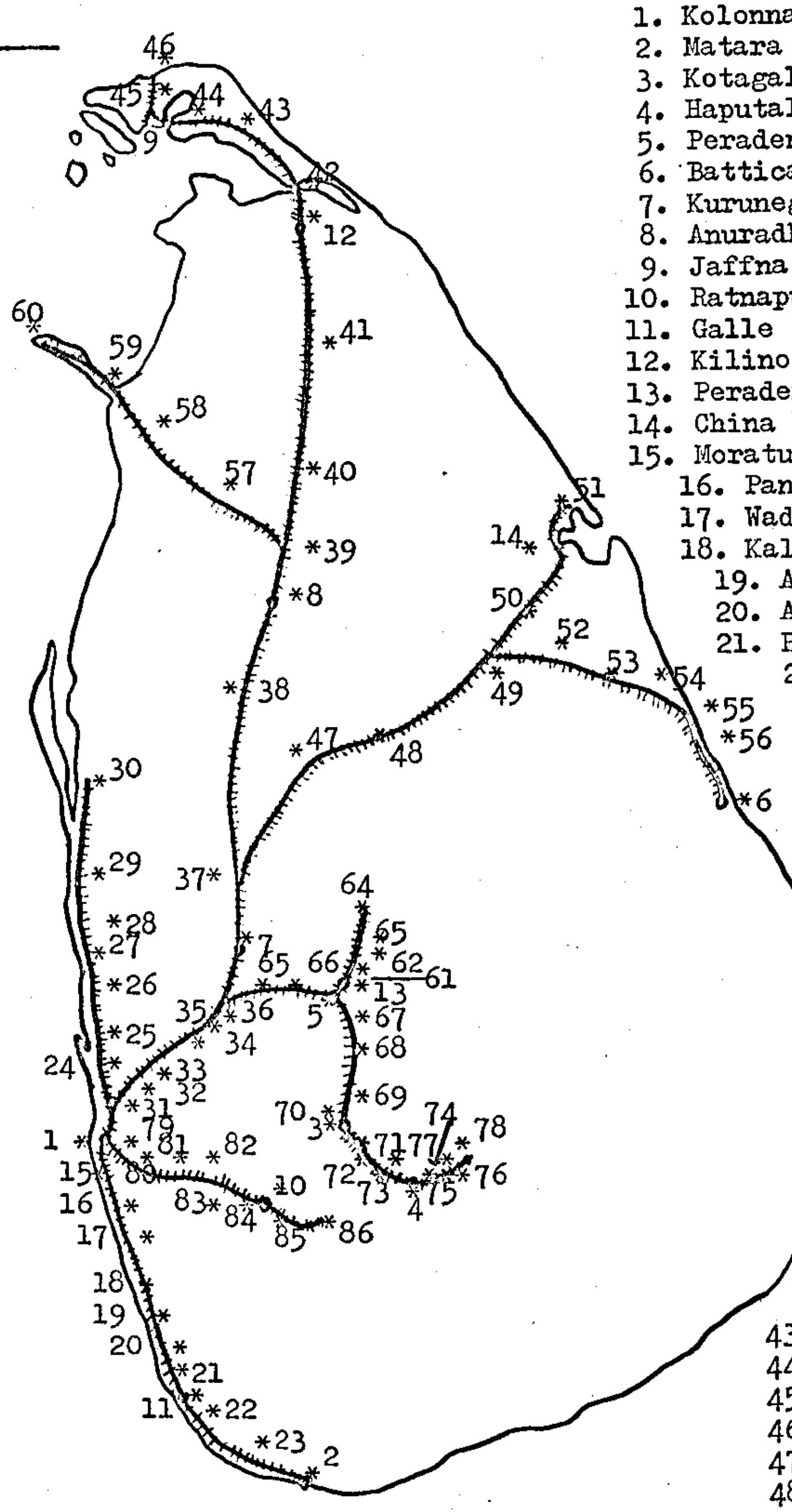
6.2.7.2. They would be designed from grass roots. Every modern development both in equipment and layout would be incorporated in the plans.

6.2.7.3. Likely increases in throughput may bring with them the benefits of economies of scale.

6.2.7.4. Accordingly, a review was made of the present operating costs of all the depots. It was noted that Peradeniya Junction, with the highest throughput of all depots has the lowest operating cost - Rs. 0.0083 per imperial gallon. It was decided thereupon that the new depots would be arbitrarily assigned an operating cost of Rs. 0.0080 per imperial gallon. This figure would hold even if the throughput fell below that of Peradeniya Junction, confirming thereby that the new depots would be more

Map No. 4

LOCATION OF THE 85 DEPOTS BEING TESTED.



KEY

1. Kolonnawa
2. Matara
3. Kotagala
4. Haputale
5. Peradeniya Junction
6. Batticaloa
7. Kurunegala
8. Anuradhapura
9. Jaffna
10. Ratnapura
11. Galle
12. Kilinochchi
13. Peradeniya (New)
14. China Bay
15. Moratuwa
16. Panadura
17. Wadduwa
18. Kalutara
19. Alutgama
20. Ambalangoda
21. Hikkaduwa
22. Habaraduwa
23. Weligama
24. Ja-ela
25. Negombo
26. Lunuwila
27. Madampe
28. Chilaw
29. Batttuluoya
30. Puttalam
31. Ragama
32. Gampaha
33. Veyangoda
34. Mirigama
35. Alawwa
36. Polgahawe
37. Maho
38. Galgamuwa
39. Madawachch
40. Vavuniya
41. Mankulam
42. Elephant Pass
43. Pallai
44. Chavakachcheri
45. Chunnakam
46. Kankesanturai
47. Kekirawa
48. Habarana
49. Galoya
50. Kantalai
51. Trincomalee
52. Hingurakgoda
53. Polonnaruwa
54. Welikanda
55. Valachchenai
56. Eravur
57. Madhu Road
58. Murunkan
59. Mannar
60. Talaimannar
61. Kandy
62. Katugastota
63. Wattegama
64. Matale
65. Rambukkana
66. Kadugannawa
67. Gampola
68. Nawalapitiya
69. Watawala
70. Hatton
71. Talawakelle
72. Watagoda
73. Nanu Oya
74. Ambawela
75. Bandarawela
76. Demodara
77. Hali-ela
78. Badulla
79. Pannipitiya
80. Homagama
81. Padukka
82. Avisawella
83. Eheliyagoda
84. Kuruwita
85. Kahawatta
86. Opanaike

efficient than the existing ones.

6.2.8. In the case of fixed costs, however, a more complex method had to be used. While it seemed reasonable enough to assume that the operating costs of new depots would not be too far deviant from those of the existing ones, a similar assumption could not be made regarding fixed costs. In the first instance, the costs of existing depots were fixed empirically. Section 6.2.5. described how this was done.

6.2.8.1. New depots had to be treated afresh. The basic assumptions were i) fixed cost would be a function of expected throughput (this is reasonable), and

ii) the location of a depot would not affect its fixed cost. (I have ignored the fact that transport costs of materials, etc., would increase with distance from Kolonnawa with the expectation that this increase would be offset by the reduction in cost of land).

6.2.8.2. For convenience, I have assumed a first order relationship between throughput and fixed cost. It must be admitted that this may not be completely realistic, but the computer program has been written in such a way that any other relationship can be easily substituted.

The expression that has been used has been

$E = P \times .001 + 7000$, where E is the monthly fixed cost in rupees, and P is the monthly throughput in standard gallons.

The justification for the use of Rs. 7000/- as the fixed element of fixed cost is based upon the fact that this amount will include a) the recurring fixed costs, such as salaries

b) the amortisation element of the initial capital cost

and c) a reasonable interest on this amount (opportunity cost).

My assumptions are

i) the accounting procedures are based on a monthly evaluation/adjustment of the capital sum outstanding,

ii) an equal monthly withdrawal of cash to reduce the capital balance outstanding and to the accumulation of the "opportunity interest",

iii) an opportunity cost of 5%. This may seem low in comparison with rates prevailing in Britain. However, considering the situation in Ceylon and the present policy of the Corporation, it is quite reasonable.

6.2.8.3. The theoretical basis of the calculation is the standard procedure used in Discounted Cash Flow analysis.[69]

Working backwards from a hypothetical case, where the capital cost is £300 and the interest rate is r% per annum, let 3 equal annual payments of £115 offset the total liability. The sum outstanding at the beginning of the first year will be £300. At the end of the first year, after the first payment of £115, the sum outstanding is £300(1 + r) − 115. At the end of the second year the sum outstanding is £$300(1 + r)^2 - 115(1 + r) - 115$. At the end of the third year, the sum outstanding will be equal to £$300(1 + r)^3 - 115(1 + r)^2 - 115(1 + r) - 115$. Since the total liability has been wiped out by this time, this sum is equal to zero.

i.e., $$300(1 + r)^3 - 115(1 + r)^2 - 115(1 + r) - 115 = 0.$$

Dividing throughout by $(1 + r)^3$ and rearranging, we get

$$\begin{aligned} 300 &= 115/(1 + r) + 115/(1 + r)^2 + 115/(1 + r)^3 \\ &= 115(1/(1 + r) + 1/(1 + r)^2 + 1/(1 + r)^3) \\ &= 115 \sum_{i=1}^{3} (1/(1 = r)^i) \end{aligned}$$

Using new general terms, where C is the initial capital cost,

P is the equal annual payment,

n is the number of such payments,

and r is the rate of interest per annum,

$$C = P \sum_{i=1}^{n} (1/(1 + r)^i)$$

This formula was applied to a specific project in[70] Ceylon where a series of estimates was made for the construction of new depots. It was estimated that the costs would vary with the projected throughput of the depot. The findings are summarised in the table given below.

Monthly throughput (gallons)	Initial capital cost (Rupees)
500,000	825,000
750,000	875,000
1,000,000	925,000

6.2.8.5. Using an interest rate of 5/12% per month (this is assumed to be equivalent to 5% per annum) and amortisation over a period of 240 months (20 years - a reasonable estimate of the life span of the facilities involved) we get, for a throughput of 1,000,000 gallons per month,

$$925{,}000 = P\left(\sum_{i=1}^{240} (1/(1 + 5/12)^i\right)$$
$$= P\left(\sum_{i=1}^{240} (1/(1.00417)^i\right)$$

It is recognised that $(1/(1.00417)^i)$ is the summation of a geometric progression. Using the formula $= a(r^n-1)/(r-1)$, we get

$$\sum_{i=1}^{240} (1/1.00417)^i = 1(1/1.00417^{240} \; 1)/1/1.00417 \; - \; 1$$
$$= .7408/.004$$
$$= 185$$
$$\therefore \quad C = P \times 185$$
$$925{,}000 = P \times 185$$
$$\therefore \quad P = 5000$$

Making similar calculations for throughputs of 500,000 and 750,000 gallons per month, we get the following values of P.

Monthly throughput (gallons)	Monthly amortisation (Rupees)
1,000,000	5000
750,000	4730
500,000	4459

Using these figures and assuming that the effect of throughput is linear (this is merely for convenience. Any relationship can be used in the new technique of analysis.) I have derived the following relationship:-

$P = T \times .001 + 4000$, where T is the monthly throughput and P is the monthly amount on account of amortisation and interest. Therefore, for values of T equalling 500,000 , 750,000 and

1,000,000 we get values of P of 5000, 4750 and 4500 respectively, which are close enough to the actual values for us to accept and use the empirical relationship set out above.

This establishes the monthly contributions towards fixed cost on account of sections b) and c) of paragraph 6.2.8.2. above as $P = T \times .001 + 4000.$

6.2.8.7. Now considering part a) of section 6.2.8.2. above, we calculate the average monthly outgoings on account of salaries of basic staff. They are

Depot Superintendent	Rs. 800/-
Clerk/Typist	400/-
Labourer	200/-
Watchmen/Checkers	1000/-
Total	2400/-

This contribution does not take into account the various benefits that are extended to all employees of the Corporation. This will considered on an organisational basis, and is not included in these costs.

This alters the relationship derived in section 6.2.8.6. to read $P = T \times .001 + 6400.$

6.2.8.8. We now make provision for the monthly expenses on annual maintenance, and I have arbitrarily selected a monthly figure of Rs. 600 on this account. This brings our expression to read

$P = T \times .001 + 7000$, which is used in all subsequent calculations in the case study.

The total fixed cost for some hypothetical throughputs is

Monthly throughput (gallons)	Total fixed cost (Rupees)
300,000	7300
500,000	7500
800,000	7800
1,000,000	8000

These figures are all fully compatible with the studies made earlier by the C.P.C.

6.2.8.9. It must be noted that the salaries of lorry drivers and other additional staff will be covered by the operating costs of the depots which were set at Rs. o.0080 per gallon in section 6.2.7.4. When we bring these costs in, we get the following

Monthly throughput (gallons)	Monthly Fixed Cost (Rupees)	Monthly Operating Cost (Rupees)
300,000	7300	2400
500,000	7500	4000
800,000	7800	6400
1,000,000	8000	8000

These totals are quite adequate to cover all costs of the proposed depots.

CONVERSION OF DATA

6.3. The following sections describe how I have manipulated and converted the data I obtained from the Ceylon Petroleum Corporation.

6.3.1. Preparation of estimates of future demand from 1967 figures.

As stated earlier, the raw data consisted of sales figures categorised by product, by customer, by point of supply and by method of supply (section 6.2.1.5.). The figures had to be consolidated into the 613 areas of demand. This was done by a special computer program (described in Appendix "C") which produced results in the following layout

Demand centre   No. of customers

Standard Gallons (A)
Standard Gallons (B)
Kolonnawa Gallons (A)
Kolonnawa Gallons (B)

For example, the figures for demand centre GALLE for February 1967 were

Galle		54
Standard Gallons (A)	=	341297.39
Standard Gallons (B)	=	1605.42
Kolonnawa Gallons (A)	=	16400.00
Kolonnawa Gallons (B)	=	0.00

The detailed figures on which the above were based are

Source	Product	Method of Supply	Quantity
Kolonnawa	High Speed Diesel	Rail/pipeline	13980
Kolonnawa	Furnace Oil	Corp. Vehicle	16400
Galle	Premium Gasoline	-do-	32800
-do-	Regular Gasoline	-do-	21200
-do-	High Speed Diesel	-do-	93600
-do-	Industrial Diesel	-do-	16050
-do-	-do-	Cust. Vehicle	1620
-do-		Corp. Vehicle	43050
-do-	Kerosene	-do-	94800

The conversion to Standard Gallons and Kolonnawa Gallons is described in section 6.3.5.1. Category A denotes quantities moved in Corporation tank lorries, while category B covers quantities moved in customers' containers and vehicles.

6.3.1.1. Similar studies were made for several months and their results used to form an estimate of average monthly demand for the 613 centres of demand.

6.3.1.2. Once average monthly demand had been obtained in "standard" and "Kolonnawa" gallons, they were adjusted to 1977 by a simple compounding process (based on the annual growth of 5.6% derived from the report referred to in section 6.2.4.)

Appendix "C" contains a list of the 613 centres of demand and their estimated throughputs in 1977. These figures were used as a direct input for the computer program (section 5.2.4.).

6.3.2. Determination of Main Sources of supply. The consolidation sub-routines described in section 5.4. and Appendix "C" gave a basis for the determination of the main source of supply to each demand centre. For example, Galle had supplies from Kolonnawa and Galle depot. Similar information was extracted for all centres of demand. Small approximations were necessary in the isolated cases where supplies were made from more than one depot in addition to Kolonnawa. (This is not due to supply of product to one customer from more than one source, but due to the fact that each centre of demand has several customers, 54 in the case of Galle, and each customer need not follow the general pattern).

This information was used to calculate the cost of the present system of distribution (see section 5.4.).

6.3.3. Fixed and Operating costs of Kolonnawa and the existing depots.

Cost figures were extracted from a special report (71) prepared by the Cost Accountant of the Corporation, and were accepted without any modification. The responsibility for grouping the figures is mine. Appendix "E" gives details of the cost data.

6.3.3.1. These figures represent transactions/costs for a six-month period in 1966. Where required they have been divided by 6 to give the monthly figure.

The monthly fixed cost for each depot was obtained by adding together Administration costs, "storage and filling" depreciation, and dividing by 6.

Location		Monthly Fixed Cost
Kolonnawa	(1.562+.904)/6	Rs. 411,000
Matara	(.037+.066)/6	7,200
Kotagala	(.066+.011)/6	13,000
Haputale	(.035+.004)/6	6,500
Peradeniya Jn.	(.085+.006)/6	15,200
Batticaloa	(.029+.012)/6	7,000

Location		Monthly Fixed Cost
Kurunegala	(.047+.012)/6	Rs. 9850
Anuradhapura	(.032+.004)/6	6000
Jaffna	(.049+.007)/6	9350
Ratnapura	(.017+.001)/6	3000
Galle	(.049+.004)/6	8850
Kilinochchi	(.017+.008)/6	4200
New Peradeniya	(.021+.004)/6	4200
China Bay	(.059+.012)/6	11500

6.3.3.2. The per gallon operating cost was obtained by dividing the Storage and Filling costs (less depreciation) by the throughput (issues).

Location		Operating cost
Kolonnawa	(2.260-.904)/95.85	Rs. 0.0141
Matara	(.048-.006)/2.248	0.0186
Kotagala	(.054-.011)/3.997	0.0107
Haputale	(.038-.004)/2.065	0.0164
Peradeniya Jn.	(.049-.006)/5.131	0.0083
Batticaloa	(.051-.012)/1.774	0.0163
Kurunegala	(.048-.012)/2.876	0.0125
Anuradhapura	(.024-.004)/1.879	0.0106
Jaffna	(.044-.007)/2.981	0.0124
Ratnapura	(.025-.001)/1.035	0.0231
Galle	(.034-.004)/2.960	0.0101
Kilinochchi	(.027-.008)/0.800	0.0247
New Peradeniya	(.028-.004)/1.276	0.0188
China Bay		

Comments made in section 6.2.5. regarding derivation of these costs are very relevant and should be considered when reading these figures. They sould be compared with the figures for the proposed depots described in sections 6.2.7.4. and 6.2.8.

6.3.4. A detailed breakdown of costs was provided in respect of tank lorry operations. It has been the practice of the C.P.C. to use tank lorries of 2 standard capacities, a rigid chassis type carrying 1200 gallons and the articulated vehicle carrying 2000 gallons. The bigger lorries are used within a radius of about 50 miles from Colombo. The smaller ones are used throughout the country.

Special mention must be made of truck operating conditions in the central highlands of Ceylon. The roads are winding and in certain places very steep. Traffic is rather heavy and driving conditions are such that vehicles are subject to more than normal wear and tear. These conditions are reflected in the special provision made in costing tank truck operations in these areas. The depots that are affected by these adverse conditions are Kotagala, Haputale, New Peradeniya, Peradeniya Junction, and, to a certain extent, Ratnapura.

The costs are reproduced below:-

6.3.4.1. <u>1200 gallon tank lorries</u>

6.3.4.1.1.	Variable costs.	<u>Cost per mile - cents</u>
	i) Fuel 12 m.p.g. of Hi-speed diesel	12.75
	ii) Tyres 6 tyres per 15,000 miles	20.00
	iii) Repairs and Maintenance	30.00
		62.75
6.3.4.1.2.	Fixed Costs	<u>Cost per month - rupees</u>
	a) Depreciation i) Chassis	433.00
	ii) Tank	50.00
	b) Licences, insurance, etc.	29.00
	c) Salaries, overtime, subsistence	850.00
	d) Overheads and administration	135.00
		1497.00
		say Rs. 1500.00

6.3.4.1.3. Monthly mileage per vehicle - 3500

$\therefore$ Fixed Cost per mile = $\frac{1500}{3500}$ = Rs. 0.4286 = 42.86 cents

Total cost per mile = 42.86 + 62.75 = 105.61 cents, say 106 cents.

$\therefore$ Cost per gallon mile = 106/1200 = 0.088 cents.

The weightage given for abnormal conditions is 4/3.

$\therefore$ the corrected cost per ton mile for the 1200 gallon vehicles is

<u>0.118 cents.</u>

6.3.4.2. <u>2000 gallon articulated trucks</u>

6.3.4.2.1. Variable costs

same as for 1200 gallon vehicles - 62.75 cents per mile

6.3.4.2.2. Fixed Costs		<u>cost per month - rupees</u>
a) Depreciation	i) Tractor	433.00
	ii) Trailer/tank	189.00
b) Licences, insurance		29.00
c) Salaries, overtime, subsistence		850.00
d) overheads and administration		135.00
		1636.00

say Rs. 1640.00 per month

6.3.4.2.3. Monthly mileage per vehicle - 3500

$\therefore$ Fixed Cost per mile = $\frac{1640}{3500}$ = Rs. 0.4686 = 46.86 cents

Total cost per mile = 46.86 + 62.75 = 109.61 cents, say 110 cents.

$\therefore$ Cost per gallon mile = 110/2000 = 0.055 cents

6.3.4.3. We now have 3 sets of costs for tank lorry operations, all in cents per gallon mile. They are

1200 gallon vehicles - normal running	-	0.088 cents
-do- - abnormal conditions	-	0.118 cents
2000 gallon vehicles - normal running	-	0.055 cents

We have now to get a composite figure which will represent an average of all conditions encountered in Ceylon.

I have used the following weightages:-

1200 gallon vehicles - normal conditions - $\frac{1}{2}$

-do- abnormal conditions- $\frac{1}{4}$

2000 gallon vehicles - normal conditions - $\frac{1}{4}$

the composite figure would then be

$$\tfrac{1}{2} \times .088 + \tfrac{1}{4} \times .118 + \tfrac{1}{4} \times .055 = 0.088 \text{ cents per gallon mile.}$$

Since this is the cost per running mile, the figure used in this study is 0.176 cents per return gallon mile.

6.3.4.4. Provision for non-linearity of Road Transport costs.

It is accepted that road transport cost is non-linear with distance. This is in spite of the fact that the costs incurred in respect of the vehicle alone are almost perfectly linear. It is the effect of the idle time at both ends of the journey and the overtime/subsistence paid to the driver/s that cause non-linearity. The former causes a pleasant (convex to origin) non-linearity because the costs of loading and discharging get spread out over a greater distance and gives an inversely proportional rate per mile. However, this effect is more than offset by the way overtime/subsistence increases with distance.

6.3.4.4.1. The data set out above indicates that the salaries/overtime/subsistence element comprises over half of the fixed cost and about a quarter of the total cost. This element increases by about $1\frac{1}{2}$ times for over 8 hours work (overtime is reckoned at time-and-a-half). There would also be additional payment for subsistence.

It has been found that the average speed of a lorry (including loading and discharging time) is between 18 and 20 m.p.h. This means that a journey of up to about 60 miles would be completed in regular time. An additional 40 miles would entail payment of overtime and meal allowances, while greater distances will incur subsistence as well. The following table is used to determine the correction factor for cost per gallon mile with increasing distance:-

Distance Range	Mid-point	No. of hours	No. of over-time hours	Correction Factor
less than 60	-	-	-	1
61 to 99	80	8	-	1.05
100 to 134	117	11½	3½	1.15
135 to 174	155	15½	7½	1.3
175 to 209	193	19	11	1.45
210 to 249	230	23	15	1.65
250 to 284	268	27	19	1.75
285 to 319	303	30	22	1.85
over 320	330	33	25	2

6.3.4.4.2. I must point out that distances over about 125 miles are generally not undertaken by tank lorry. However, it is necessary to calculate the effect of longer distances for this study.

The relationship between cost per gallon mile and distance varies according to $y = mx + c$, where m is the correction factor. Since it changes value with different ranges of values of x, we have now produced the required non-linear expression, but have still maintained its validity, because the actual values of m are based on realistic cost figures.

The constant c can denote the operating cost of Kolonnawa and/or the depot, and the freight cost between Kolonnawa and the depot.

6.3.4.4.3. The same approach can be used in the general problem.

6.3.5. The next set of data that had to be converted were the costs of transporting products from Kolonnawa to the depots in tank wagons. Working from historical records, the oil companies and the C.P.C. had

agreed a set of rail freight costs with the Railway. These costs were based on the published tariff of the Railway, in which different rates are charged for different classes of goods. Unfortunately, all petroleum fuels are not grouped together. The basis of classification is the Flash Point. The relevant groups are

Group 7 - Premium and Regular gasoline - Flash point below 73°F.

Group 4 - Kerosene and High Speed Diesel - F.P. between 73° and 150°F.

Group 3 - Industrial Diesel and Furnace Oil - F.P. above 150°F.

6.3.5.1. In order to enable the conversion to "standard" gallons to be made (see section 6.3.6.) it was necessary to set up an initial relationship between (a) the products themselves on the basis of specific gravity and (b) the different groups of commodities carried by rail on the basis of relative costs.

6.3.5.2. Taking the specific gravities first (it was decided to use typical product specifications), I obtained the following ratios:-

Premium Gasoline	.9205
Regular Gasoline	.9038
Kerosene	1.0000
High Speed Diesel	1.0576
Industrial Diesel Oil	1.0653
Furnace Oil	1.1859

6.3.5.3. These figures are not specific gravities. They are the ratios of specific gravities using kerosene as a base. Since the gasolines are lighter than kerosene they have values less than 1, and, equal volumes of premium gasoline and furnace oil will have weights in the proportions of 9205:11859.

I have used kerosene as the base; it will be the "standard" product that will be used to represent all fuels in this study.

6.3.5.4. The railway tariff was also studied to get an idea of the variation in cost for the 3 groups of product in the 9 separate railway lines described in section 6.2.6.

6.3.5.5. The ratios of freight costs in the three groups are as

Line	Group 3	Group 4	Group 7
Main (1)	.9301	1	1.6616
* Main (2)	.9265	1	1.8446
Coast	.9339	1	1.6243
Northern	.9272	1	1.6898
Puttalam	.9391	1	1.5754
Batticaloa	.9277	1	1.6853
Trincomalee	.9273	1	1.6892
Matale	.9265	1	1.8446
Kelani Valley	.9392	1	1.5786

* The Main line has been divided into two for the calculation of freight rates. All stations beyond Rambukkana are charged at a higher rate. The altitude of the line increases sharply beyond Rambukkana and costs follow suit.

6.3.5.7. Having derived a basis whereby all products could be converted into "kerosene equivalents", it is now necessary to calculate the freight rate for the transportation of kerosene from Kolonnawa to the 85 depot locations involved.

(73) Actual costs of moving kerosene to 50 railside locations were used to estimate transport costs to the other 35 locations. The known costs were segregated according to the Railway's demarcation of freight zones (Low Country Broad Guage, Hill Country Broad Guage and the Kelani Valley Narrow Guage) and the method of least squares was used to extract a relationship between cost and distance.

6.3.5.7.1. <u>Low Country Broad Guage</u>

Order No.	Coefficient	
0	0.2726E 1	
1	0.1736E 2	
2	0.4233E 2	
3	-0.9436E 2	Mean Square Error
4	0.1139E 3	
5	-0.7303E 2	0.2572E -2
6	0.1731E 2	
7	0.7225E 1	
8	-0.6247E 1	

6.3.5.7.2. Hill Country Broad Guage

Order No.	Coefficient		
0	-0.1032E 4		
1	0.6092E 4		
2	-0.1499E 5		
3	0.2095E 5	Mean Square Error	
4	-0.1941E 5		
5	0.1374E 5	0.5196E -1	
6	-0.7812E 4		
7	0.3060E 4		
8	-0.5366E 3		

6.3.5.7.3. Kelani Valley Narrow Guage

Order No.	Coefficient		
0	0.7639E 2		
1	-0.6399E 3		
2	0.1689E 4		
3	-0.4863E 3	Mean Square Error	
4	-0.1625E 4		
5	-0.2499E 4	0.9002E -5	
6	0.3256E 4		
7	0.6864E 4		
8	-0.3139E 4		

6.3.5.7.4. Since the fit in all three cases was quite good, these curves were used to estimate transport costs for the other 35 depot sites. The costs have been incorporated in the transport cost data grid referred to in section 5.3.2.

6.3.6. I have introduced the concept of "standard" gallons into this study. I have "converted" all products into "kerosene equivalents" and called such equivalents "standard" products. By doing so I have narrowed down this study to one product rather than dealing with 6 different fuels in use today. This is not because the algorithm used for the computation cannot handle multiple products. A very simple method of doing so is to assume that there is a separate set of demands for each of the products that is being studied. If there are 4 products, there will be 4 times as many "centres" of demand. The size of the cost grid will be increased four-fold.

6.3.6.1. Let us assume that centre of demand X requires 1000 gallons of premium gasoline, 1500 gallons of regular gasoline, 3000 gallons of kerosene, 2500 gallons of high speed diesel and 1000 gallons of furnace oil. Let us also assume that they add up to 10,000 "standard" gallons. The case study works on the basis that X requires 10,000 gallons of the composite product. If products are treated separately there would be 4 centres of demand X_1, X_2, X_3 and X_4 with requirements of 2500 gallons gasoline, 3000 gallons of kerosene, 2500 gallons of high speed diesel and 1000 gallons of furnace oil respectively. The latter approach would require certain modifications to the calculation. These are quite basic and can be easily attended to.

6.3.6.1.1. One point of note is that the effect of increasing the size of the problem, and of the cost matrix by a factor of n, results in a like increase in computing time - n -, and not n^2 as with certain other algorithms.

6.3.6.2. I have decided to restrict my study to the treatment of "standard" products. The reasons for doing so are :-

6.3.6.2.1. The treatment of products separately could result in one centre of demand being supplied with different products from different depots. While this may not be specifically objectionable in certain industries, it is undesirable in the oil industry. The average customer prefers to deal with only one source, particularly when he places orders such that more than one product is required to make up a full lorry load. If a load has to be made up of drops to several dealers, there is considerable loss of efficiency of utilisation of the vehicle. This loss will be duplicated if similar rounds are made with other products as well. Minimum transport cost will be incurred if each lorry calls at only one outlet to drop its full load, and if a dealer cannot accept a full load of one product, he could order several products to make up the load. This is possible if all products are available at all depots, and this is the natural sequel to treating all products together as one "standard" product.

It is interesting to note that dealers in Ceylon have been persuaded to order full loads in single drops - contrary to the practice that prevails even to this day in Britain.

6.3.6.2.2. Treatment of products separately would increase computation time proportionately. In view of the comments made above it is doubtful whether this extra time will be well spent.

6.3.6.2.3. It would also require an optimisation within an optimisation - i.e., the allocation of the individual product requirements of a demand centre while at the same time allocating the centre itself.

6.3.6.2.4. Having decided to use a composite product, I give below the basis of conversion of the various products into "standard" gallons.

6.3.6.3. I have based the conversion on the specific gravity and freight cost ratios derived in sections 6.3.5.2. and 6.3.5.7. respectively.

i.e., to make other products "equivalent" to kerosene (in so far as our problem requires) I have used the ratios which make them compatible with kerosene as regards specific gravity (conversion from gallons to tons, since rail freight is computed by weight) and rail freight (to remove the differential freight rates). The conversions are:-

6.3.6.3.1. Main Line (section 1)

Premium gasoline	.9205	x	1.6616	=	1.5295
Regular Gasoline	.9038	x	1.6616	=	1.5017
High Speed Diesel	1.0576	x	1	=	1.0576
Industrial Diesel Oil	1.0653	x	.9301	=	.9908
Furnace Oil	1.1859	x	.9301	=	1.1030

6.3.6.3.2. Main Line (section 2, including Matale Line)

Premium Gasoline	.9205	x	1.8446	=	1.6974
Regular Gasoline	.9038	x	1.8446	=	1.6671
High Speed Diesel	1.0576	x	1	=	1.0576
Industrial Diesel Oil	1.0653	x	.9265	=	.9870
Furnace Oil	1.1859	x	.9265	=	1.0987

6.3.6.3.3. Coast Line

Premium Gasoline	.9205	x	1.6243	=	1.4951
Regular Gasoline	.9038	x	1.6243	=	1.4680
High Speed Diesel	1.0576	x	1	=	1.0576
Industrial Diesel Oil	1.0653	x	.9339	=	.9948
Furnace Oil	1.1859	x	.9339	=	1.1075

6.3.6.3.4. Northern Line

Premium Gasoline	.9205	x	1.6898	=	1.5554
Regular Gasoline	.9038	x	1.6898	=	1.5272
High Speed Diesel	1.0576	x	1	=	1.0576
Industrial Diesel Oil	1.0653	x	.9272	=	.9877
Furnace Oil	1.1859	x	.9272	=	1.0995

6.3.6.3.5. Puttalam Line

Premium Gasoline	.9205	x	1.5754	=	1.4501
Regular Gasoline	.9038	x	1.5754	=	1.4238
High Speed Diesel	1.0576	x	1	=	1.0576
Industrial Diesel Oil	1.0653	x	.9391	=	1.0004
Furnace Oil	1.1859	x	.9391	=	1.1136

6.3.6.3.6. Batticaloa Line (including Trincomalee Line)

Premium Gasoline	.9205	x	1.6892	=	1.5549
Regular Gasoline	.9038	x	1.6892	=	1.5296
High Speed Diesel	1.0576	x	1	=	1.0576
Industrial Diesel Oil	1.0653	x	.9273	=	.9878
Furnace Oil	1.1859	x	.9273	=	1.0996

6.3.6.3.7. Talaimannar Line

Premium Gasoline	.9205	x	1.6913	=	1.5568
Regular Gasoline	.9038	x	1.6913	=	1.5284
High Speed Diesel	1.0576	x	1	=	1.0576
Industrial Diesel Oil	1.0653	x	.9270	=	.9875
Furnace Oil	1.1859	x	.9270	=	1.0993

6.3.6.3.8. Kelani Valley Line

Premium Gasoline	.9205	x	1.5786	=	1.4531
Regular Gasoline	.9038	x	1.5786	=	1.4267
High Speed Diesel	1.0576	x	1	=	1.0576
Industrial Diesel Oil	1.0653	x	.9392	=	1.0005
Furnace Oil	1.1859	x	.9392	=	1.1137

6.3.6.3.9. In order to consolidate these figures into a composite function for each product, I have used the following weighting factors:-

Main Line (section 2)	3
All other lines (7 in all)	1
	10

giving a final series of weightings

Premium Gasoline	1.5687
Regular Gasoline	1.5403
High Speed Diesel	1.0576
Industrial Diesel oil	.9910
Furnace Oil	1.1032

indicating that each gallon of premium gasoline is 1.5687 gallons of "standard" product or "kerosene equivalent".

6.3.6.4. The sales figures mentioned in section 6.2.1.5. have been multiplied by these weightings to convert them into "standard" gallons. When figures for several months were averaged a further correction was made to cover the increase in demand over the next decade at the rate of 5.6% per year.(68) The demand figures in Appendix "C" are the final data which have been used as input for this study.

6.3.6.4.1. A final comment upon this conversion would be relevant. The conversion to "standard" gallons should be made only to the quantities that have been moved at one time or another by rail; i.e., products that are either delivered or collected from a depot. In the case study, the same converted figures continue to be used for calculating road haulage charges as well. This introduces an approximation into the final cost figure that is derived from this analysis. This further supports my earlier contention that this study (using the data that I have prepared) will not give the total transport cost with absolute accuracy; it will, however, determine the ideal structure of the distribution network, which is the main purpose of the work.

APPLICATION OF NEW TECHNIQUE AND RESULTS OBTAINED THEREFROM

6.4. The new technique was applied to a real life problem in order to (a) demonstrate its capabilities and (b) produce a meaningful answer to an existing problem, which concerns the re-organisation of the distribution network operated by the Ceylon Petroleum Corporation - a monopolist in Ceylon.

The preceding sections describe the existing pattern of distribution and give details of the data that was used, how they were adapted, and the assumptions that were made. The computer program that was used is described in section 5.10.1. Appendix "G" gives a comprehensive record of the iterations and the final results.

6.4.1. The main points of the results were as follows:-

a) A reduction of 4.21% from the present cost of distribution. The monthly saving is Rs. 114,612.51 - equivalent to over £8000.

b) Five existing depots are to be closed down.

c) Five new depots are to be opened.

6.4.2. The sensitivity analysis played an important part in this study. The analysis did produce a bonus. It showed how the results of the first run could be brought closer to the optimum (compare with Keuhn and Hamburger's Bump-and-Shift routine).

6.4.2.1. The first run produced an improvement of only 4.02%, and required the closure of 4 existing depots and the opening of 4 new ones. The first sensitivity analysis showed potential for further improvement with the exclusion of 3 of the basis depots (one existing and two proposed sites).

6.4.2.2. The next run, with the above modifications produced an improvement of 4.18%, with the closure of 5 existing depots and the opening of 5 new ones. The second sensitivity analysis showed further potential for improvement with the exclusion of one of the new depots.

6.4.2.3. The final run gave an improvement of 4.21% with the closure of the same 5 existing depots and the opening of 5 new ones.

6.4.2.4. The results are summarised below:-

6.4.2.4.1. Result of Run No. 1.

Improvement over present cost = 4.02%

Closure of 4 existing outlets - Kotagala
Haputale
Ratnapura
Peradeniya (New)

Opening of 4 new depots - Ambalangoda
Lunuwila
Pallai
Opanaike

Sensitivity Analysis showed that the exclusion of these depots would make further savings as follows -

Kilinochchi	Rs. 1,078.75 per month plus entry of Vavuniya into basis
Lunuwila	Rs. 3,515.87 per month plus entry of Madampo into basis
Pallai	Rs. 26.32 per month plus entry of Chavakachcheri into basis

The next run was undertaken with the exclusion of these three depots.

6.4.2.4.2. Result of Run No. 2.

Improvement over present cost = 4.18%

Closure of 5 existing outlets - Kotagala
Haputale
Ratnapura
Peradeniya (New)
Kilinochchi

Opening of 5 new depots - Ambalangoda
Opanaike
Madampo
Vavuniya
Chavakachcheri

Marginal improvement (over Run No. 1) = 0.16%
plus closure of Kilinochchi depot
plus opening of Madampe vice Lunuwila
Chavakachcheri vice Pallai
Vavuniya

Sensitivity Analysis showed that the exclusion of one further depot, Vavuniya, which would show an additional saving of Rs. 791.38

per month, plus the entry of Mankulam into the basis.

The next run was therefore undertaken with the exclusion of 4 depots, Kilinochchi, Lunuwila, Pallai and Vavuniya from the basis.

6.4.2.4.3. Result of Run No. 3.

Improvement over present cost = 4.21%

Closure of 5 existing depots - Kotagala
Haputale
Ratnapura
Peradeniya (New)
Kilinochchi

Opening of 4 new depots - Ambalangoda
Opanaike
Madampe
Chavakachcheri
Mankulam

Marginal improvement (over Run No. 2) = 0.03%
plus opening of Mankulam vice Vavuniya

The last sensitivity analysis showed no further potential for improvement.

The detailed results are summarised below:-

Depot	Throughput	Fixed Cost	Variable Cost
Kolonnawa	12,255,938.78	411,000.00	576,103.83
Matara (E)	632,715.96	7,200.00	98,773.16
Peradeniya Jn (E)	2281,653.81	15,200.00	307,110.90
Batticaloa (E)	382,731.37	7,000.00	105,984.40
Kurunegala (E)	884,463.48	9,850.00	115,065.82
Anuradhapura (E)	394,215.03	6,000.00	72,167.44
Jaffna (E)	485,626.90	9,350.00	129,063.56
Galle (E)	969,285.31	8,850.00	113,858.85
China Bay (E)	333,047.50	11,500.00	42,463.45
Ambalangoda (N)	341,810.64	7,341.81	32,125.27
Madampe (N)	538,937.87	7,538.94	53,503.20
Mankulam (N)	150,684.03	7,150.68	34,514.11
Chavakachcheri(N)	535,437.35	7,535.44	144,881.19
Opanaike (N)	996,221.93	7,996.22	177,595.09

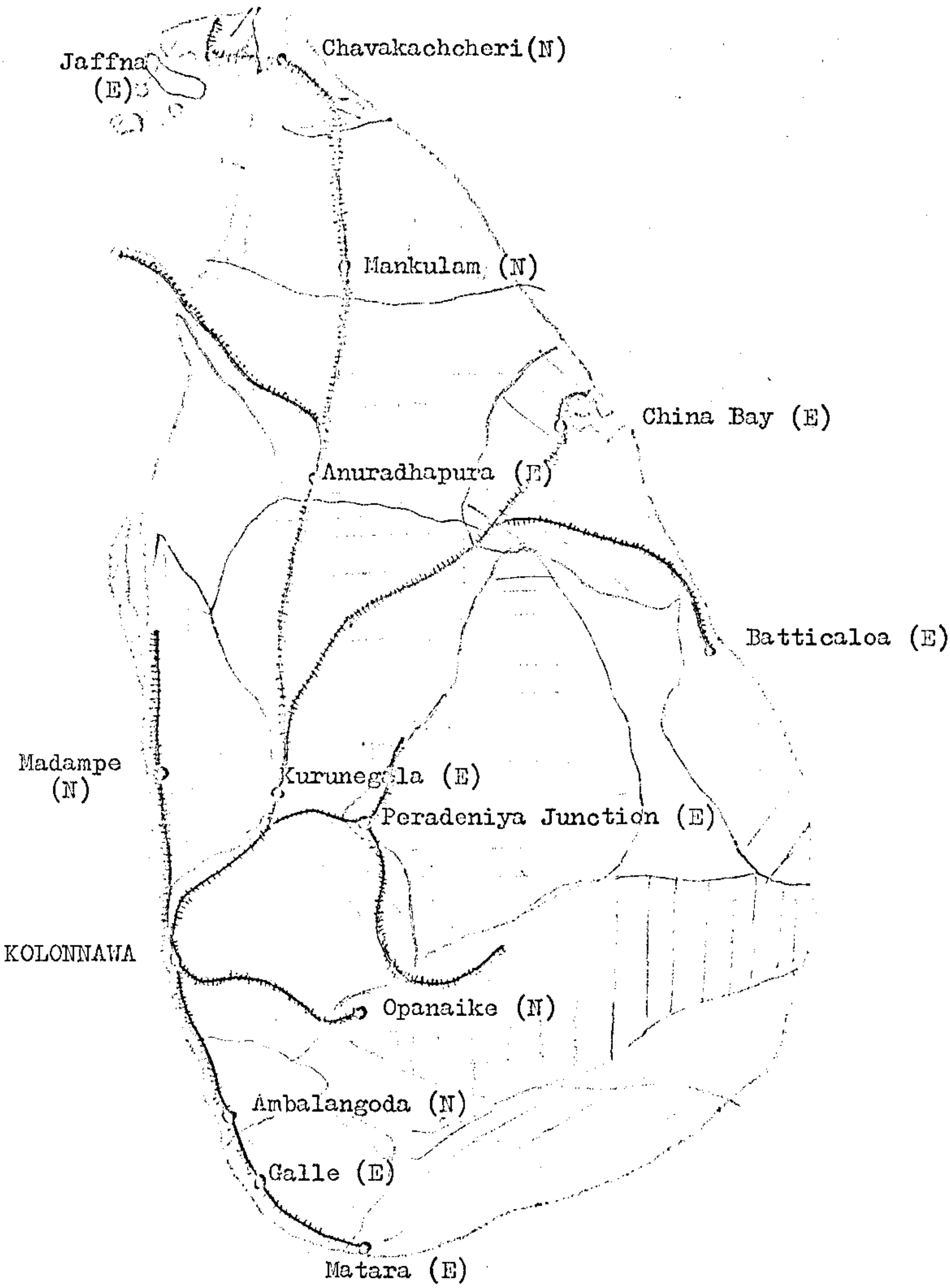
(E) denotes an existing depot

(N) denotes a new depot.

Map No. 5 depicts the new set up.

Map No. 5

THE NEW SET UP SUGGESTED FOR CEYLON



E denotes an Existing Depot

N denotes a New Depot

Fixed cost of optimal network	=	Rs. 523,513.09
Variable cost of optimal network	=	Rs. 2,003,210.27
Total Cost of Collections	=	Rs. 80,134.38
Total Cost of Optimal Network	=	Rs. 2,606.857.75
SAVINGS	=	Rs. 114,612.51 per month
Improvement over present system	=	4.21%

The detailed results are presented in Appendix "G".

ANALYSIS OF RESULTS

6.5. The application of the new technique has produced 3 sets of results, each progressively better than the last. There have been significant differences in the bases with small improvements in cost. It is suggested that all three sets of results should be considered, since each represents the consequences, suitably quantified, of three different courses of action. This multiplicity of results could very well be an added advantage of this type of analysis, since management will have a fair spread of information on which to make its decision.

My analysis will look at the depots that are affected by this exercise.

6.5.1. I shall take the existing depots first; those that will have to be closed down.

6.5.1.1. Kotagala

At the moment this depot plays a very important part in the distribution of Industrial Diesel Oil and Furnace Oil to the tea estates in the Central Province. It is an ex-Shell installation and is well equipped for its task. Its present throughput (in absolute terms - actual 1967 figures) is around

40,000	gallons per month of	Premium Gasoline
65,000	- do -	Regular Gasoline
82,000	- do -	High Speed Diesel
225,000	- do -	Industrial Diesel Oil
100,000	- do -	Furnace Oil
75,000	- do -	Kerosene

It has achieved its importance by virtue of its geographical location.

6.5.1.1.1. This study has revealed that Kotagala depot does not pay its way. It does not bring about adequate savings in transportation cost to offset its fixed cost. This aspect of financial analysis has not been carried out, at least by its present owners; it has been allowed to operate merely because it belonged to an oil company.

6.5.1.1.2. The reason for its unprofitability lies not in the inadequate reduction of road transport charges to its customers, but because trunking cost to it is high. Kotagala is supplied by rail - along the Main Line - over a distance of 111.3 miles from Kolonnawa. The road distance from Kolonnawa is only 77 miles. In addition to being about 45% further, the journey by rail is along the high-rate section of the Main Line. This effectively adds to the distance.

6.5.1.1.3. The nett result is that the fixed cost of Kotagala is not saved by sending product to it by rail, and this has been highlighted by the current study. Kotagala was dropped from the basis in the third iteration. All supplies to the present "Kotagala area" will be direct from Kolonnawa.

6.5.1.1.4. While this change can be justified in terms of hard cash, it is doubtful whether the new arrangement would be wholly acceptable to the customers. They have become used to a very short lead time - an advantage which has been almost self-achieved. The roads in this part of the country, particularly on the estates, are narrow and winding and not conducive to the use of heavy lorries. Smaller lorries carrying less product have been used and, as a consequence, the tankage installed at customers' premises is small. This has required a short lead time.

6.5.1.1.5. A further complication is that the transit time between Kolonnawa and Kotagala is high. A lorry will be able to do only one trip per day and the number of vehicles required to supply this area from Kolonnawa will greatly exceed the number now stationed at Kotagala. While operating cost has been incorporated in the calculations, no consideration has been paid to the immediate requirement of a large sum for the purchase of the extra vehicles.

6.5.1.1.6. The last significant point that has to be considered about Kotagala is that it is a relatively large and well-equipped depot. It was built to the present specifications by Shell whose deliberations regarding choice of site would have been influenced by their own pattern of demand , which is quite different from the present pattern.

6.5.1.1.7. If, after considering all its implications, it is decided to close the Kotagala depot, the bulk of its facilities can be transferred to one of the new sites. The saving on this account (which has not been estimated for this study) would help in easing the burden of purchasing the additional vehicles required to make supplies to this area from Kolonnawa.

6.5.1.2. Haputale

This too is an ex-Shell depot, also mainly concerned with the supply of heavy fuels to tea estates. It is a relatively small depot and does not have facilities for Furnace Oil. The tankage for kerosene and industrial diesel oil was supplemented by the C.P.C. after acquisition from Shell by incorporating an adjacent dealer-operated railside depot into the bulk depot.

6.5.1.2.1. Haputale depot did not figure in the original network of depots planned by the C.P.C. It was taken over because of the necessity to acquire all oil company assets and was then put into operation because it was available. Neither its tankage capacity nor its lay-out is conducive to efficient operation and there is no room for expansion.

6.5.1.2.2. In view of the above factors it would appear that the C.P.C. would gain in ways other than financial if Haputale were to close. Supplies to this area will be made from the new depot proposed for Opanaike, which will be taken up later.

6.5.1.2.3. The unprofitability of Haputale arises because it too is on the high-rate section of the Main Line, at a distance of 153.48 rail miles from Kolonnawa. The road distance is only 109 miles. Supply through Opanaike involves a rail distance (Kolonnawa to Opanaike) of 72 miles and a road distance (Opanaike to Haputale) of 38 miles, making a total rail-cum-road journey of only 110 miles. This explains why Haputale depot cannot justify itself, when compared with Opanaike.

6.5.1.3. <u>Ratnapura</u>

This too is an ex-Shell depot, which has facilities for only 2 fuels, High Speed Diesel and Industrial Diesel Oil. Shell had more fuels available here, but served only a small market. When the C.P.C. started monopoly supplies, it did not use Ratnapura depot at all. The decision to operate Ratnapura under the C.P.C. was clearly an afterthought. The tankage was so meagre that only two products could be handled here.

6.5.1.3.1. Its closure will be very insignificant to the C.P.C. Its turnover can be easily diverted to the new Opanaike depot, of which more later. Since it has no room for expansion, its continued existence was in doubt all along.

6.5.1.3.2. It is supplied by rail, via the narrow guage Kelani Valley Line, which is the real Cinderella of the Ceylon Government Railway. Further comments will be made on this when discussing Opanaike which is the terminus of the Kelani Valley Line.

6.5.1.3.4. All in all, the closure of Ratnapura will be no real loss to the C.P.C.

6.5.1.4. <u>Peradeniya (New)</u>

This too is an ex-Shell depot. It has small tankage and is on a congested site about 1 mile away from the large ex-Caltex depot at Peradeniya Junction. It used to handle all fuels under Shell but has been converted into a black oil depot by the C.P.C. It is used to make supplies to the tea and rubber estates in the area.

6.5.1.4.1. It is being operated by the C.P.C. for the same reasons as Ratnapura and Haputale. It supplements the facilities at Peradeniya Junction. The latter has ample room for expansion and can be enlarged to cope with the volume that is being handled now by the depot at Peradeniya (New).

6.5.1.4.2. Here too is a depot that can be easily closed down when the adjoining depot is enlarged.

6.5.1.5. <u>Kilinochchi</u>

This is a large modern depot acquired from Shell. It did not figure actively in the C.P.C.'s distribution network for a long time after acquisition. It was being used as buffer storage for the Jaffna depot until early 1967, when it became fully operational. However, it still handles only the marginal volumes which Jaffna cannot cope with conveniently and its throughput falls far short of its designed capacity.

6.5.1.5.1. This depot was completed by Shell shortly before acquisition, and even they did not operate it anywhere near full capacity as they too had their depot at Jaffna and their demand in this area did not warrant the need for 2 depots. It was built as a long-term measure and it has been admitted even by Shell that it may have been a tactical error on their part.

6.5.1.5.2. Taken even in the wider context of the C.P.C.'s operations, it still remains a white elephant. Its location at the centre of a comparatively barren (i.e., of demand for petroleum products) area and its distance from the Jaffna conurbation are both factors which emphasise its weakness as a feasible depot location.

6.5.1.5.3. The closure of Kilinochchi will place no great strain on the C.P.C. Its present small throughput can be easily reverted to Jaffna or to any other depot within the Jaffna Peninsula, and the bulk of the equipment installed there can be used for new depots.

6.5.2. The comments that follow concern the new depots that are required to replace those that are being closed, or to supplement the other depots in the network.

6.5.2.1. <u>Ambalangoda</u>

This new site is on the Coast Line located between Kolonnawa and Galle. It is 53.9 rail miles from the former and 18.3 rail miles from the latter. There is a small dealer-operated railside depot at

Ambalangoda and can be developed if it is decided to open a bulk depot there.

6.5.2.1.1. The areas assigned to Ambalangoda are now supplied from Kolonnawa and marginally from Galle. The question to be considered now is whether it is worthwhile to open a new depot at Ambalangoda. The site will have a reasonable throughput, but sensitivity analysis has shown that the cost of excluding Ambalangoda from the basis will be only Rs. 300/- per month (Rs. 299.62). This would be only a very small loss (about ¼%), and it is felt, even without further study, that the additional capital expenditure of opening a new depot is not justified by this return.

6.5.2.1.2. This belief is strengthened by the fact that the exclusion of Ambalangoda, with the loss of Rs. 300/- per month, will not affect the basis in any other way. The number of depots is reduced by 1, and the areas assigned to Ambalangoda revert to Kolonnawa and Galle. i.e., the status quo is maintained.

6.5.2.1.3. It seems therefore that this is an instance where the pure cost approach produces a result which is rejected on other grounds by management.

6.5.2.2. <u>Opanaike</u>

This is the terminus of the narrow guage Kelani Valley Line. This line has always been a step-child of the Railway and little or no effort has been made to improve its operating conditions. There are several uncharitable interpretations given for the reason why Ceylon was burdened with a small length of narrow guage railway when the rest of its network was the universal broad guage. The fact remains that this line is operating under severe constraints, and the opening of a new C.P.C. depot might well be the impetus that initiates its development.

6.5.2.2.1. Opanaike has been assigned a throughput of nearly 1 million gallons per month. It will be the second biggest depot in the country. It will draw off supply to the present Kolonnawa, Ratnapura and

Haputale areas. It is situated 72 rail miles from Kolonnawa and is ideally placed to serve this part of the country. It has a small dealer-operated railside depot that can be improved.

6.5.2.2.2. The economics of the new depot are sound. The sensitivity analysis indicates that if it is excluded, 3 additional depots are required to minimise total costs, which are still about Rs. 12,000/- per month higher. The 3 depots are Ratnapura, Kahawatta and Haputale. On these grounds alone, its entry is very desirable. The only factors which could affect this decision are outside the control of the C.P.C., namely, the future prospects of the Kelani Valley Line itself. If the line is found to be uneconomic, even after the additional business guaranteed by the new bulk depot, the Railway might close it down entirely. In such an event, Opanaike and 2 of its 3 substitutes will become infeasible, since all are on this line. This possibility has been studied separately and the results presented in Appendix "D".

6.5.2.3. Madampe

The selection of Madampe throws a new light on the distribution network. It is 44.15 rail miles from Kolonnawa on the Puttalam Line. This line has had fluctuating fortunes during its lifetime. It was initially constructed to link the extensive coconut estates on the north-western seaboard of Ceylon with Colombo. During the Second World War, parts of this line were dismantled, mainly to provide much needed iron for defence construction. The line has since been relaid and extended to link up with a large cement factory near Puttalam.

6.5.2.3.1. There are no bulk depots on this line. The only rail-fed petroleum outlets are 3 dealer-operated railside depots, one of which is Madampe. Road deliveries are made from Kolonnawa.

6.5.2.3.2. The selection of Madampe seems to be a logical and necessary step (in the right direction). It will relieve Kolonnawa of many long-distance deliveries and will release tank lorries for other uses. e.g., for supplying those areas now covered by Kotagala, if the latter is closed.

6.5.2.3.3. The sensitivity analysis indicates that exclusion of Madampe would result in an additional cost of Rs. 844.27 per month, even though a new depot will be required at Chilaw. There would be no reduction in capital expenditure and an increased cost. Other factors such as customer convenience and strategic desirability support the need for this depot.

6.5.2.3.4. It appears therefore that Madampe is a very desirable site from every point of view.

6.5.2.4. Chavakachcheri

This depot has been selected mainly to take up the slack created by the closure of Kilinochchi. It will also draw off some of the throughput from the Jaffna depot, mainly the volumes back-hauled towards Kolonnawa. Chavakachcheri is 10 miles south of Jaffna and is closer to the neck of the Jaffna Peninsula. It therefore commands a greater catchment area than Jaffna. It will relieve Jaffna depot of a fair gallonage and will also supplement the total storage available in the peninsula. The latter will be very desirable particularly if Kilinochchi is closed down because of the distance of this area from Kolonnawa. It has not been uncommon to have rail communications disrupted (mainly due to flooding) and the additional storage/distribution point could be strategically vital. Furthermore, the presence of two depots so close to each other would permit a certain degree of specialisation. For instance, only one need have tankage/facilities for the black oils.

6.5.2.4.1. The sensitivity analysis indicates that the exclusion of Chavakachcheri from the basis results in an additional cost of Rs. 670/- per month. The number of depots is reduced by 1. However, the load on Jaffna is doubled and since Kilinochchi has already been excluded, it will not be desirable to have only one depot charged with the responsibility of supplying the Jaffna area.

6.5.2.4.2. All in all, the decision to close Kilinochchi and open Chavakachcheri will depend on factors other than pure economics. If the former is closed, it would be almost essential to open the latter even though its omission would incur an additional cost of only Rs. 670/- per month The strategic desirability would strengthen the economic weakness of Chavakachcheri.

6.5.2.5. Mankulam

Here too is a depot being located in a previously uncovered area. Deliveries to the proposed Mankulam area are being made from Anuradhapura, about 60 miles south. Since the new area covers points as much as 50 miles from Mankulam, a new supply source certainly seems useful.

6.5.2.5.1. The additional cost of excluding Mankulam is almost Rs. 1000/- per month, and since Vavuniya has already been excluded, the number of depots in the sub-optimal basis falls by 1.

6.5.2.5.2. The monthly throughput of the new depot is small (just over 150,000 standard gallons per month), but the distances involved are such that even this low figure produces sufficient savings to offset its fixed cost.

6.5.2.5.3. Here too is a case where strategic desirability overcomes the doubts cast on its effectiveness on economic grounds alone.

CONCLUSIONS

7. The results obtained in the case study and the manner in which they were reached indicate the efficacy of the new technique. It does not require the knowledge of any advanced mathematical or computational techniques, and is therefore within the grasp of any person who has only the briefest understanding of distribution practice.

7.1. All that is required in the implementation of this technique is an understanding of the costs of the various operations involved. These costs could very well be traced by a competent accountant. Thereafter remains the somewhat arduous task of preparing a mileage matrix. The degree of complexity of the matrix is dictated by the degree of accuracy that is required. A great deal of secondary information can be gathered if an accurate mileage grid is prepared. If, on the other hand, the result sought is only the main optimisation, much labour can be saved by representing the obviously infeasible routes by arbitrary high mileages.

7.2. The final conclusion that can be drawn is that this technique will, in many cases, produce an acceptable result, if not producing a solution that is the absolute optimum.

RECOMMENDATIONS FOR FURTHER WORK

8. The next step to be taken is the modification of this technique to cope with more than one main source. Preliminary work was done on this modification and the following principles were established for increasing the number of main sources to 2.

8.1. expansion of the mileage matrix by one column to represent the distances between the second source and the destinations.

8.2. determination of the optimal production patterns at the 2 main sources, assuming that they are refineries. Alternatively, the ratio of optimal capacities could be determined. This would establish the basic capabilities of the two sources.

8.3. estimation of the additional costs that would be incurred if the ratio or pattern established in section 8.2. is not observed. e.g., if the production pattern takes the ratio 2:3, then a penalty would be incurred at both sources if the assigned pattern (as required by the allocation of demand) is 1:1.

8.4. the introduction of a sub-routine into the main program which would keep trach of the allocation of depots, and not destinations, to each source.

8.5. The rationale is that, in the ideal case, a depot would be supplied from only one source. The optimisation program would therefore first assign demand centres to the depots and then the depots to the sources. The first allocation, demand centres to depots, would have to consider the possibility of supplying each depot from either source.

8.6. The other important advance is the expansion of the capabilities of the sensitivity analysis, particularly that part which assesses the effect of dropping selected depots from the basis. As it is, it will drop one depot at a time. The modification that is intended is that it should drop more than one depot at a time. The actual mechanism is simple. The relevant KD value would be set to 5. What has to be done is to draw up a systematic procedure that would take up all possible combinations of depots in a predetermined pattern. The number of combinations among the selected depots will be very much less than among all possible depots.

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APPENDIX "A"

THE COMPUTER

The computer used for this project was the ICT 1905 configuration installed at the Computer Centre of the Loughborough University of Technology, Loughborough, Leicestershire.

It has an internal core store of 32 K, out of which about 24 K is avaliable for the normal program. The time taken for the following operations is

	Fixed point	Floating Point
Addition/subtraction	7	13
Multiplication	40	29
Division	44	51
Logical Operations	7	

The off-line equipment that was used was

1) Magnetic disc unit. 100 track units were used
2) Magnetic tape unit. 40 Kc/sec. tape decks, with a packing density of 556 bits per inch.
3) Card Reader. the operating speed was 900 cards/minute
4) Line Printer. output of 1350 lines/minute.

APPENDIX "B"

CALCULATION OF TRANSPORT COST DATA GRID

The conversion of the mileage grid into a transport cost grid was accomplished with the use of a specially written computer program. This program, which is reproduced below, makes due provision for the non-linearities mentioned earlier.

```
     LIST(LP)
     SEND TO(ED,FORTCOMPAREA.CNE)
     PROGRAM(G012)
     INPUT 1=CRO
     CREATE 2=MTO(COST MATRIX)
     END

     MASTER TRANSPORT COST GRID
     DIMENSION IS(613),TT(86),TX(86),D(613)
     IC=613
     ID=86
     DO 12 I=1,ID
     READ(1,8)(IS(K),K=1,IC)
8    FORMAT(26I3)
     DO 13 k=1,IC
     IF(IS(K).LT.61)GO TO 203
     IF(IS(K).GT.60.AND.IS(K).LT.100)GO TO 204
     IF(IS(K).GT.99.AND.IS(K).LT.135)GO TO 205
     IF(IS(K).GT.134.AND.IS(K).LT.175)GO TO 206
     IF(IS(K).GT.174.AND.IS(K).LT.210)GO TO 207
     IF(IS(K).GT.209.AND.IS(K).LT.250)GO TO 208
     IF(IS(K).GT.249.AND.IS(K).LT.285)GO TO 209
     IF(IS(K).GT.284.AND.IS(K).LT.320)GO TO 210
     IF(IS(K).GT.319)GO TO 211
203  RX=RR
     GO TO 11
204  RX=RR*1.05
     GO TO 11
205  RX=RR*1.15
     GO TO 11
206  RX=RR*1.3
     GO TO 11
207  RX=RR*1.45
     GO TO 11
208  RX=RR*1.65
     GO TO 11
209  RX=RR*1.75
     GO TO 11
210  RX=RR*1.85
     GO TO 11
211  RX=RR*2
11   D(K)=CK+TT(I)+TX(I)+IS(K)*RX
```

```
13    CONTINUE
12    WRITE(2)(D(K),K=1,IC)
      STOP
      END
      FINISH
```

APPENDIX "C"

CONSOLIDATION OF SALES DATA

The sales figures obtained from the Ceylon Petroleum Corporation(72) were tabulated in the following format:-

Product	Customer Number	Source of Supply	Quantity Supplied Deliveries (CPC lorry)	Collections (Customers' vehicles)	Rail/pipeline

Having decided to recast the island-wide demand pattern into 613 centres of demand (based on post office areas), it was necessary to write a special computer program which would do so conveniently. This program would take each month's sales figures and prepare a summary which gives the demand concentrated into the 613 areas. These monthly figures were then converted into "standard" gallons so that they were compatible with the main optimisation program. Figures for several months were averaged and compounded (at the rate of 5.6% per annum) for the next decade to represent estimated demand in 1977.

The computer program which accomplished the first part of this is listed below. It has been written in FORTRAN IV.

```
      LIST (LP)

      SEND TO (ED,FORTCOMPAREA.ONE)
      PROGRAM (G060)
      INPUT 1=CRO
      COMPRESS INTEGER
      OUTPUT 2=LPO
      OUTPUT 3=CPO
      END

      MASTER DEMAND SUMMARY
      DIMENSION JX(12),J1(3800),J2(3800),J3(3800),J4(3800),J5(1900),IC(6
     150),DP(15),KA(15,7,3),KB(15,7,3),L(15,7,3),TP(3),P(7)
      CALL TIME(T)
      WRITE(2,51)T
51    FORMAT(3X13HSTART TIME = A8)
      LA=-1
2     LA=LA+2
      LB=LB+1
      READ(1,3)(JX(I),I=1,6)
3     FORMAT(6I0)
      IF(JX(2)-9999)29,4,4
```

```
29    READ(1,3)(JX(I),I=7,12)
      J1(LA)=JX(2)
      J2(LA)=JX(4)
      J3(LA)=JX(5)
      J4(LA)=JX(6)
      J1(LA+1)=JX(8)
      J2(LA+1)=JX(10)
      J3(LA+1)=JX(11)
      J4(LA+1)=JX(12)
      CALL LUTU1(JX(1),JX(3),JX(7),JX(9),J5(LB))
      IF(JX(8)-9999)2,4,4
4     LA=LA-1
      WRITE(2,5)LA
5     FORMAT(3XI4,8H ENTRIES//)
      CALL TIME(T)
      WRITE(2,83)T
83    FORMAT(3X19HCORE LOADED TIME = A8/)
      READ(1,28)DP
      READ(1,28)P
      READ(1,28)TP
28    FORMAT(10A8)
6     READ(1,7)IN,TA,ID
7     FORMAT(I0,A8,I0)
90    M=0
      IF(IN-999)9,30,30
9     READ(1,11)(IC(I),I=1,ID)
11    FORMAT(20I4)
      N=1
12    M=M+1
      IF(M-LA)40,40,15
40    IF(J1(M))13,12,14
14    IF(IC(N)-J1(M))12,16,12
15    N=N+1
      IF(N-ID)17,17,10
17    M=0
      GO TO 12
16    IF(M/2*2.EQ.M)GO TO 38
      IP=LUTU2(1,J5((M+1)/2))
      IQ=LUTU2(2,J5((M+1)/2))
      GO TO 84
38    IP=LUTU2(3,J5(M/2))
      IQ=LUTU2(4,J5(M/2))
84    IF(IP.GT.17.OR.IP.LT.11)GO TO 13
      IF(IQ.GT.15.OR.IQ.LT.0)GO TO 13
      IP=IP-10
      KA(IQ,IP,1)=J2(M)
      KA(IQ,IP,2)=J3(M)
      KA(IQ,IP,3)=J4(M)
      J1(M)=0
      GO TO 18
13    WRITE(2,39)IP,J1(M),IQ,J2(M),J3(M),J4(M)
39    FORMAT(/2X17HMISPUNCHED CARD   ,6I0/)
      GO TO 12
18    DO 25 I=1,3
      KB(IQ,IP,I)=KB(IQ,IP,I)+KA(IQ,IP,I)
      L(IQ,IP,I)=L(IQ,IP,I)+KA(IQ,IP,I)
25    KA(IQ,IP,I)=0
      GO TO 12
10    WRITE(2,50)IN,TA,ID
50    FORMAT(//1XI3,2XA8,2XI3/)
      TW,TX,TY,TZ=0
```

```
      DO 85 I=2,15
      J=1
      TX=TX+KB(I,1,J)*1.5687+KB(I,2,J)*1.5403+KB(I,3,J)*1.0576+KB(I,4,J
     1)*.9910+KB(I,5,J)*.9910+KB(I,6,J)*1.1032+KB(I,7,J)
      J=2
      TY=TY+KB(I,1,J)*1.5687+KB(I,2,J)*1.5403+KB(I,3,J)*1.0576+KB(I,4,J
     1)*.9910+KB(I,5,J)*.9910+KB(I,6,J)*1.1032+KB(I,7,J)
85    CONTINUE
      TZ=KB(1,1,1)+KB(1,21,)+KB(1,3,1)+KB(1,4,1)+KB(1,5,1)+KB(1,6,1)+KB(
     11,7,1)
      TW=KB(1,1,2)+KB(1,2,2)+KB(1,3,2)+KB(1,4,2)+KB(1,5,2)+KB(1,6,2)+KB(
     11,7,2)
      WRITE(2,56)TX,TY,TZ,TW
56    FORMAT(3X,22HSTANDARD GALLONS(A) = F12.2,3X,22HSTANDARD GALLONS(B)
     1 = F12.2,3X,23HKOLONAWA GALLONS(A)= F12.2,3x,23HKOLONAWA GALLON
     2S(B) = F12.2/)
      WRITE(3,66)IN,TA,ID,TX,TY,TZ,TW
66    FORMAT(1XI3,1XI8,1XI3,4(1XF12.2))
      DO 54 LY=1,15
      DO 54 LZ=1,7
      DO 54 LB=1,3
      IF(KB(LY,LZ,LB))93,93,57
57    WRITE(2,58)DP(LY),P(LZ),TP(LB),KB(LY,LZ,LB)
58    FORMAT(3(1XA8),I10)
93    KA(LY,LZ,LB)=0
      KB(LY,LZ,LB)=0
54    CONTINUE
      GO TO 6
30    CALL TIME(T)
      WRITE(2,67)T
67    FORMAT(3X23HLOOP COMPLETION TIME = A8/)
      WRITE(3,50)IN,TA,ID
      WRITE(2,33)
33    FORMAT(//3X5HDEPOT25X18HPRESENT THROUGHPUT//)
      WRITE(2,34)
34    FORMAT(23X,12HCORP VEHICLE,5X,12HCUST VEHICLE,5X,13HRAIL/PIPELINE/
     1)
      DO 36 I=1,15
      WRITE(2,62)DP(I)
62    FORMAT(1XA8)
      DO 36 LC=1,7
      WRITE(2,63)P(LC),(L(I,LC,LB),LB=1,3)
63    FORMAT(9XA8,3(5XI11))
36    CONTINUE
      WRITE(2,43)
43    FORMAT(///3X27HUNASSIGNED CUSTOMER NUMBERS/)
      DO 68 I=1,LA
      IF(J1(I).EQ.0)GO TO 68
      IF(I/2*2.EQ.I)GO TO 65
      IP=LUTU2(1,J5((I+1)/2))
      IQ=LUTU2(2,J5((I+1)/2))
      GO TO 31
65    IP=LUTU2(3,J5(I/2))
      IQ=LUTU2(4,J5(I/2))
31    WRITE(2,32)IP,J1(I),IQ,J2(I),J3(I),J4(I)
32    FORMAT(3XI2,3XI4,3XI2,3(3XI7))
68 C  CONTINUE
      WRITE(2,37)
37    FORMAT(//3X10HEND OF JOB)
      CALL TIME(T)
      WRITE(2,1)T
1     FORMAT(1X7HTIME = A8/)
      STOP
      END
```

The reference to LUTU2 in the program is made when it calls for the Library sub-routine LUTU, which in its two sections LUTU1 and LUTU2 provides a means where integers can be stored four to a space. This sub-routine and the Compress Integer mode were required because the space required for the program exceeded the computer's internal storage capacity.

The results were printed in the following format:-

Town number   Town Name   No. of customers

Standard Gallons (A) =	....	A denotes deliveries
Standard Gallons (b) =	....	B denotes collections
Kolonnawa Gallons(A) =	....	
Kolonnawa Gallons(B) =	....	Standard Gallons are for supplies ex the depots.

A series of entries of the form

Source   Product   Mode of Supply   Quantity.

Notes   a) the conversion into standard gallons took place in the statement which built up the values of TX and TY.

b) an additional output of this program was a series of punched cards which contained the town summaries (standard gallons (A) and (B) and Kolonnawa gallons (A) and (B)). These summaries were then used with those of other months to produce an average. This average was then compounded at the rate of 5.6% per annum to obtain the estimates for 1977.

c) there was provision in the program to print out the cases (if any) where the sales had not been allocated to any of the 613 centres of demand.

d) the whole program was timed.

I now reproduce the estimates for 1977 as prepared by the above computer program and the averaging/compounding routine. The figures represent standard gallons in the case of deliveries that have originated from depots and kerosene equivalents for figures representing deliveries from Kolonnawa Terminal.

CENTRE OF DEMAND	STANDARD GALLONS(A)	STANDARD GALLONS(B)	KOLONNAWA GALLONS(A)	KOLONNAWA GALLONS(B)
ADALCHNA	0.00	0.00	0.00	5794.00
AGALWATA	0.00	0.00	31499.12	0.00
AGRAPTNA	34885.15	8886.20	0.00	0.00
AHANGAMA	28825.70	0.00	0.00	0.00
AHUNGALA	0.00	0.00	3908.65	0.00
AKARPATU	11719.60	9127.62	0.00	24236.51
AKMIMANA	2050.66	0.00	0.00	0.00
AKURANA	14203.48	0.00	0.00	5535.34
AKURESSA	76244.60	4562.73	0.00	3931.64
ALAVEDDY	17933.81	0.00	0.00	0.00
ALAWTGDA	33656.38	0.00	0.00	0.00
ALAWWA	0.00	0.00	26325.91	1138.11
ALUTGAMA	0.00	0.00	76103.72	801.85
ALUTNWRA	0.00	0.00	201.18	33281.01
AMBLGODA	0.00	0.00	87082.44	844.96
AMBLTOTA	18853.40	0.00	689.76	27935.36
AMBAWELA	0.00	0.00	0.00	0.00
AMBEPUSA	0.00	0.00	0.00	0.00
AMPARAI	141774.14	33862.06	0.00	32591.25
AMPITIYA	1367.11	0.00	0.00	0.00
ANAMDUWA	0.00	0.00	0.00	8225.41
ANDIAMBM	0.00	0.00	0.00	1551.96
ANGAMUWA	0.00	0.00	2069.29	9596.31
ANGODA	0.00	0.00	4138.57	0.00
ANGRWELA	0.00	0.00	0.00	20454.31
ANHTGAMA	360.68	0.00	0.00	7527.03
ANKMBURA	6195.44	0.00	0.00	2250.35
ANRDPURA	233028.39	6750.09	0.00	4138.57
ARAKWILA	0.00	0.00	9426.74	0.00
ARANAYKA	0.00	0.00	459.84	18856.36
ARCHKTWA	0.00	0.00	0.00	17976.92
ARIYALAI	2759.04	0.00	0.00	32539.52
ATTABAGE	0.00	0.00	0.00	0.00
ATCHUVLY	17947.52	0.00	0.00	1810.63
ATTNGALA	0.00	0.00	11381.07	0.00
ATTIDIYA	0.00	0.00	0.00	775.98
ATBLSHLA	0.00	0.00	15979.48	672.52
ATURGRYA	0.00	0.00	151057.85	517.32
AVERNGAL	14485.00	0.00	0.00	0.00
AVISWELA	1458.99	0.00	177556.20	2974.59
BDLKMBRA	5710.97	0.00	0.00	0.00
BADDGAMA	32752.49	2409.53	0.00	0.00
BADULLA	113767.65	0.00	4371.36	38281.79
BADRELYA	0.00	0.00	15864.52	5199.08
BAKIELLA	0.00	0.00	0.00	6026.79
BALNGODA	26718.64	769.00	45528.88	36144.67
BALAPTYA	0.00	0.00	23681.83	0.00
BALLKTWA	5016.82	0.00	0.00	20031.84
BAMNPOLA	0.00	0.00	0.00	0.00
BANDRGMA	0.00	0.00	67021.86	1888.22

CENTRE OF DEMAND	STANDARD GALLONS(A)	STANDARD GALLONS(B)	KOLONNAWA GALLONS(A)	KOLONNAWA GALLONS(B)
BANDRWLA	99160.14	0.00	919.68	50352.61
BANGDNYA	0.00	0.00	0.00	0.00
BARMPOLA	0.00	0.00	0.00	2198.62
BATAPOLA	0.00	0.00	11725.95	0.00
BATICALO	113483.49	6120.71	0.00	34832.97
BATULUOA	0.00	0.00	8277.14	0.00
BELIATTA	39591.15	0.00	1149.60	13726.26
BELIHLOY	3987.40	0.00	0.00	0.00
BEMMULLA	0.00	0.00	6667.69	0.00
BENDYMLA	0.00	0.00	21152.69	0.00
BENGMUWA	0.00	0.00	0.00	0.00
BENTOTA	0.00	0.00	0.00	0.00
BERAGAMA	0.00	0.00	0.00	0.00
BERLPNTR	0.00	0.00	0.00	1655.43
BERUWALA	0.00	0.00	54836.07	0.00
BIBILE	4249.76	0.00	0.00	28449.81
BINGRIYA	0.00	0.00	18393.65	7992.61
BIYAGAMA	0.00	0.00	17933.81	0.00
BOGWTLWA	24568.63	0.00	2529.12	0.00
BOMBWELA	0.00	0.00	0.00	1655.43
BOOSSA	0.00	0.00	0.00	0.00
BOPTLAWA	0.00	0.00	0.00	0.00
BOPITIYA	0.00	0.00	2069.28	0.00
BORAGAS	0.00	0.00	0.00	0.00
BORALNDA	1876.43	0.00	2414.17	0.00
BORLSGMA	0.00	0.00	20692.86	155.20
BLTKHPTA	0.00	0.00	11725.95	7035.57
BUTTALA	4288.94	0.00	0.00	9311.78
CHDYNTLW	0.00	0.00	0.00	8277.14
CHANKANI	15152.02	0.00	0.00	0.00
CHVKCHRI	65041.32	999.70	0.00	0.00
CHDIKLAM	0.00	920.21	0.00	0.00
CHMPNPTU	0.00	0.00	0.00	362.13
CNHKLADI	35568.72	1939.96	0.00	2069.29
CHILAW	3187.32	0.00	135653.17	387.99
CHINABAY	0.00	0.00	0.00	2690.07
CHLIPRAM	0.00	0.00	0.00	0.00
CHUNAKAM	50268.12	0.00	0.00	12829.57
COLOMBO	482963.26	7227.01	3660630.54	222741.34
DADALLA	0.00	0.00	0.00	0.00
DALWKTWA	0.00	0.00	15864.53	0.00
DAMBDNYA	0.00	0.00	3448.81	0.00
DAMBULLA	22171.34	0.00	0.00	12398.47
DANKTUWA	0.00	0.00	24946.39	34056.99
DEDUGALA	0.00	0.00	0.00	0.00
DEHIOWTA	1062.44	0.00	1149.60	17252.67
DEHIWELA	0.00	0.00	99325.71	3595.39
DEIYNDRA	7587.38	0.00	0.00	0.00
DEKATANA	0.00	0.00	14485.00	0.00
DELGODA	0.00	0.00	6552.73	0.00

CENTRE OF DEMAND	STANDARD GALLONS(A)	STANDARD GALLONS(B)	KOLONNAWA GALLONS(A)	KOLONNAWA GALLONS(B)
DELTOTA	8088.72	5696.29	0.00	3724.72
DELWALA	0.00	0.00	0.00	0.00
DEMODARA	0.00	0.00	0.00	0.00
DENIPTYA	569.63	0.00	0.00	0.00
DENIYAYA	58180.50	0.00	0.00	4397.23
DERNYGLA	0.00	0.00	23854.27	3092.44
DHRGTOWN	0.00	0.00	7817.30	0.00
DICKOYA	32348.84	0.00	0.00	0.00
DICKWELA	25982.06	0.00	0.00	19399.55
DIMBULLA	0.00	0.00	0.00	0.00
DIVLPTYA	0.00	0.00	32188.89	646.65
DIYTLAWA	11110.13	0.00	0.00	2741.81
DODNDUWA	0.00	0.00	38799.10	0.00
DDNGSLND	2164.06	0.00	0.00	27883.63
DONDGODA	0.00	0.00	9196.82	0.00
DOLSBAGE	18761.27	0.00	0.00	0.00
DMBGHWLA	5026.98	703.01	0.00	5561.21
DOMPE	0.00	0.00	20233.01	0.00
DONDRA	39951.10	0.00	0.00	0.00
DUMLDNYA	0.00	0.00	17933.81	0.00
DUMLSRYA	0.00	0.00	12645.63	258.66
ELTHMDWL	0.00	0.00	9311.79	919.68
EGODUYNA	0.00	0.00	14485.00	0.00
EHLYGODA	3187.32	0.00	36212.50	2922.87
EKALA	0.00	0.00	7587.38	0.00
ELAHERA	0.00	805.78	0.00	0.00
ELLE	4150.81	0.00	229.92	4828.34
ELLAMLLA	569.63	0.00	0.00	0.00
ELKADUWA	11278.64	0.00	0.00	2845.26
ELPITIYA	0.00	0.00	61388.81	51.73
EMBLPTYA	28261.13	0.00	0.00	0.00
EPITWELA	0.00	0.00	0.00	18701.17
EPPAWALA	0.00	0.00	0.00	24960.76
ERAVUR	0.00	0.00	0.00	14485.00
ETTMPTYA	15174.76	0.00	0.00	689.76
ETULKOTE	0.00	0.00	18278.69	0.00
GALGDERA	14391.09	0.00	0.00	0.00
GALAHA	42808.06	1215.63	0.00	413.86
GALPTMDA	0.00	0.00	0.00	2069.29
GALBODA	0.00	0.00	0.00	0.00
GALNBDNW	4138.57	756.43	0.00	9130.72
GALEWELA	31253.01	11530.19	0.00	0.00
GALGMUWA	20242.83	0.00	0.00	25297.02
GALIGMWA	0.00	0.00	19083.41	0.00
GALLE	565582.84	4460.19	13617.05	1034.64
GALOYA	0.00	0.00	0.00	0.00
GALPATHA	0.00	0.00	14714.92	0.00
GAMMDUWA	2734.22	0.00	0.00	0.00
GAMPAHA	0.00	0.00	65182.49	0.00
GAMPOLA	169011.41	0.00	0.00	0.00

CENTRE OF DEMAND	STANDARD GALLONS(A)	STANDARD GALLONS(B)	KOLONNAWA GALLONS(A)	KOLONNAWA GALLONS(B)
GANDARA	0.00	0.00	0.00	0.00
GANEGODA	0.00	0.00	0.00	0.00
GANEMULA	0.00	0.00	23566.87	0.00
GELIOYA	0.00	0.00	0.00	0.00
GINGTHNA	0.00	0.00	21382.61	2974.60
GIRITALE	1062.44	0.00	0.00	3259.12
GIRIULLA	0.00	0.00	57595.12	0.00
GODAGAMA	0.00	0.00	18163.73	0.00
GODKWELA	5228.03	0.00	32073.93	0.00
GODPTIYA	0.00	153.80	0.00	0.00
GODIGMWA	0.00	0.00	21842.46	0.00
GONPNWLA	0.00	0.00	6207.85	0.00
GONAPOLA	0.00	0.00	4828.33	0.00
GONAWELA	0.00	0.00	22762.14	0.00
GOVINNA	0.00	0.00	1379.53	258.66
GURTLAWA	0.00	0.00	0.00	0.00
HABRDUWA	11725.95	0.00	0.00	0.00
HABARANA	8202.95	0.00	0.00	15105.78
HAKMANA	37253.35	3233.25	2069.29	0.00
HALDDWNA	0.00	0.00	0.00	0.00
HALDMULA	7771.27	0.00	1379.52	6233.72
HALGNOYA	24044.54	0.00	689.76	0.00
HALIELA	0.00	0.00	0.00	344.88
HAMBTOTA	23219.25	0.00	1379.52	17071.60
HANGRKTA	35135.81	897.16	0.00	0.00
HANWELLA	0.00	0.00	43799.88	0.00
HAPUTALE	115423.43	1378.50	0.00	775.98
HARNKHWA	0.00	0.00	0.00	0.00
HARSBDDA	8874.57	0.00	0.00	0.00
HATRLYDA	0.00	0.00	0.00	4293.77
HATTON	83072.25	373.62	689.76	98627.32
HEDENIYA	15386.61	0.00	0.00	0.00
HEMTGAMA	0.00	0.00	0.00	17175.07
HENDALA	0.00	0.00	26900.71	0.00
HENEGAMA	0.00	0.00	12990.51	0.00
HETIMULA	0.00	0.00	11036.19	2664.21
HETIPOLA	0.00	0.00	8047.22	15648.97
HEWAHETA	8306.94	8316.58	0.00	0.00
HIKKDUWA	0.00	0.00	25118.83	0.00
HINGULA	0.00	0.00	4828.33	0.00
HINGRKGD	74102.10	0.00	0.00	12493.31
HINIDUMA	0.00	0.00	0.00	0.00
HIRIPTYA	0.00	0.00	0.00	0.00
HITTETYA	0.00	0.00	0.00	0.00
HOMAGAMA	0.00	0.00	148586.20	0.00
HORMBAWA	0.00	0.00	0.00	1914.09
HORANA	0.00	0.00	138412.21	4693.25
HUNGAMA	2873.96	0.00	0.00	1939.96
HUNSGRYA	22471.86	1139.26	0.00	0.00
HUNUPTYA	0.00	0.00	30234.56	0.00

CENTRE OF DEMAND	STANDARD GALLONS(A)	STANDARD GALLONS(B)	KOLONNAWA GALLONS(A)	KOLONNAWA GALLONS(B)
HURIKDWA	11725.95	0.00	0.00	0.00
HURLWEWA	0.00	0.00	0.00	6181.99
IBBGMUWA	25854.78	258.66	0.00	17407.87
IDLGSHNA	8968.49	0.00	0.00	0.00
ILLKWELA	6150.99	0.00	0.00	0.00
IMADUWA	22910.30	0.00	0.00	0.00
IMBLGODA	0.00	0.00	13105.48	0.00
INDURUWA	0.00	0.00	15749.56	0.00
INGNYGLA	0.00	0.00	0.00	1784.76
INGIRIYA	0.00	0.00	24716.47	2241.72
ITTAKNDA	0.00	0.00	0.00	0.00
ITTAPANA	0.00	0.00	5543.96	4966.29
JAELA	0.00	0.00	152839.73	0.00
JAFFNA	320162.87	3353.41	1379.52	26754.14
KADAWATA	0.00	0.00	225667.09	0.00
KADIRANA	0.00	0.00	2069.28	0.00
KADGNAWA	8574.61	0.00	0.00	0.00
KADUWELA	0.00	0.00	35999.82	620.79
KAHADUWA	0.00	0.00	10806.27	1422.63
KHTGSDLY	13730.63	7054.40	3448.81	17537.20
KAHAWATA	51242.36	0.00	54034.22	0.00
KAHAWELA	0.00	0.00	3448.81	0.00
KIKAWELA	0.00	0.00	0.00	0.00
KAKPLIYA	0.00	0.00	0.00	9699.78
KALGDHNA	0.00	0.00	3448.81	0.00
KALAWANA	5241.50	0.00	8277.14	6388.92
KALVNCHK	7830.98	820.68	0.00	0.00
KALAWEWA	0.00	0.00	0.00	0.00
KALMUNAI	36912.58	0.00	0.00	32513.65
KALPTIYA	0.00	0.00	1379.53	7475.29
KALUTARA	0.00	0.00	125191.77	0.00
KMBGMUWA	0.00	0.00	0.00	3957.51
KMBRPTYA	35487.85	768.99	0.00	11467.29
KANDANA	0.00	0.00	45294.36	0.00
KANDPOLA	25961.88	0.00	0.00	9311.79
KANDY	501600.56	5410.20	46277.28	1163.98
KANKSTRA	15220.51	0.00	0.00	8084.59
KANTALAI	124454.29	0.00	0.00	7371.83
KNUKTIYA	3475.30	0.00	0.00	4164.44
KRDIYNRU	0.00	0.00	0.00	0.00
KARANAGA	12036.53	0.00	0.00	0.00
KARNDPNA	0.00	0.00	0.00	8406.48
KATANA	0.00	0.00	16784.21	2690.07
KATRGAMA	729.49	0.00	0.00	14821.26
KATNKUDI	1284.68	2224.48	0.00	32410.19
KATGSTTA	101338.59	0.00	919.69	0.00
KATKTULA	8475.49	0.00	0.00	0.00
KATKRNDA	0.00	0.00	20807.81	0.00
KATUNYKA	0.00	0.00	23279.47	569.06
KATUNRYA	0.00	0.00	13335.40	517.32

CENTRE OF DEMAND	STANDARD GALLONS(A)	STANDARD GALLONS(B)	KOLONNAWA GALLONS(A)	KOLONNAWA GALLONS(B)
KATUPOTA	0.00	0.00	5518.09	11950.12
KATUWANA	387.99	3776.44	0.00	0.00
KAUDULLA	2188.47	0.00	0.00	0.00
KAUDPLLA	0.00	0.00	0.00	0.00
KAYTS	9139.07	328.27	0.00	18287.31
KEBTGLWA	0.00	0.00	0.00	3595.39
KEGALLE	0.00	0.00	155311.38	4552.43
KEKIRAWA	17276.77	0.00	0.00	28840.67
KELANIYA	0.00	0.00	55543.07	1655.43
KEPTPOLA	29334.89	0.00	9656.66	0.00
KESBEWA	0.00	0.00	6437.78	0.00
KILNOCHI	60824.51	0.00	0.00	0.00
KIMBLPTY	0.00	0.00	2299.20	2690.07
KINNIYAI	0.00	0.00	0.00	8328.87
KIRAMA	0.00	1862.36	0.00	2874.01
KIRBTGDA	0.00	0.00	17818.85	0.00
KIRIELLA	0.00	0.00	4943.29	6026.80
KIRINDA	2069.29	0.00	0.00	0.00
KRNDWELA	0.00	0.00	23221.98	0.00
KITALAWA	0.00	0.00	4828.33	0.00
KITLGALA	0.00	0.00	7472.42	3621.25
KOBEIGNA	1379.52	0.00	1379.52	879.44
KOCKKADE	0.00	0.00	58284.87	4552.43
KODIKMAM	5661.93	0.00	0.00	3026.33
KOGGALA	0.00	0.00	0.00	0.00
KOLNKLDI	0.00	0.00	0.00	0.00
KOLONNO	0.00	0.00	0.00	8665.14
KOLNNAWA	0.00	0.00	162657.34	0.00
KOPAY	17914.65	0.00	0.00	9518.71
KOSGAMA	0.00	0.00	7472.42	0.00
KOSLANDA	6345.16	487.03	0.00	2302.08
KOSWT JN	0.00	0.00	4023.61	0.00
KOTDNYWA	0.00	0.00	0.00	931.18
KOTAGALA	50516.35	5126.66	0.00	0.00
KOTAPOLA	2863.66	0.00	0.00	2327.95
KOTIKWTA	0.00	0.00	22302.30	0.00
KTYKMBRA	0.00	0.00	0.00	1991.69
KOTMALE	56077.41	911.41	0.00	0.00
KOTNTIVU	0.00	0.00	2644.09	1086.37
KOTTAWA	0.00	0.00	3333.85	0.00
KOTTE	0.00	0.00	3333.85	0.00
KOTEGODA	689.76	0.00	0.00	24702.10
KOTUGODA	0.00	0.00	8622.02	0.00
KUCHVELI	0.00	0.00	0.00	0.00
KULYPTYA	0.00	0.00	47938.45	21184.31
KUNDSALE	4295.47	0.00	0.00	0.00
KURANA	0.00	0.00	9656.67	0.00
KURNGALA	389264.32	51.73	0.00	5121.49
KURUWITA	153.80	435.77	919.68	0.00
LABUKELE	0.00	0.00	0.00	0.00

CENTRE OF DEMAND	STANDARD GALLONS(A)	STANDARD GALLONS(B)	KOLONNAWA GALLONS(A)	KOLONNAWA GALLONS(B)
LATPNDRA	0.00	0.00	6322.82	724.25
LAXAPANA	0.00	0.00	0.00	0.00
LELOPTYA	0.00	0.00	0.00	0.00
LELWELA	10346.43	0.00	0.00	0.00
LINDULA	102284.26	8544.42	0.00	0.00
LUNAWA	0.00	0.00	37247.14	0.00
LUNUGALA	18931.85	0.00	0.00	0.00
LUNUWILA	0.00	0.00	44144.76	1888.22
MADAMPE	1803.38	0.00	42650.27	0.00
MADAWALA	14990.59	0.00	0.00	0.00
MADHU CH	1075.50	0.00	0.00	0.00
MADLKELE	13314.06	1139.26	0.00	0.00
MADLSIMA	3293.02	0.00	0.00	0.00
MADRNKLI	0.00	0.00	8277.14	7630.49
MAGGONA	0.00	0.00	23796.78	0.00
MAHABAGE	0.00	0.00	13795.24	0.00
MAHAEDND	0.00	0.00	6897.62	0.00
MAHAGAMA	1253.18	0.00	689.76	0.00
MHAILPLM	0.00	0.00	0.00	0.00
MAHAOYA	2658.53	0.00	0.00	827.72
MAHARA	0.00	0.00	0.00	0.00
MHRAGAMA	0.00	0.00	177268.80	724.25
MHVLCHYA	3980.99	2594.06	0.00	0.00
MAHAWEWA	15174.76	0.00	23796.78	0.00
MAHYNGNA	0.00	0.00	0.00	0.00
MAHO	2206.06	0.00	0.00	17537.19
MAKOLA	0.00	0.00	5173.22	0.00
MAKLPOTA	0.00	0.00	0.00	0.00
MAKMBURA	15864.52	0.00	0.00	0.00
MALABE	0.00	0.00	1149.60	0.00
MALIBODA	0.00	0.00	0.00	2586.61
MALGWATA	0.00	0.00	0.00	0.00
MALLAKAM	12899.46	0.00	0.00	0.00
MALPTIYA	0.00	0.00	0.00	0.00
MALWANA	0.00	0.00	0.00	0.00
MALWATAI	1530.91	0.00	0.00	7940.89
MNGLELYA	0.00	0.00	0.00	9104.85
MANIPAY	15063.53	358.87	0.00	0.00
MANKULAM	32856.11	0.00	0.00	0.00
MANNAR	56090.77	3282.71	0.00	5302.54
MANTHIKI	18719.33	0.00	0.00	0.00
MRDKDWLA	0.00	0.00	0.00	2974.60
MRDGHMLA	0.00	0.00	48168.37	0.00
MARASANA	0.00	0.00	0.00	0.00
MARAWILA	0.00	0.00	8966.90	0.00
MRTHNMDM	12749.10	0.00	0.00	19942.74
MASKLIYA	63736.25	0.00	0.00	0.00
MASPOTHA	2734.22	0.00	0.00	0.00
MATALE	192030.57	0.00	0.00	0.00
MATARA	233480.47	2614.60	6207.86	145614.48

CENTRE OF DEMAND	STANDARD GALLONS(A)	STANDARD GALLONS(B)	KOLONNAWA GALLONS(A)	KOLONNAWA GALLONS(B)
MATTAKA	0.00	0.00	2759.05	2664.20
MATUGAMA	0.00	0.00	132319.32	0.00
MAWANELA	0.00	0.00	66562.02	517.32
MAWTGAMA	30253.37	0.00	0.00	0.00
MEDAGAMA	0.00	0.00	0.00	0.00
MEDWCHYA	31463.78	1076.60	0.00	18045.90
MEDAWELA	0.00	0.00	0.00	0.00
MGHETENE	0.00	0.00	5518.09	0.00
MEEGODA	0.00	0.00	0.00	0.00
METYGODA	0.00	0.00	0.00	14045.28
MELSRPRA	22798.40	0.00	0.00	12519.18
METKMBRA	0.00	0.00	0.00	6156.12
MIDDNIYA	8966.90	0.00	0.00	0.00
MIHNTALE	0.00	0.00	0.00	0.00
MINIPE	0.00	0.00	0.00	0.00
MINNRIYA	13717.02	0.00	0.00	0.00
MINWNGDA	0.00	0.00	59664.40	0.00
MIRIGAME	0.00	0.00	42420.35	0.00
MIRISSA	24831.42	0.00	0.00	0.00
MIRSWTTA	0.00	0.00	32993.61	0.00
MONRGALE	16411.50	0.00	0.00	26564.45
MONMLDNY	0.00	0.00	0.00	3517.79
MORGHENA	0.00	0.00	0.00	0.00
MORAGALA	0.00	0.00	2759.05	0.00
MORATUWA	0.00	0.00	166405.05	2715.94
MORAWAKA	6732.22	0.00	0.00	0.00
MTLAVNIA	0.00	0.00	137377.57	0.00
MUDNGODA	0.00	0.00	13335.40	0.00
MULATIVU	23606.96	729.49	0.00	517.32
MULWALAI	12006.68	0.00	0.00	0.00
MUNDEL	1062.44	0.00	13910.20	3362.59
MURUNKAN	9601.14	0.00	0.00	19916.87
MURTLAWA	0.00	0.00	0.00	7759.82
MUTTUR	0.00	0.00	0.00	25038.36
MYLIDDY	6374.64	0.00	620.79	12855.44
NAGODA	0.00	0.00	38051.86	0.00
NAGLGODA	0.00	0.00	0.00	2741.80
NINAMDMA	0.00	0.00	11955.87	181.06
NAKYDNYA	20731.20	0.00	0.00	0.00
NAKLGMWA	0.00	0.00	0.00	258.66
NALANDA	0.00	0.00	0.00	0.00
NALLUR	23419.21	109.42	0.00	14588.47
NAMNKULA	8538.70	0.00	0.00	17933.81
NANATTAN	0.00	0.00	0.00	6544.12
NANUOYA	56299.72	0.00	0.00	0.00
NARAMALA	0.00	0.00	33338.49	8613.40
NATNDIYA	0.00	0.00	40810.91	120708.33
NAULA	16517.59	0.00	0.00	0.00
NAUTDUWA	0.00	0.00	6322.81	0.00
NAWALA	0.00	0.00	0.00	0.00

CENTRE OF DEMAND	STANDARD GALLONS(A)	STANDARD GALLONS(B)	KOLONNAWA GALLONS(A)	KOLONNAWA GALLONS(B)
NAWLPTYA	131253.98	0.00	0.00	0.00
NEBODA	0.00	0.00	19083.41	155.20
NEDNKENI	0.00	0.00	0.00	4009.24
NEGOMBO	1770.73	0.00	252452.84	4138.57
NELLIADY	58925.36	51.27	0.00	0.00
NELNDNYA	18623.57	0.00	7587.38	2146.88
NELUWA	512.66	0.00	0.00	0.00
NIKWRTYA	44230.47	0.00	0.00	17490.06
NILDHNNA	0.00	569.63	0.00	0.00
NINTAVUR	5745.31	136.78	0.00	10372.30
NIRVELI	0.00	0.00	0.00	0.00
NITMBUWA	0.00	0.00	31499.12	1991.69
NIVTGALA	6265.91	0.00	14714.92	0.00
NYNDRPLA	0.00	0.00	3448.81	0.00
NOCHYGMA	18668.56	0.00	0.00	1448.50
NORTBRGE	14998.23	0.00	0.00	9311.79
NORWOOD	32626.73	0.00	0.00	0.00
NUGEGODA	0.00	0.00	205778.96	0.00
NUWELIYA	164965.54	0.00	4828.34	8121.94
OHIYA	640.84	1537.99	0.00	0.00
OLUVIL	0.00	0.00	0.00	2198.62
OMANTHAI	0.00	0.00	0.00	387.99
OPANAIKE	5810.21	0.00	0.00	5949.20
PADAVIYA	8294.34	10580.59	0.00	905.31
PADIRUPU	0.00	0.00	0.00	3121.17
PADYPELA	9635.95	2509.01	0.00	0.00
PADUKKA	0.00	0.00	55410.87	646.65
PAYGLALN	0.00	0.00	517.32	25.87
PALAKUDA	0.00	0.00	6552.74	0.00
PALAMUNA	0.00	0.00	0.00	0.00
PALLAI	15762.94	0.00	517.32	26644.92
PALLEGMA	0.00	0.00	0.00	2715.94
PALLEPLA	4138.57	0.00	0.00	362.13
PALLEWLA	885.37	0.00	15289.72	0.00
PALLWTTA	10942.38	0.00	0.00	0.00
PANADURA	0.00	0.00	159220.03	1422.64
PANAGODA	22311.24	0.00	26900.71	2759.05
PANDTRPU	51391.83	128.16	0.00	14200.48
PANLKNDA	0.00	0.00	0.00	0.00
PANKULAM	0.00	0.00	0.00	0.00
PANNALA	1803.38	0.00	6782.66	258.66
PANNPTYA	0.00	0.00	60814.01	2353.81
PANWILA	1253.18	1230.40	0.00	0.00
PANWLTNE	0.00	0.00	0.00	0.00
PARAKDWA	0.00	0.00	5633.06	5431.87
PARANTAN	20355.13	0.00	1034.64	4311.01
PASSARA	42512.60	0.00	0.00	517.32
PASYALA	0.00	0.00	8277.14	0.00
PATANA	0.00	0.00	0.00	0.00
PELAWATA	0.00	0.00	11725.95	2276.21

CENTRE OF DEMAND	STANDARD GALLONS(A)	STANDARD GALLONS(B)	KOLONNAWA GALLONS(A)	KOLONNAWA GALLONS(B)
PELYGODA	0.00	0.00	498645.52	689.76
PELMDULA	20408.62	0.00	54031.35	0.00
PERDNIYA	71160.55	4280.15	0.00	0.00
PESALAI	0.00	0.00	0.00	5509.48
PILMTLWA	26575.30	0.00	0.00	0.00
PILYNDLA	0.00	0.00	91175.02	0.00
PITBDARA	8212.76	0.00	0.00	0.00
PITIGALA	0.00	0.00	6897.62	1293.31
PITIPANE	0.00	0.00	11036.19	0.00
PODDALA	0.00	0.00	0.00	0.00
PT PEDRO	64554.74	0.00	0.00	0.00
PLGHWELA	0.00	0.00	49088.05	463.59
PLGSOWTA	0.00	0.00	0.00	0.00
POLGOLLA	21115.38	0.00	0.00	0.00
POLNRUWA	91876.86	0.00	2080.78	13553.82
PONAKERI	0.00	0.00	0.00	0.00
POONGALA	10632.19	0.00	0.00	0.00
PVRSKLAM	0.00	0.00	0.00	0.00
POTTUVIL	2327.65	1607.63	0.00	13605.55
PUGODA	0.00	0.00	9311.79	0.00
PUJPTIYA	17323.16	0.00	0.00	0.00
PULMODAI	5514.37	0.00	0.00	3750.58
PILOLI	16651.20	0.00	0.00	0.00
PINDLOYA	30083.23	7609.46	0.00	2327.95
PUNGDTVU	2164.06	0.00	0.00	18468.38
PUNNALAI	7055.57	0.00	0.00	0.00
PUNLKDWN	35388.53	512.66	0.00	0.00
PUPURESA	9656.66	0.00	0.00	0.00
PUSELAWA	30167.76	1708.88	0.00	0.00
PUSSELLA	0.00	0.00	21842.46	0.00
PUTTALAM	507.30	0.00	111511.50	6595.85
PUTKDRPU	0.00	0.00	0.00	2922.87
PUTTUR	2124.88	0.00	1149.60	0.00
PUWKPTYA	0.00	0.00	1724.40	0.00
RAGALA	17690.23	0.00	0.00	7501.16
RAGAMA	0.00	0.00	37821.95	51.74
RAJAGAMA	0.00	0.00	0.00	0.00
RAJKDLWA	0.00	0.00	1954.33	0.00
RAKWANA	17669.81	0.00	13680.28	0.00
RAMBODA	26198.72	1253.18	0.00	0.00
RAMBDGLA	0.00	0.00	0.00	0.00
RAMBKANA	0.00	0.00	43435.00	0.00
RMBKPTYA	0.00	0.00	0.00	0.00
RANALA	0.00	0.00	35867.62	3362.59
RANGALLA	13785.00	0.00	0.00	1138.11
RANNA	0.00	0.00	0.00	0.00
RATGAMA	0.00	0.00	4828.33	2431.41
RATMLANA	6348.60	256.33	387991.04	103.46
RATMALE	0.00	0.00	0.00	0.00
RATNPURA	107515.22	4943.81	81621.82	517.32

CENTRE OF DEMAND	STANDARD GALLONS(A)	STANDARD GALLONS(B)	KOLONNAWA GALLONS(A)	KOLONNAWA GALLONS(B)
RATTOTA	1413.05	0.00	0.00	0.00
RIDIGAMA	16577.09	0.00	0.00	0.00
RIDYAGMA	0.00	0.00	0.00	0.00
RIKLGSKD	22864.46	0.00	0.00	0.00
ROZELLE	2734.21	0.00	0.00	0.00
RUANWELA	0.00	0.00	31614.09	1965.82
SINTHMRT	0.00	0.00	0.00	15959.36
SAMNTHRA	1753.35	2207.02	0.00	11381.07
SANDLNKW	0.00	0.00	65297.46	0.00
SAPGHWTA	0.00	0.00	4598.41	0.00
SEEDUWA	0.00	0.00	30340.90	103.46
SEEPKLAM	0.00	0.00	0.00	0.00
SILVTURA	5312.20	0.00	0.00	0.00
SITNKENI	10741.94	0.00	0.00	0.00
TABBOWA	0.00	0.00	0.00	0.00
TALMANAR	0.00	0.00	0.00	0.00
TALALLA	0.00	0.00	0.00	0.00
TALNGAMA	0.00	0.00	0.00	0.00
TALTUDYA	22072.38	0.00	0.00	258.66
TALWKELE	129220.86	8658.35	0.00	22129.86
TALWTGDA	0.00	0.00	18278.69	0.00
TALGSWLA	0.00	0.00	13437.71	646.65
TALPE	0.00	0.00	0.00	0.00
TAMBTGMA	10704.00	0.00	0.00	0.00
TMPLKMAM	0.00	0.00	0.00	13941.81
TANMWILA	8277.15	0.00	0.00	0.00
TANGALLA	19087.51	0.00	459.84	41589.76
TAWALAMA	0.00	0.00	0.00	0.00
TWLNTENE	0.00	0.00	0.00	0.00
TEBUWANA	0.00	0.00	9311.78	1060.51
TELDNIYA	22480.92	928.38	0.00	25038.36
TELJWILA	0.00	281.97	0.00	0.00
TELIPALI	20679.82	0.00	0.00	0.00
TENEKBRA	25978.34	0.00	0.00	0.00
TALAGAHA	0.00	0.00	0.00	0.00
TIHAGODA	3151.32	711.25	0.00	0.00
TNDMANAR	20068.46	0.00	0.00	0.00
TUNNUKAI	0.00	0.00	0.00	0.00
TRKTSWRN	2846.23	0.00	0.00	4914.55
TRWNKTYA	0.00	0.00	41845.55	0.00
TISMRAMA	11307.34	0.00	129.33	76554.95
TRNCMALE	130956.00	0.00	8897.93	116299.59
TUMODARA	0.00	0.00	0.00	0.00
UDHNTENE	0.00	0.00	0.00	0.00
UDAKRWTA	5126.66	0.00	0.00	0.00
UDPSLAWA	39793.24	0.00	0.00	12157.05
UDAWALWE	0.00	0.00	0.00	2327.94
UDISPATU	8121.03	1914.09	0.00	0.00
UDABDAWA	0.00	738.61	62423.45	0.00
UDUGAMA	15321.94	786.23	0.00	0.00

CENTRE OF DEMAND	STANDARD GALLONS(A)	STANDARD GALLONS(B)	KOLONNAWA GALLONS(A)	KOLONNAWA GALLONS(B)
UDGMPOLA	0.00	0.00	23451.90	0.00
UHANA	1419.25	0.00	0.00	0.00
UKUWELA	2050.66	0.00	0.00	0.00
ULAPANE	8133.90	0.00	0.00	0.00
UNDUGODA	0.00	0.00	574.80	9234.19
UPCOT	57571.87	0.00	0.00	3103.93
URALA	8270.62	0.00	0.00	0.00
URAPOLA	0.00	0.00	10921.23	0.00
URUBOKKA	8451.93	0.00	0.00	0.00
URUGALA	0.00	387.99	0.00	0.00
URGSMNHD	0.00	0.00	11725.95	0.00
URUMPRAI	4138.57	0.00	0.00	29539.05
UYLNKLAM	8519.11	1192.16	491.45	25219.42
VADUKODA	0.00	0.00	0.00	0.00
VALCHENA	22699.58	109.42	1008.78	28219.88
VAVETURI	39710.07	0.00	0.00	0.00
VASAVLAN	2069.28	0.00	0.00	0.00
VAVNKLAM	0.00	0.00	0.00	0.00
VAVUNIYA	45269.49	646.65	775.98	86073.66
VELANAI	3710.32	490.53	0.00	46196.80
VEYNGODA	0.00	0.00	110706.78	0.00
WADAKADA	5106.45	0.00	0.00	6466.52
WADDUWA	0.00	0.00	49777.81	129.33
WAGA	0.00	0.00	1149.60	77.60
WAHARAKA	0.00	0.00	1264.56	5716.40
WAIKKAL	0.00	0.00	18508.61	0.00
WALSGALA	15065.11	0.00	0.00	0.00
WALSMULA	24832.97	0.00	3448.81	0.00
WALAWE	972.65	0.00	0.00	0.00
WANDRBMA	0.00	0.00	0.00	0.00
WARKGODA	0.00	0.00	5288.17	0.00
WARKPOLA	0.00	0.00	37592.02	0.00
WARALLA	3691.19	922.80	0.00	0.00
WARYPOLA	16773.56	0.00	0.00	42135.83
WASKDUWA	0.00	0.00	0.00	4474.83
WATAGODA	0.00	0.00	1600.82	0.00
WATAWALA	721.35	0.00	0.00	3052.20
WATTALA	0.00	0.00	63228.17	0.00
WATTGAMA	23841.40	0.00	1615.19	1612.32
WATUGDRA	0.00	0.00	5518.09	0.00
WATUMULA	0.00	569.63	0.00	543.19
WATRGAMA	0.00	0.00	11725.95	0.00
WERAGODA	0.00	731.70	0.00	8277.14
WERAKTYA	15285.95	0.00	0.00	0.00
WELIGAMA	84040.37	0.00	0.00	0.00
WELIKADA	0.00	0.00	86220.23	0.00
WELIKNDA	0.00	0.00	0.00	0.00
WELIMADA	83389.98	0.00	17244.04	10061.90
WELIPENE	0.00	0.00	0.00	0.00
WELIWRYA	0.00	0.00	35177.85	0.00

CENTRE OF DEMAND	STANDARD GALLONS(A)	STANDARD GALLONS(B)	KOLONNAWA GALLONS(A)	KOLONNAWA GALLONS(B)
WELLMPTY	0.00	0.00	117792.35	0.00
WELAWAYA	11268.27	0.00	0.00	2379.67
WENAPUWA	0.00	0.00	34488.10	1370.90
WERAHERA	0.00	0.00	5357.15	0.00
WERLGAMA	28927.74	201.18	0.00	0.00
WEWLDNYA	0.00	0.00	48973.09	517.32
WIRAWILA	0.00	0.00	0.00	4138.57
YAKKALA	0.00	0.00	5403.13	0.00
YAKKLMLA	0.00	0.00	0.00	0.00
YATAWATA	0.00	0.00	0.00	0.00
YATIYANA	18045.00	512.67	0.00	3595.38
YATNTOTA	0.00	0.00	33798.33	310.40
YODKNDYA	0.00	0.00	0.00	0.00

APPENDIX "D"

THE CONSTRAINT ON THE KELANI VALLEY LINE

The summary of the alterations to the optimal solution by the exclusion of the new depots on the Kelani Valley Line is given below. I have also set up the problem such that there is a maximum of 500,000 gallons placed on the throughput of the existing Ratnapura depot. This has been done to demonstrate the sub-routine which operates under these circumstances.

AMENDED OPTIMAL BASIS

Depot	Throughput	Fixed Cost	Variable Cost
Kolonnawa	12125243.22	411000.00	565546.01
Matara	660993.11	7200.00	101050.57
Haputale	511253.37	6500.00	116667.83
Peradeniya Jn.	2387219.27	15200.00	329088.36
Batticaloa	385059.02	7000.00	106827.05
Kurunegala	884463.48	9850.00	115065.82
Anuradhapura	394215.03	6000.00	72167.44
Jaffna	485626.90	9350.00	129063.56
Ratnapura	499493.86	3000.00	62491.20
Galle	969285.31	8850.00	113858.85
China Bay	333047.50	11500.00	42463.45
Ambalangoda	341810.64	7341.81	32125.27 *
Madampe	538937.87	7539.94	53503.20 *
Mankulam	150684.03	7150.68	34514.11 *
Chavakachcheri	535437.35	7535.44	144881.19 *

* denotes a new depot.

The existing depots which have been dropped are Kotagala
Kilinochchi
New Peradeniya

Total Fixed Cost = 525016.87
Total Variable Cost = 2019313.91
Cost of Collections = 80134.38

Total Overall cost = 2624465.17

Improvement over present system = 97005.10
Percentage Improvement = 3.56%

GENERATED THROUGHPUT OF 776732.82 AT RATNPURA EXCEEDS ITS MAXIMUM VALUE O
500000 BY 276732.82
E MAXIMUM THROUGHPUT OF RATNPURA DEPOT HAS BEEN REACHED AFTER 7 DESTINATI
ANGED IN DECREASING ORDER OF SAVINGS)ARE SUPPLIED FROM IT

TNPURA DEPOT WILL ENTER THE BASIS

PROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT RATNPURA IS 499493.86

FIXED COST OF RATNPURA IS 3000.00
INITIAL VARIABLE COST OF RATNPURA IS 62491.20

INITIAL GROSS SAVING BY INCLUSION OF RATNPURA IN THE BASIS IS 5656.9
CONTRIBUTION TO NETT SAVING BY INCLUSION OF RATNPURA IS 2656.94

OTS IN BASIS

POT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
ONAWA	13657718.62	411000.00	770743.31
ARA	946254.55	7200.00	151656.79
UTALE	515503.13	6500.00	117927.03
DNIYA	2387219.27	15200.00	329088.36
ICALO	385059.02	7000.00	106827.05
NGALA	1016964.99	9850.00	164776.13
RPURA	692667.76	6000.00	151356.04
ENA	1081888.76	9350.00	299824.18
NPURA	499493.86	3000.00	62491.20

ED COST OF KOLONAWA AND 8 DEPOT/S IS 475100.00
IABLE COST OF KOLONAWA AND 8 DEPOT/S IS 2134690.09

AL COST OF ALL COLLECTIONS = 80134.38

ICED OVERALL COST = 2689924.47

NITIAL NETT SAVING BY INCLUSION OF RATNPURA IN THE BASIS IS 2656.94

OVEMENT OVER COST OF PRESENT SYSTEM = 31545.80

RCENTAGE IMPROVEMENT = 1.16

E DEPOT WILL ENTER THE BASIS

OVED SUPPLY PATTERN

APPENDIX "E"

The following pages contain the information and cost data received from the Finance Division of the Ceylon Petroleum Corporation. Much of it has been accepted without any modification. I have described earlier the manner in which the other data has been adapted for my requirements.

ANALYSIS BY LOCATION OF STORAGE & FILLING AND GENERAL ADMINISTRATION EXPENSES

	CAPITAL INVEST-MENTS	ISSUES	STORAGE & FILLING				
			Depre-ciation	Remune-ration	Materials Occupan-cy Chgs. etc.	Total Opera-ting Cost	Cost per gallon Rs.
KOLONNAWA	28.500	95.850	.904	1.062	.294	2.260	.02
DEPOTS:							
MATARA	.203	2.248	.006	.040	.002	.048	.02
GALLE	.111	2.960	.004	.029	.001	.034	.01
PERADENIYA	.193	5.131	.006	.041	.002	.049	.01
BATTICALOA	.373	1.774	.012	.025	.004	.041	.02
KURUNEGALA	.373	2.876	.012	.032	.004	.048	.02
NEW PERADENIYA	.116	1.276	.004	.023	.001	.028	.02
JAFFNA	.218	2.981	.007	.035	.002	.044	.01
RATNAPURA	.040	1.035	.001	.023	.001	.025	.02
HAPUTALE	.126	2.065	.004	.033	.001	.038	.02
ANURADHAPURA	.124	1.879	.004	.019	.001	.024	.01
KOTAGALA	.339	3.997	.011	.039	.004	.054	.01
KILLINOCHCHI	.284	0.800	.008	.016	.003	.027	.033
	31.000	124.872	.983	1.417	.320	2.720	-

VALUE - In millions of Rupees unless otherwise stated.

QUANTITY-In millions of Gallons

ANALYSIS BY LOCATION OF STORAGE & FILLING AND GENERAL ADMINISTRATION EXPENSES

	ADMINISTRATION			
	Depreciation	Remuneration & other Chgs.	Total Operating Cost	Cost per gallon Rs.
KOLONNAWA	.049	1.513	1.562	.02
DEPOTS:				
MATARA	.002	.035	.037	.02
GALLE	.002	.047	.049	.02
PERADENIYA	.004	.081	.085	.02
BATTICALOA	.001	.028	.029	.02
KURUNEGALA	.002	.045	.047	.02
NEW PERADENIYA	.001	.020	.021	.02
JAFFNA	.002	.047	.049	.02
RATNAPURA	.001	.016	.017	.02
HAPUTALE	.002	.033	.035	.02
ANURADHAPURA	.002	.030	.032	.02
KOTAGALA	.003	.063	.066	.02
KILLINOCHCHI	.001	.016	.017	.006
	.071	1.958	2.029	-

VALUE - In millions of Rupees unless otherwise stated.

QUANTITY - In millions of Gallons.

THE BREAKDOWN OF INVESTMENT

COST

			In Million Rupees
Kolonnawa -	Storage Tanks, buildings, etc.		28.500
Depots	Matara	.203	
	Galle	.111	
	Peradeniya Junction	.193	
	Batticaloa	.373	
	Kurunegala	.373	
	New Peradeniya	.116	
	Jaffna	.218	
	Ratnapura	.040	
	Haputale	.126	
	Anuradhapura	.124	
	Kotagala	.339	
	Killinochchi	.284	2.500
Bloemendhal (Barge)			2.000
Trincomalee			3.300
			36.300
Retail outlets (including Kerosene outlets)		41.200	
Consumer Points (Storage Tanks and Pumps only)		5.000	46.200
Transport			7.000
	TOTAL		89.500

THE BREAKDOWN OF INVESTMENT AT RETAIL OUTLETS AND CONSUMER POINTS ACCORDING TO TYPE OF INVESTMENT

	In Million Rupees
Buildings	19.500
Pumps	10.400
Storage Tanks	8.700
Hoists	1.200
Air Compressors	2.300
Air Scales	.300
Lubestors	.800
Miscellaneous	3.000
	46.200

SUMMARY OF ISSUES OF BULK PRODUCTS FOR THE PERIOD 1.1.66 TO 30.6.66 AT KOLONNAWA AND DEPOTS.

Kolonnawa -	Sales	61.937
	Transfers	33.913
	Total issues	95.850
Depots -	Matara	2.248
	Galle	2.960
	Peradeniya	5.131
	Batticaloa	1.774
	Kurunegala	2.876
	New Peradeniya	1.276
	Jaffna	2.981
	Ratnapura	1.035
	Haputale	2.065
	Anuradhapura	1.879
	Kotagala	3.997
	Killinochchi	-
		124.072

FINANCIAL RESULTS
(Approximate)

Units: Rs.'000' Half Year Ending 30.6.1966 SUMMARY OF EXPENSES

	Storage & Filling	Distribution Admn.	Distribution Facilities	Gen. Admn.	Delivery	I.B.	Trinco	Total
1. Remuneration								
Salaries								
Supervisory	209	189	82	461	-	23	9	973
Clerical	309	145	-	733	-	5	27	1219
Wages								
Labour	564	-	263	-	588	47	131	1593
	1082	334	345	1194	588	75	167	3785
Overtime								
Clerical	132	21	11	87	-	7	4	262
Labour	203	-	95	-	465	14	18	795
TOTAL	1417	355	451	1281	1053	96	189	4842
2. Materials M&R 3. Direct Maintenance	344	-	870	154	755	82	42	2247
4. Fuel Consumption	-	-	-	-	287	-	-	287
5. Insurances & Licences	119	-	22	10	49	15	10	225
6. Travelling	25	70	30	47	115	-	3	290
7. Entertainment	-	-	-	10	-	-	-	10
8. Advertising & Publicity	-	159	-	-	-	-	-	159
9. Welfare Medical	-	-	-	50	-	-	-	50
10. (a) Uniforms	-	-	-	62	-	-	-	62
(b) Employee Training	-	-	-	-	-	-	-	-
11. Professional Fees	-	-	-	63	-	-	-	63
12. Occupancy Chgs.								
a. Rent	105	-	6	8	-	-	-	119
b. Rates	69	-	164	12	-	5	-	250
c. Electricity & Gas	40	-	115	8	-	-	12	175
d. Hire of Furniture	-	-	-	1	-	-	-	1
13. General Administration								
a. Telephone	-	-	-	75	-	-	-	75
b. Postage	-	-	-	20	-	-	-	20
c. Bank Charges	-	-	-	116	-	-	-	116
d. Printing & Stationery	-	-	-	160	-	-	-	160
e. Misc. Expenses	-	-	-	15	-	-	-	15
f. Hire of I.B.M.	-	-	-	38	-	-	-	38
g. Board Expenses	-	-	-	26	-	-	-	26
h. Sundry Advertisement	-	-	-	20	-	-	-	20
i. Sundry Storage Expenses	-	-	-	25	-	-	-	25
14. Transport (Rail Freight)	-	-	-	-	4800	-	-	4800
15. Sales Expenses	-	250	-	-	-	-	-	250
	2119	834	1658	2201	7059	198	256	14325
Depreciation	983	71	1736	-	700	143	167	3800
	3102	905	3394	2201	7759	341	423	181[illegible]

TANKAGE CAPACITIES

	LS	LP	LAD	LHD	LSK	LF	TOTAL
Matara	27,000	35,697	32,700	20,850	52,798	-	169,045
Galle	12,000	20,000	12,000	12,000	36,000	-	92,000
Peradeniya	20,000	40,000	40,000	20,000	40,000	-	160,000
Batticaloa	27,000	39,000	109,000	-	120,200	15,000	310,200
Kurunegala	22,541	45,082	125,494	-	116,849	-	309,966
New Peradeniya	24,000	24,000	11,800	15,900	12,000	8,900	96,600
Jaffna	22,000	39,000	48,450	14,000	57,850	-	181,300
Ratnapura	-	-	22,000	11,000	-	-	33,000
Haputale	11,600	23,200	31,200	19,900	18,450	-	104,350
Anuradhapura	22,600	22,600	34,800	-	23,200	-	103,200
Kotagala	12,000	24,000	12,000	186,000	24,000	24,000	282,000
Killinochchi	33,068	49,602	36,636	-	116,692	-	235,998
	233,809	362,181	516,080	299,650	618,039	47,900	2077,659
Total - Depots (Million gallons)	0.234	0.362	0.516	0.300	0.618	0.048	2.078
Kolonnawa "	4.840	8.355	6.646	6.763	11.146	8.321	46.071
	5.074	8.717	7.162	7.063	11.764	8.369	48.149

LS = Premium Gasoline
LP = Regular Gasoline
LAD= High Speed Diesel
LHD= Industrial Diesel Oil
LSK= Kerosene
LF = Furnace Oil

ALLOCATION OF EXPENSES FOR THE PERIOD 1.1.66 - 30.6.66

	Bulk	Lubes	Total
Storage & Filling	2.720	.382	3.102
General Administration	2.029	.172	2.201
Distribution Administration	.838	.067	.905
Distribution Facilities	3.341	.053	3.394
Trincomalee			.423
Bunkering			.341
Delivery			7.759
			18.125
Expenses as per Accounts - Schedule 4		14.325	
Provision for Depreciation - Schedule 4		3.800	
			18.125
In Million Rupees			

APPENDIX "F"

A NOTE ON HEURISTIC PROGRAMMING

The numerical study of management sciences has been mostly concerned with the creation and use of mathematical models and the derivation of optimum solutions to problems as represented by these models. Various computational routines referred to as algorithms are used and their application has tended, according to Keuhn,(49) to become technique-oriented; i.e., users tend to adapt their problems/models for use in the existing algorithms. e.g., the elegance and convenience of Linear Programming has resulted in many non-linear relationships being approximated to linearity, or wide range non-linearities being subject to piecewise linearisation.

Keuhn attributes the development of techniques such as Simulation and Heuristic Programming to the rapid advances in the technology of the computer with its vast capacity firstly for data storage and secondly for repetitive calculation. The user enjoys much greater freedom of expression since the constraints of the more inflexible techniques do not arise. The model can now bear a much closer relationship to reality and the approach becomes problem-oriented. This advantage has, however, to be weighed against the possibility that solutions obtained by heuristic methods may not be optimal.

Heuristic programming contains an element of a trial and error approach to problem solving. Heuristics have been defined as "aids to discovery"(49) or rules of thumb selected with the intention of solving specific problems. The more technical definition of Newell, Shaw and Simon(50) mentions principles or devices that contribute, on the average, to reduction of search in problem-solving activity. Heuristics can help in solving problems but do not guarantee that the best solution, or indeed any solution, will be found.

Simon and Newell[51] have suggested three characteristics of the well-structured type of problem for which conventional programming techniques are useful.

1) The problem can be described in easily quantifiable variables.

2) The objective can be specifically described in terms of maximisation of profit, minimisation of cost, etc.

3) The characteristics of the problem are well suited to the algorithms available.

The ill-structured problems for which heuristic programming techniques may prove appropriate have the following general characteristics:-

1) There are non-numerical variables, with their inter-relationships.

2) The objective too may be non-numerical and only an "acceptable" solution is sought.

3) There is no optimal algorithm that is appropriate to the problem.

Tonge[52] makes some interesting comments on the use of heuristic programming and surveys the literature on this subject, while Hinkle and Keuhn[53] have written a more leisurely paper which describes heuristics and some of their applications. A more detailed account of a specific use of heuristics is given by Keuhn[49] in connection with the travelling salesman problem, i.e., to determine the best route that a salesman has to follow in making a predetermined number of calls before returning to his starting point. The criterion in selecting the route may be minimum travel time, minimum distance travelled, minimum cost, maximum time spent with customers, or some other desirable end. The linear programming approach has been studied by Dantzig, Fulkerson and Johnson.[54]

The heuristic approach adopted by Thompson and Kay[55] is based upon the random selection of three cities and the insertion of the other calls, also selected at random, in between these three cities, and a constant evaluation to determine whether the selection criterion is being achieved. The procedure is repeated indefinitely, each time starting with a random set of three cities and proceeding until a lowest cost (or highest profit) solution is reached. The variability of the solution obtained is an indication of the spread of costs (or profits) and provides a basis for estimating the probable value of the optimal solution.

The meaning that has been given in the present study is that a heuristic is a routine which is itself well defined and inflexible, which can handle a large-scale problem and produce, with a small amount of computation, a reasonable solution. It conforms to earlier definitions regarding the repetitive procedure which may not guarantee optimality. My technique also conforms to the statement that a heuristic is a rule of thumb - it has been developed empirically to suit the requirements of the depot location problem and contains provision for all its important constraints. It is also believed that the super-imposition of the sensitivity analysis upon the heuristic routine brings the ultimate solution very close to the optimum, if it does not eventually reach it.

APPENDIX "G"

THE DETAILED RESULTS

Representative sections of the results obtained from the computer are annexed hereto. They are

a) the summary of country-wide demand. The items are i) present source, ii) deliveries ex depots, iii) collections ex depots, iv) deliveries ex Kolonnawa, v) collections ex Kolonnawa, vi) total deliveries, vii) total collections, viii) total demand, for every centre of demand, plus a cumulative total of variable costs for all centres of demand.

b) the summary of the costs of the present system of distribution

c) a listing of the depots (existing and proposed) plus their operating costs, supply costs, and together with the operating cost of the central source, the total costs ex each of these depots.

d) the cost of supplying all centres of demand from the central source only.

e) the print out of several iterations. The first two are normal iterations, but the third is one in which a depot in the basis drops out when so many centres are re-allocated elsewhere that it becomes unprofitable.

f) the fourth iteration has been adjusted to provide a complete print out of how each centre of demand is allocated.

g) the next 16 iterations complete the first run through of the main program.

h) the indicator IR has been activated (IR = 136), and the program loops back.

i) in the next 4 iterations, a depot which had been rejected earlier comes into the basis again and is again rejected. (Ratnapura)

j) the indicator IR has been activated again, but the second loop does not produce any alterations in the basis.

k) the next section summarises the allocation of destinations to the depots selected for the basis.

l) a summary of the depots, their throughputs, and fixed and variable costs, and indications of whether existing depots have not been retained in the final basis, or whether new depots will be included.

m) a time check, this time together with the time noted at the commencement of the program gives the time taken by the program up to this stage.

n) the sensitivity analysis.

o) the first iteration in this segment deals with the suggestion that a depot in the final basis be excluded. The result at the end of the iteration shows that the cost will be increased if this is allowed to happen.

p) the next case is one where a depot that has been dropped is forced into the basis. The extra cost of doing so is shown.

q) the last part of the results is again a case of an included depot being dropped. The example chosen is that of Opanaike, a new depot.

SUMMARY OF ITERATIONS

Present distribution cost = Rs. 2,721,470.26 per month

S denotes the central source - Kolonnawa

Number of depots in basis	Cost	Improvement over cost of present system	Percentage improvement	Improvement over last iteration
S	3,529,894.08	-808,423.82	-29.71	-
S + 1	3,466,957.27	-745,487.01	-27.39	62,936.91
S + 2	3,439,311.18	-717,840.91	-26.38	27,646.09
S + 2	3,402,845.40	-681,375.14	-25.04	36,465.78
S + 3	3,177,980.27	-456,510.01	-16.77	224,865.13
S + 4	3,140,981.12	-419,510.86	-15.41	36,999.15
S + 5	3,033,168.97	-311,698.71	-11.45	107,812.15
S + 6	2,808,972.45	-87,502.18	-3.22	224,196.52
S + 7	2,692,581.41	28,888.86	1.06	116,391.04
S + 8	2,688,101.78	33,368.48	1.23	4,479.63
S + 9	2,657,390.03	64,080.23	2.35	30,711.75
S + 10	2,629,823.55	91,646.71	3.37	27,566.48
S + 11	2,629,523.93	91,946.34	3.38	299.62
S + 12	2,625,629.21	95,841.05	3.52	3,894.72
S + 13	2,623,311.82	98,158.44	3.61	2,317.39
S + 14	2,622,642.48	98,827.78	3.63	669.34
S + 13	2,611,243.28	110,226.98	4.05	11,399.20
S + 13	2,617,779.25	103,691.01	3.81	-6,535.97
S + 13	2,612,266.00	109,204.26	4.01	5,513.25
S + 14	2,609,357.91	112,112.35	4.12	2,908.08
S + 14	2,608,564.33	112,905.93	4.15	793.58
S + 13	2,606,857.75	114,612.51	4.21	1,706.58

The negative improvement from 4.05% to 3.81% is due to a depot being dropped from the basis, and its demand centres being reverted to Kolonnawa. This set-back is soon wiped out when the program is recycled.

```
)NSOLIDATED BY XPCL 5B      DATE     25/06/69    TIME 07/19/47

{OGRAM GP03
)MPACT DATA (15AM)
)MPACT PROGRAM (DBM)
)RE                 21312

|   *00000120      80
'   *00000122      82
;   *00000360     240
'   *00000400     256
'   *00001465     821
:   *00001507     839
|   *00013752    6122
|   *00016374    7420
'   *00016624    7572
|   *00051473   21307

:G  *00001507     839  %%%F
|P  *00016374    7420  %FIOINF
.P  *00001322     722  %FIOLIST
:G  *00012530    5464  %FIOCARD
:G  *00012642    5538  %FIOLP
:G  *00013133    5723  %FIOMT
|P  *00016424    7444  %FIOBUF
:G  *00010446    4390  %FERL
:G  *00001507     839  DISTRIBUTIONCOSTANALYSIS
:G  *00010125    4181  %FAP4
|T  *00010513    4427  %FPM
:G  *00013710    6088  TIME
:G  *00010640    4512  %FINOUT
:G  *00007733    4059  UTD1
:G  *00010446    4390  %FPP
:G  *00007777    4095  UTD2
G   *00013715    6093  COPY
:G  *00013062    5682  %FIOTA
:G  *00010550    4456  %FSTOP
|T  *00010545    4453  %FERND
.V  *00000360     240  %LIB
.V  *00000370     248  %FMC
.V  *00000373     251  %FMARK
|T  *00010507    4423  %FRL
.P  *00001331     729  %AA4K
.P  *00001431     793  %ATYPB
.P  *00001432     794  %FITER
|T  *00010446    4390  %FPRO2
|T  *00010515    4429  %FER
|T  *00010547    4455  %FMN4
|T  *00010640    4512  %FIOAUX
.P  *00001433     795  %FDIS
.P  *00001435     797  %ACLOS
.P  *00001436     798  %FPNO
.P  *00001437     799  %FDMK
|T  *00010743    4579  %FINF
.V  *00000374     252  %FIOPER
.V  *00000375     253  %FIOLEN
.V  *00000377     255  %FINCH
.P  *00001440     800  %FIOZ
|T  *00011421    4881  %FIOE
```

```
T *00011673   5033 %FIOB
T *00011737   5087 %FIOA
T *00012141   5217 %FIOC
T *00012322   5330 %FIOD
G *00013000   5632 %FINIL
T *00013025   5653 %FOTR
P *00001452    810 %FIOWRB
T *00013421   5905 %FIOCHT
T *00013454   5932 %FIORWD
T *00013667   6071 %FIOREL
T *00013435   5917 %FIOALLO
T *00013444   5924 %FIOREN
G *00013251   5801 %FINMT
T *00013553   5995 %FIRD
T *00013566   6006 %FIWT
T *00013602   6018 %FIOBKSP
T *00013501   5953 %FIOENDF
```

ART TIME = 07/20/31

SUMMARY OF COUNTRY WIDE DEMAND PATTERN

DESTN	DEPOT	DEL EX DEPOT	COL EX DEPOT	DEL EX KOL	COL EX KOL	TOTAL DEL	TOTAL COL	TOTAL DEMAND	TOTAL COST
ALCHNA	KOLONAWA	0	0	0	5794	0	5794	5794	82.
ALWATA	KOLONAWA	0	0	31499	0	31499	0	31499	3021.
RAPTNA	KOTAGALA	34885	8886	0	0	34885	8886	43771	11024.
ANGAMA	GALLE	28825	0	0	0	28825	0	28825	14509.
UNGALA	KOLONAWA	0	0	3908	0	3908	0	3908	14894.
ARPATU	BATICALO	11719	9127	0	24236	11719	33364	45083	21047.
MIMANA	GALLE	2050	0	0	0	2050	0	2050	21270.
URANA	PERDNIYA	14203	0	0	5535	14203	5535	19738	23092.
URESSA	GALLE	76244	4562	0	3931	76244	8494	84738	34422.
AVEDDY	JAFFNA	17933	0	0	0	17933	0	17933	39158.
AWTGDA	PERDNIYA	33656	0	0	0	33656	0	33656	43411.
AWWA	KOLONAWA	0	0	26325	1138	26325	1138	27464	45512.
UTGAMA	KOLONAWA	0	0	76103	801	76103	801	76905	51686.
UTNWRA	KOLONAWA	0	0	201	33281	201	33281	33482	52206.
BLGODA	KOLONAWA	0	0	87082	844	87082	844	87927	61569.
BLTOTA	MATARA	18853	0	689	27935	19543	27935	47478	66036.
BAWELA	KOLONAWA	0	0	0	0	0	0	0	66036.
BEPUSA	KOLONAWA	0	0	0	0	0	0	0	66036.
PARAI	BATICALO	141774	33862	0	32591	141774	66453	208227	118313.
PITIYA	NEWPERAD	1367	0	0	0	1367	0	1367	118482.
AMDUWA	KOLONAWA	0	0	0	8225	0	8225	8225	118598.
DIAMBM	KOLONAWA	0	0	0	1551	0	1551	1551	118620.
GAMUWA	KOLONAWA	0	0	2069	9596	2069	9596	11665	119060.
GODA	KOLONAWA	0	0	4138	0	4138	0	4138	119147.
GRWELA	KOLONAWA	0	0	0	20454	0	20454	20454	119436.
HTGAMA	KOLONAWA	360	0	0	7527	360	7527	7887	119569.
KMBURA	PERDNIYA	6195	0	0	2250	6195	2250	8445	120427.
RDPURA	ANURPURA	233028	6750	0	4138	233028	10888	243917	157009.
AKWILA	KOLONAWA	0	0	9426	0	9426	0	9426	157557.
ANAYKA	KOLONAWA	0	0	459	18856	459	18856	19316	157885.
GHKTWA	KOLONAWA	0	0	0	17976	0	17976	17976	158139.
IYALAI	JAFFNA	2759	0	0	32539	2759	32539	35298	159345.
TABAGE	KOLONAWA	0	0	0	0	0	0	0	159345.
GHUVLY	JAFFNA	17947	0	0	1810	17947	1810	19758	164490.
TNGALA	KOLONAWA	0	0	11381	0	11381	0	11381	165172.
TIDIYA	KOLONAWA	0	0	0	775	0	775	775	165183.
BLSHLA	KOLONAWA	0	0	15979	672	15979	672	16652	166599.

(249)

DLKMBRA	HAPUTALE	5710	0	0	0	5710	0	5710	188038.
ADDGAMA	GALLE	32752	2409	0	0	32752	2409	35162	192291.
ADULLA	HAPUTALE	113767	0	4371	38281	118139	38281	156420	221371.
ADRELYA	KOLONAWA	0	0	15864	5199	15864	5199	21063	223148.
AKIELLA	KOLONAWA	0	0	0	6026	0	6026	6026	223233.
ALNGODA	RATNPURA	26718	769	45528	36144	72247	36913	109161	235784.
ALAPTYA	KOLONAWA	0	0	23681	0	23681	0	23681	237744.
ALLKTWA	HAPUTALE	5016	0	0	20031	5016	20031	25048	239204.
AMNPOLA	KOLONAWA	0	0	0	0	0	0	0	239204.
ANDRGMA	KOLONAWA	0	0	67021	1888	67021	1888	68910	243006.
ANDRWLA	HAPUTALE	99160	0	919	50352	100079	50352	150432	264600.
ANGDNYA	KOLONAWA	0	0	0	0	0	0	0	264600.
ARMPOLA	KOLONAWA	0	0	0	2198	0	2198	2198	264631.
ATAPOLA	KOLONAWA	0	0	11725	0	11725	0	11725	266035.
ATICALO	BATICALO	113483	6120	0	34832	113483	40953	154437	295216.
ATULUOA	KOLONAWA	0	0	8277	0	8277	0	8277	296265.
ELIATTA	MATARA	39591	0	1149	13726	40740	13726	54467	303481.
ELIHLOY	KOLONAWA	3987	0	0	0	3987	0	3987	304200.
EMMULLA	KOLONAWA	0	0	6667	0	6667	0	6667	304529.
ENDYMLA	KOLONAWA	0	0	21152	0	21152	0	21152	305423.
ENGMUWA	KOLONAWA	0	0	0	0	0	0	0	305423.
ENTOTA	KOLONAWA	0	0	0	0	0	0	0	305423.
ERAGAMA	KOLONAWA	0	0	0	0	0	0	0	305423.
ERLPNTR	KOLONAWA	0	0	0	1655	0	1655	1655	305446.
ERUWALA	KOLONAWA	0	0	54836	0	54836	0	54836	309501.
IBILE	HAPUTALE	4249	0	0	28449	4249	28449	32699	311161.
INGRIYA	KOLONAWA	0	0	18393	7992	18393	7992	26386	313607.
IYAGAMA	KOLONAWA	0	0	17933	0	17933	0	17933	314112.
OGWTLWA	RATNPURA	24568	0	2529	0	27097	0	27097	320889.
OMBWELA	KOLONAWA	0	0	0	1655	0	1655	1655	320912.
OOSSA	KOLONAWA	0	0	0	0	0	0	0	320912.
OPTLAWA	KOLONAWA	0	0	0	0	0	0	0	320912.
OPITIYA	KOLONAWA	0	0	2069	0	2069	0	2069	320992.
ORAGAS	KOLONAWA	0	0	0	0	0	0	0	320992.
ORALNDA	KOLONAWA	1876	0	2414	0	4290	0	4290	322147.
ORLSGMA	KOLONAWA	0	0	20692	155	20692	155	20848	322805.
LTKHPTA	KOLONAWA	0	0	11725	7035	11725	7035	18761	324039.
UTTALA	HAPUTALE	4288	0	0	9311	4288	9311	13600	325291.
HDYNTLW	KOLONAWA	0	0	0	8277	0	8277	8277	325407.
HANKANY	JAFFNA	15152	0	0	0	15152	0	15152	329623.
HVKCHRY	JAFFNA	65041	999	0	0	65041	999	66041	348206.
HDIKLAM	KOLONAWA	0	920	0	0	0	920	920	348219.
HMPNPTU	KOLONAWA	0	0	0	362	0	362	362	348225.
NHKLADY	BATICALO	35568	1939	0	2069	35568	4009	39577	357752.
HILAW	KOLONAWA	3187	0	135653	387	138840	387	139228	371933.
HINABAV	KOLONAWA	0	0	0	2690	0	2690	2690	371971.
HLIPRAM	KOLONAWA	0	0	0	0	0	0	0	371971.
HUNAKAM	JAFFNA	50268	0	0	12829	50268	12829	63097	385782.
OLOMBO	KOLONAWA	482963	7227	3660630	222741	4143593	229968	4373562	483913.
ADALLA	KOLONAWA	0	0	0	0	0	0	0	483913.
ALWKTWA	KOLONAWA	0	0	15864	0	15864	0	15864	484779.
AMBDNYA	KOLONAWA	0	0	3448	0	3448	0	3448	485070.
AMBULLA	KURNGALA	22171	0	0	12398	22171	12398	34569	488560.
ANKYUWA	KOLONAWA	0	0	24946	34056	24946	34056	59003	490709.
EDUGALA	KOLONAWA	0	0	0	0	0	0	0	490709.
EHIOWTA	KOLONAWA	1062	0	1149	17252	2212	17252	19464	491108.
EHIWELA	KOLONAWA	0	0	99325	3595	99325	3595	102921	493608.
EIYNDRA	MATARA	7587	0	0	0	7587	0	7587	494896.
EKAYANA	KOLONAWA	0	0	14485	0	14485	0	14485	495457.
ELGODA	KOLONAWA	0	0	6552	0	6552	0	6552	495676.
ELTOTA	NEWPERAD	8088	5696	0	3724	8088	9421	17509	497500.
ELWALA	KOLONAWA	0	0	0	0	0	0	0	497500.
EMODARA	KOLONAWA	0	0	0	0	0	0	0	497500.
ENIPTYA	KOLONAWA	569	0	0	0	569	0	569	497605.
ENIVAYA	GALLE	58180	0	0	4397	58180	4397	62577	508493.

ENIYAIA	GALLE	58180	0	0	4397	58180	4397	62577	508695.
ERNYGLA	KOLONAWA	0	0	23854	3092	23854	3092	26946	510669.
HRGTOWN	KOLONAWA	0	0	7817	0	7817	0	7817	511315.
ICKOYA	KOTAGALA	32348	0	(250) 0	0	32348	0	32348	516722.
ICKWELA	MATARA	25982	0	0	19399	25982	19399	45381	520993.
IMBULLA	KOLONAWA	0	0	0	0	0	0	0	520993.
IVLPTYA	KOLONAWA	0	0	32188	646	32188	646	32835	522816.
IYTLAWA	HAPUTALE	11110	0	0	2741	11110	2741	13851	525169.
ODNDUWA	KOLONAWA	0	0	38799	0	38799	0	38799	530376.
DNGSLND	KURNGALA	2164	0	0	27883	2164	27883	30047	531013.
ONDGODA	KOLONAWA	0	0	9196	0	9196	0	9196	531661.
OLSBAGE	NEWPERAD	18761	0	0	0	18761	0	18761	534705.
MBGHWLA	HAPUTALE	5026	703	0	5561	5026	6264	11291	536458.
OMPE	KOLONAWA	0	0	20233	0	20233	0	20233	537313.
ONDRA	MATARA	39951	0	0	0	39951	0	39951	542898.
UMLDNYA	KOLONAWA	0	0	17933	0	17933	0	17933	544319.
UMLSRYA	KOLONAWA	0	0	12645	258	12645	258	12904	545613.
LTHMDWL	KOLONAWA	0	0	9311	919	9311	919	10231	552085.
GODUYNA	KOLONAWA	0	0	14485	0	14485	0	14485	553546.
HLYGODA	KOLONAWA	3187	0	36212	2922	39399	2922	42322	556639.
KALA	KOLONAWA	0	0	7587	0	7587	0	7587	556933.
LAHERA	KOLONAWA	0	805	0	0	0	805	805	556945.
LLE	HAPUTALE	4150	0	229	4828	4380	4828	9209	557981.
LLAMLLA	NEWPERAD	569	0	0	0	569	0	569	558079.
LKADUWA	NEWPERAD	11278	0	0	2845	11278	2845	14123	559791.
LPITIYA	KOLONAWA	0	0	61388	51	61388	51	61440	567140.
MBLPTYA	MATARA	28261	0	0	0	28261	0	28261	573727.
PITWELA	KOLONAWA	0	0	0	18701	0	18701	18701	573991.
PPAWALA	KOLONAWA	0	0	0	24960	0	24960	24960	574342.
RAVUR	KOLONAWA	0	0	0	14485	0	14485	14485	574547.
TTMPTYA	HAPUTALE	15174	0	0	689	15174	689	15864	577958.
TULKOTE	KOLONAWA	0	0	18278	0	18278	0	18278	578408.
ALGDERA	PERDNIYA	14391	0	0	0	14391	0	14391	580125.
ALAHA	PERDNIYA	42808	1215	0	413	42808	1629	44437	585437.
ALPTMDA	KOLONAWA	0	0	0	2069	0	2069	2069	585466.
ALBODA	KOLONAWA	0	0	0	0	0	0	0	585466.
ALNBDNW	ANURPURA	4138	756	0	9130	4138	9887	14025	586542.
ALEWELA	KURNGALA	31253	11530	0	0	31253	11530	42783	591678.
ALGMUWA	KURNGALA	20242	0	0	25297	20242	25297	45539	595239.
ALIGMWA	KOLONAWA	0	0	19083	0	19083	0	19083	596919.
ALLE	GALLE	565582	4460	13617	1034	579199	5494	584694	656818.
ALOYA	KOLONAWA	0	0	0	0	0	0	0	656818.
ALPATHA	KOLONAWA	0	0	14714	0	14714	0	14714	657854.
AMMDUWA	NEWPERAD	2734	0	0	0	2734	0	2734	658317.
AMPAHA	KOLONAWA	0	0	65182	0	65182	0	65182	661072.
AMPOLA	PERDNIYA	169011	0	0	0	169011	0	169011	681235.
ANDARA	KOLONAWA	0	0	0	0	0	0	0	681235.
ANEGODA	KOLONAWA	0	0	0	0	0	0	0	681235.
ANEMULA	KOLONAWA	0	0	23566	0	23566	0	23566	682106.
ELIOYA	KOLONAWA	0	0	0	0	0	0	0	682106.
INGTHNA	KOLONAWA	0	0	21382	2974	21382	2974	24357	684939.
IRITALE	KOLONAWA	1062	0	0	3259	1062	3259	4321	685260.
IRIULLA	KOLONAWA	0	0	57595	0	57595	0	57595	689721.
ODAGAMA	KOLONAWA	0	0	18163	0	18163	0	18163	690553.
ODKWELA	RATNPURA	5228	0	32073	0	37301	0	37301	696385.
ODPTIYA	MATARA	0	153	0	0	0	153	153	696405.
ODIGMWA	KOLONAWA	0	0	21842	0	21842	0	21842	697904.
ONPNWLA	KOLONAWA	0	0	6207	0	6207	0	6207	698726.
ONAPOLA	KOLONAWA	0	0	4828	0	4828	0	4828	698956.
ONAWELA	KOLONAWA	0	0	22762	0	22762	0	22762	699838.
OVINNA	KOLONAWA	0	0	1379	258	1379	258	1638	699934.
URTLAWA	KOLONAWA	0	0	0	0	0	0	0	699934.
ABRDUWA	GALLE	11725	0	0	0	11725	0	11725	701268.
ABARANA	KURNGALA	8202	0	0	15105	8202	15105	23308	702895.
AKMANA	MATARA	37253	3233	2069	0	39322	3233	42555	709767.
ALDDUWA	KOLONAWA	0	0	0	0	0	0	0	709767.

ALIELA	KOLONAWA	0	0	0	344	0	344	344	717502.
AMBTOTA	MATARA	23219	0	1379	17071	24598	17071	41670	723197.
ANGRKTA	PERDNIYA	35135	897	(251) 0	0	35135	897	36032	728160.
ANWELLA	KOLONAWA	0	0	43799	0	43799	0	43799	730088.
APUTALE	HAPUTALE	115423	1378	0	775	115423	2154	117577	753604.
ARNKHWA	KOLONAWA	0	0	0	0	0	0	0	753604.
ARSBDDA	KOTAGALA	8874	0	0	0	8874	0	8874	755665.
ATRLYDA	KOLONAWA	0	0	0	4293	0	4293	4293	755725.
ATTON	KOTAGALA	83072	373	689	98627	83762	99000	182762	770721.
EDENIYA	PERDNIYA	15386	0	0	0	15386	0	15386	772475.
EMTGAMA	KOLONAWA	0	0	0	17175	0	17175	17175	772718.
ENDALA	KOLONAWA	0	0	26900	0	26900	0	26900	773381.
ENEGAMA	KOLONAWA	0	0	12990	0	12990	0	12990	775797.
ETIMULA	KOLONAWA	0	0	11036	2664	11036	2664	13700	776903.
ETIPOLA	KOLONAWA	0	0	8047	15648	8047	15648	23696	778189.
EWAHETA	PERDNIYA	8306	8316	0	0	8306	8316	16623	780216.
IKKDUWA	KOLONAWA	0	0	25118	0	25118	0	25118	783401.
INGULA	KOLONAWA	0	0	4828	0	4828	0	4828	783954.
INGRKGD	KURNGALA	74102	0	0	12493	74102	12493	86595	799819.
INIDUMA	KOLONAWA	0	0	0	0	0	0	0	799819.
IRIPTYA	KOLONAWA	0	0	0	0	0	0	0	799819.
ITTETYA	KOLONAWA	0	0	0	0	0	0	0	799819.
OMAGAMA	KOLONAWA	0	0	148586	0	148586	0	148586	806621.
ORMBAWA	KOLONAWA	0	0	0	1914	0	1914	1914	806648.
ORANA	KOLONAWA	0	0	138412	4693	138412	4693	143105	814756.
UNGAMA	KOLONAWA	2873	0	0	1939	2873	1939	4813	815568.
UNSGRYA	PERDNIYA	22471	1139	0	0	22471	1139	23611	819077.
UNUPTYA	KOLONAWA	0	0	30234	0	30234	0	30234	819769.
URIKDWA	PERDNIYA	11725	0	0	0	11725	0	11725	821148.
URLWEWA	KOLONAWA	0	0	0	6181	0	6181	6181	821235.
3BGMUWA	KURNGALA	25854	258	0	17407	25854	17666	43521	824185.
DLGSHNA	HAPUTALE	8968	0	0	0	8968	0	8968	826085.
LLKWELA	KURNGALA	6150	0	0	0	6150	0	6150	826745.
MADUWA	GALLE	22910	0	0	0	22910	0	22910	829595.
MBLGODA	KOLONAWA	0	0	13105	0	13105	0	13105	830102.
NDURUWA	KOLONAWA	0	0	15749	0	15749	0	15749	831461.
NGNYGLA	KOLONAWA	0	0	0	1784	0	1784	1784	831486.
NGIRIYA	KOLONAWA	0	0	24716	2241	24716	2241	26958	833258.
TTAKNDA	KOLONAWA	0	0	0	0	0	0	0	833258.
TTAPANA	KOLONAWA	0	0	5543	4966	5543	4966	10510	833865.
AELA	KOLONAWA	0	0	152839	0	152839	0	152839	838710.
AFFNA	JAFFNA	320162	3353	1379	26754	321542	30107	351649	924964.
ADAWATA	KOLONAWA	0	0	225667	0	225667	0	225667	931323.
ADIRANA	KOLONAWA	0	0	2069	0	2069	0	2069	931436.
ADGNAWA	PERDNIYA	8574	0	0	0	8574	0	8574	932399.
ADUWELA	KOLONAWA	0	0	35999	620	35999	620	36620	933422.
AHADUWA	KOLONAWA	0	0	10806	1422	10806	1422	12228	934972.
ITGSDLV	ANURPURA	13730	7054	3448	17537	17179	24591	41771	940023.
AHAWATA	RATNPURA	51242	0	54034	0	105276	0	105276	954275.
AHAWELA	KOLONAWA	0	0	3448	0	3448	0	3448	954463.
IKAWELA	KOLONAWA	0	0	0	0	0	0	0	954463.
AKPLIYA	KOLONAWA	0	0	0	9699	0	9699	9699	954600.
ALGDHNA	KOLONAWA	0	0	3448	0	3448	0	3448	954776.
ALAWANA	RATNPURA	5241	0	8277	6388	13518	6388	19907	956787.
ALVNCHK	BATICALO	7830	820	0	0	7830	820	8651	959068.
ALAWEWA	KOLONAWA	0	0	0	0	0	0	0	959068.
ALMUNAI	BATICALO	36912	0	0	32513	36912	32513	69426	969879.
ALPTIYA	KOLONAWA	0	0	1379	7475	1379	7475	8854	970288.
ALUTARA	KOLONAWA	0	0	125191	0	125191	0	125191	978003.
ABGMUWA	KOLONAWA	0	0	0	3957	0	3957	3957	978058.
ABRPTYA	MATARA	35487	768	0	11467	35487	12236	47724	983657.
ANDANA	KOLONAWA	0	0	45294	0	45294	0	45294	985013.
ANDPOLA	KOTAGALA	25961	0	0	9311	25961	9311	35273	990762.
ANDY	PERDNIYA	501600	5410	46277	1163	547877	6574	554452	*105251
ANKSTRA	JAFFNA	15220	0	0	8084	15220	8084	23305	*105691

NUKTIYA	KURNGALA	3475	0	0	4164	3475	4164	7639	*107311
RDIYNRU	KOLONAWA	0	0	(252) 0	0	0	0	0	*107311
ARANAGA	JAFFNA	12036	0	0	0	12036	0	12036	*107650
ARNDPNA	KOLONAWA	0	0	0	8406	0	8406	8406	*107662
ATANA	KOLONAWA	0	0	16784	2690	16784	2690	19474	*107764
ATRGAMA	KOLONAWA	729	0	0	14821	729	14821	15550	*107811
ATNKUDI	BATICALO	1284	2224	0	32410	1284	34634	35919	*107942
ATGSTTA	PERDNIYA	101338	0	919	0	102258	0	102258	*109129
ATKTULA	PERDNIYA	8475	0	0	0	8475	0	8475	*109258
ATKRNDA	KOLONAWA	0	0	20807	0	20807	0	20807	*109394
ATUNYKA	KOLONAWA	0	0	23279	569	23279	569	23848	*109509
ATUNRYA	KOLONAWA	0	0	13335	517	13335	517	13852	*109609
ATUPOTA	KOLONAWA	0	0	5518	11950	5518	11950	17468	*109685
ATUWANA	MATARA	387	3776	0	0	387	3776	4164	*109742
AUDULLA	KURNGALA	2188	0	0	0	2188	0	2188	*109781
AUDPLLA	KOLONAWA	0	0	0	0	0	0	0	*109781
AYTS	JAFFNA	9139	328	0	18287	9139	18615	27754	*110071
EBTGLWA	KOLONAWA	0	0	0	3595	0	3595	3595	*110076
EGALLE	KOLONAWA	0	0	155311	4552	155311	4552	159863	*111504
EKIRAWA	KURNGALA	17276	0	0	28840	17276	28840	46117	*111837
ELANIYA	KOLONAWA	0	0	55543	1655	55543	1655	57198	*111996
EPTPOLA	HAPUTALE	29334	0	9656	0	38991	0	38991	*112925
ESBEWA	KOLONAWA	0	0	6437	0	6437	0	6437	*112951
ILNOCHI	KILINCHI	60824	0	0	0	60824	0	60824	*114386
IMBLPTV	KOLONAWA	0	0	2299	2690	2299	2690	4989	*114404
INNIYAI	KOLONAWA	0	0	0	8328	0	8328	8328	*114415
IRAMA	KOLONAWA	0	1862	0	2874	0	4736	4736	*114422
IRB7GDA	KOLONAWA	0	0	17818	0	17818	0	17818	*114463
IRIELLA	KOLONAWA	0	0	4943	6026	4943	6026	10970	*114514
IRINDA	MATARA	2069	0	0	0	2069	0	2069	*114546
RNDWELA	KOLONAWA	0	0	23221	0	23221	0	23221	*114677
ITALAWA	KOLONAWA	0	0	4828	0	4828	0	4828	*114731
ITLGALA	KOLONAWA	0	0	7472	3621	7472	3621	11093	*114816
OBEIGNA	KOLONAWA	1379	0	1379	879	2759	879	3638	*114858
OCKKADE	KOLONAWA	0	0	58284	4552	58284	4552	62837	*115203
ODIKMAM	JAFFNA	5661	0	0	3026	5661	3026	8688	*115370
OGGALA	KOLONAWA	0	0	0	0	0	0	0	*115370
OLNKLDI	KOLONAWA	0	0	0	0	0	0	0	*115370
OLONNO	KOLONAWA	0	0	0	8665	0	8665	8665	*115383
OLNNAWA	KOLONAWA	0	0	162657	0	162657	0	162657	*115641
OPAY	JAFFNA	17914	0	0	9518	17914	9518	27433	*116134
OSGAMA	KOLONAWA	0	0	7472	0	7472	0	7472	*116172
OSLANDA	HAPUTALE	6345	487	0	2302	6345	2789	9134	*116330
OSWT JN	KOLONAWA	0	0	4023	0	4023	0	4023	*116342
OTDNYWA	KOLONAWA	0	0	0	931	0	931	931	*116344
OTAGALA	KOTAGALA	50516	5126	0	0	50516	5126	55643	*117214
OTAPOLA	MATARA	2863	0	0	2327	2863	2327	5191	*117273
OTIKWTA	KOLONAWA	0	0	22302	0	22302	0	22302	*117317
TYKMBRA	KOLONAWA	0	0	0	1991	0	1991	1991	*117319
OTMALE	NEWPERAD	56077	911	0	0	56077	911	56988	*118279
OTNTIVU	KOLONAWA	0	0	2644	1086	2644	1086	3730	*118317
OTTAWA	KOLONAWA	0	0	3333	0	3333	0	3333	*118328
OTTE	KOLONAWA	0	0	3333	0	3333	0	3333	*118335
OTEGODA	KOLONAWA	689	0	0	24702	689	24702	25391	*118387
OTUGODA	KOLONAWA	0	0	8622	0	8622	0	8622	*118422
UCHVELI	KOLONAWA	0	0	0	0	0	0	0	*118422
ULYPTYA	KOLONAWA	0	0	47938	21184	47938	21184	69122	*118949
UNDSALE	PERDNIYA	4295	0	0	0	4295	0	4295	*118999
URANA	KOLONAWA	0	0	9656	0	9656	0	9656	*119045
URNGALA	KURNGALA	389264	51	0	5121	389264	5173	394437	*122543
URUWITA	RATNPURA	153	435	919	0	1073	435	1509	*122558
ABUKELE	KOLONAWA	0	0	0	0	0	0	0	*122558
ATPNDRA	KOLONAWA	0	0	6322	724	6322	724	7047	*122623
AXAPANA	KOLONAWA	0	0	0	0	0	0	0	*122623
ELOPTYA	KOLONAWA	0	0	0	0	0	0	0	*122623

.INDULA	KOTAGALA	102284	8544	0	0	102284	8544	110828	*124713
.UNAWA	KOLONAWA	0	0	37247	0	37247	0	37247	*124838
.UNUGALA	HAPUTALE	18931	0	0	0	18931	0	18931	*125362
.UNUWILA	KOLONAWA	0	0	44144	1888	44144	1888	46032	*125691
IADAMPE	KOLONAWA	1803	0	42650	0	44453	0	44453	*126098
IADAWALA	PERDNIYA	14990	0	0	0	14990	0	14990	*126279
IADHU CH	KOLONAWA	1075	0	0	0	1075	0	1075	*126329
IADLKELE	NEWPERAD	13314	1139	0	0	13314	1139	14453	*126541
IADLSIMA	HAPUTALE	3293	0	0	0	3293	0	3293	*126631
IADRNKLY	KOLONAWA	0	0	8277	7630	8277	7630	15907	*126772
IAGGONA	KOLONAWA	0	0	23796	0	23796	0	23796	*126939
IAHABAGE	KOLONAWA	0	0	13795	0	13795	0	13795	*126968
IAHAEDNB	KOLONAWA	0	0	6897	0	6897	0	6897	*127047
IAHAGAMA	PERDNIYA	1253	0	689	0	1942	0	1942	*127087
IHAILPLM	KOLONAWA	0	0	0	0	0	0	0	*127087
IAHAOYA	BATICALO	2658	0	0	827	2658	827	3486	*127168
IAHARA	KOLONAWA	0	0	0	0	0	0	0	*127168
IHRAGAMA	KOLONAWA	0	0	177268	724	177268	724	177993	*127700
IHVLCHYA	ANURPURA	3980	2594	0	0	3980	2594	6575	*127810
IAHAWEWA	KOLONAWA	15174	0	23796	0	38971	0	38971	*128146
IAHYNGNA	KOLONAWA	0	0	0	0	0	0	0	*128146
IAHO	KURNGALA	2206	0	0	17537	2206	17537	19743	*128201
IAKOLA	KOLONAWA	0	0	5173	0	5173	0	5173	*128215
IAKLPOTA	KOLONAWA	0	0	0	0	0	0	0	*128215
IAKMBURA	GALLE	15864	0	0	0	15864	0	15864	*128407
IALABE	KOLONAWA	0	0	1149	0	1149	0	1149	*128411
IALIBODA	KOLONAWA	0	0	0	2586	0	2586	2586	*128415
IALGWATA	KOLONAWA	0	0	0	0	0	0	0	*128415
IALLAKAM	JAFFNA	12899	0	0	0	12899	0	12899	*128767
IALPTIYA	KOLONAWA	0	0	0	0	0	0	0	*128767
IALWANA	KOLONAWA	0	0	0	0	0	0	0	*128767
ALWATAY	BATICALO	1530	0	0	7940	1530	7940	9471	*128824
NGLELYA	KOLONAWA	0	0	0	9104	0	9104	9104	*128837
IANIPAY	JAFFNA	15063	358	0	0	15063	358	15422	*129244
IANKULAM	KILINCHI	32856	0	0	0	32856	0	32856	*130106
IANNAR	ANURPURA	56090	3282	0	5302	56090	8585	64676	*131682
ANTHIKY	JAFFNA	18719	0	0	0	18719	0	18719	*132242
IRDKDWLA	KOLONAWA	0	0	0	2974	0	2974	2974	*132246
RDGHMLA	KOLONAWA	0	0	48168	0	48168	0	48168	*132526
IARASANA	KOLONAWA	0	0	0	0	0	0	0	*132526
ARAWILA	KOLONAWA	0	0	8966	0	8966	0	8966	*132597
IRTHNMDM	KOLONAWA	12749	0	0	19942	12749	19942	32691	*133565
ASKLIYA	KOTAGALA	63736	0	0	0	63736	0	63736	*135447
ASPOTHA	NEWPERAD	2734	0	0	0	2734	0	2734	*135493
ATALE	PERDNIYA	192030	0	0	0	192030	0	192030	*138088
IATARA	MATARA	233480	2614	6207	145614	239688	148229	387917	*141564
ATTAKA	KOLONAWA	0	0	2759	2664	2759	2664	5423	*141609
ATUGAMA	KOLONAWA	0	0	132319	0	132319	0	132319	*142727
AWANELA	KOLONAWA	0	0	66562	517	66562	517	67079	*143431
AWTGAMA	KURNGALA	30253	0	0	0	30253	0	30253	*143734
EDAGAMA	KOLONAWA	0	0	0	0	0	0	0	*143734
EDWCHYA	ANURPURA	31463	1076	0	18045	31463	19122	50586	*144344
EDAWELA	KOLONAWA	0	0	0	0	0	0	0	*144344
GHETENE	KOLONAWA	0	0	5518	0	5518	0	5518	*144399
EEGODA	KOLONAWA	0	0	0	0	0	0	0	*144399
ETYGODA	KOLONAWA	0	0	0	14045	0	14045	14045	*144419
ELSRPRA	KURNGALA	22798	0	0	12519	22798	12519	35317	*144705
ETKMBRA	KOLONAWA	0	0	0	6156	0	6156	6156	*144714
IDDNIYA	MATARA	8966	0	0	0	8966	0	8966	*144899
IHNTALE	KOLONAWA	0	0	0	0	0	0	0	*144899
INIPE	KOLONAWA	0	0	0	0	0	0	0	*144899
INNRIYA	CHINABAY	13717	0	0	0	13717	0	13717	*145177
INWNGDA	KOLONAWA	0	0	59664	0	59664	0	59664	*145450
IRIGAME	KOLONAWA	0	0	42420	0	42420	0	42420	*145741
[illegible]	GALLE	[illegible]	0	0	0	[illegible]	0	[illegible]	[illegible]

IRSWTTA	KOLONAWA	0	0	32993	0	32993	0	32903	*146217
ONRGALE	HAPUTALE	16411	0	0	26564	16411	26564	42975	*146721
ONMLDNY	KOLONAWA	0	0 (254)	0	3517	0	3517	3517	*146726
ORGHENA	KOLONAWA	0	0	0	0	0	0	0	*146726
ORAGALA	KOLONAWA	0	0	2759	0	2759	0	2759	*146753
ORATUWA	KOLONAWA	0	0	166405	2715	166405	2715	169120	*147343
ORAWAKA	GALLE	6732	0	0	0	6732	0	6732	*147457
TLAVNIA	KOLONAWA	0	0	137377	0	137377	0	137377	*147844
UDNGODA	KOLONAWA	0	0	13335	0	13335	0	13335	*147896
ULATIVU	KILINCHI	23606	729	0	517	23606	1246	24853	*148654
ULWALAI	KILINCHI	12006	0	0	0	12006	0	12006	*149022
UNDEL	GALLE	1062	0	13910	3362	14972	3362	18335	*149260
URUNKAN	ANURPURA	9601	0	0	19916	9601	19916	29518	*149526
URTLAWA	KOLONAWA	0	0	0	7759	0	7759	7759	*149536
UTTUR	KOLONAWA	0	0	0	25038	0	25038	25038	*149572
YLIDDY	JAFFNA	6374	0	620	12855	6995	12855	19850	*149823
AGODA	KOLONAWA	0	0	38051	0	38051	0	38051	*150085
AGLGODA	KOLONAWA	0	0	0	2741	0	2741	2741	*150088
INAMDMA	KOLONAWA	0	0	11955	181	11955	181	12136	*150179
AKYDNYA	GALLE	20731	0	0	0	20731	0	20731	*150448
AKLGMWA	KOLONAWA	0	0	0	258	0	258	258	*150448
ALANDA	KOLONAWA	0	0	0	0	0	0	0	*150448
ALLUR	JAFFNA	23419	109	0	14588	23419	14697	38117	*151094
AMNKULA	HAPUTALE	8538	0	0	17933	8538	17933	26472	*151325
ANATTAN	KOLONAWA	0	0	0	6544	0	6544	6544	*151334
ANUOYA	KOTAGALA	56299	0	0	0	56299	0	56299	*152443
ARAMALA	KOLONAWA	0	0	33338	8613	33338	8613	41951	*152766
ATNDIYA	KOLONAWA	0	0	40810	120708	40810	120708	161519	*153281
AULA	PERDNIYA	16517	0	0	0	16517	0	16517	*153557
AUTDUWA	KOLONAWA	0	0	6322	0	6322	0	6322	*153618
AWALA	KOLONAWA	0	0	0	0	0	0	0	*153618
AWLPTYA	PERDNIYA	131253	0	0	0	131253	0	131253	*155438
EBODA	KOLONAWA	0	0	19083	155	19083	155	19238	*155593
EDNKENY	KOLONAWA	0	0	0	4009	0	4009	4009	*155599
EGOMBO	KOLONAWA	1770	0	252452	4138	254223	4138	258362	*156902
ELLIADY	JAFFNA	58925	51	0	0	58925	51	58976	*158626
ELNDNYA	KOLONAWA	18623	0	7587	2146	26210	2146	28357	*158846
ELUWA	KOLONAWA	512	0	0	0	512	0	512	*158858
IKWRTYA	KURNGALA	44230	0	0	17490	44230	17490	61720	*159466
ILDHNNA	NEWPERAD	0	569	0	0	0	569	569	*159473
INTAVUR	BATICALO	5745	136	0	10372	5745	10509	16254	*159657
IRVELI	KOLONAWA	0	0	0	0	0	0	0	*159657
ITMBUWA	KOLONAWA	0	0	31499	1991	31499	1991	33490	*159826
IVTGALA	RATNPURA	6265	0	14714	0	20980	0	20980	*160088
YNDRPLA	KOLONAWA	0	0	3448	0	3448	0	3448	*160116
OCHYGMA	ANURPURA	18668	0	0	1448	18668	1448	20117	*160446
ORTBRGE	KOTAGALA	14998	0	0	9311	14998	9311	24310	*160728
ORWOOD	KOTAGALA	32626	0	0	0	32626	0	32626	*161290
UGEGODA	KOLONAWA	0	0	205778	0	205778	0	205778	*161798
UWELIYA	KOTAGALA	164965	0	4828	8121	169793	8121	177915	*165285
HIVA	HAPUTALE	640	1537	0	0	640	1537	2178	*165333
LUVIL	KOLONAWA	0	0	0	2198	0	2198	2198	*165336
MANTHAI	KOLONAWA	0	0	0	387	0	387	387	*165336
PANAIKP	RATNPURA	5810	0	0	5949	5810	5949	11759	*165423
ADAVIYA	ANURPURA	8294	10580	0	905	8294	11485	19780	*165775
ADIRUPU	KOLONAWA	0	0	0	3121	0	3121	3121	*165779
ADYPELA	PERDNIYA	9635	2509	0	0	9635	2509	12144	*165952
ADUKKA	KOLONAWA	0	0	55410	646	55410	646	56057	*166246
AVGLALN	KOLONAWA	0	0	517	25	517	25	543	*166249
ALAKUDA	KOLONAWA	0	0	6552	0	6552	0	6552	*166375
ALAMUNA	KOLONAWA	0	0	0	0	0	0	0	*166375
ALLAI	KILINCHI	15762	0	517	26644	16280	26644	42925	*166871
ALLEGMA	KOLONAWA	0	0	0	2715	0	2715	2715	*166874
ALLEPLA	PERDNIYA	4138	0	0	362	4138	362	4500	*166941
ALLEWLA	KOLONAWA	885	0	15290	0	16175	0	16175	[illegible]

ANADURA	KOLONAWA	0	0	159220	1422	159220	1422	160642	*167954
ANAGODA	ANURPURA	22311	0	26900	2759	49211	2759	51971	*169123
ANDTRPU	JAFFNA	51391	128	0	14200	51391	14328	65720	*170594
ANLKNDA	KOLONAWA	0	0	0	0	0	0	0	*170594
ANKULAM	KOLONAWA	0	0	0	0	0	0	0	*170594
ANNALA	ANURPURA	1803	0	6782	258	8586	258	8844	*170710
ANNPTYA	KOLONAWA	0	0	60814	2353	60814	2353	63167	*170906
ANWILA	NEWPERAD	1253	1230	0	0	1253	1230	2483	*170936
ANWLTNE	KOLONAWA	0	0	0	0	0	0	0	*170936
ARAKDWA	KOLONAWA	0	0	5633	5431	5633	5431	11064	*170992
ARANTAN	KILINCHI	20355	0	1034	4311	21389	4311	25700	*171545
ASSARA	HAPUTALE	42512	0	0	517	42512	517	43029	*172618
ASYALA	KOLONAWA	0	0	8277	0	8277	0	8277	*172665
ATANA	KOLONAWA	0	0	0	0	0	0	0	*172665
ELAWATA	KOLONAWA	0	0	11725	2276	11725	2276	14002	*172792
ELYGODA	KOLONAWA	0	0	498645	689	498645	689	499335	*173847
ELMDULA	RATNPURA	20408	0	54031	0	74439	0	74439	*174821
ERDNIYA	PERDNIYA	71160	4280	0	0	71160	4280	75440	*175601
ESALAI	KOLONAWA	0	0	0	5509	0	5509	5509	*175608
ILMTLWA	PERDNIYA	26575	0	0	0	26575	0	26575	*175897
ILYNDLA	KOLONAWA	0	0	91175	0	91175	0	91175	*176235
ITBDARA	GALLE	8212	0	0	0	8212	0	8212	*176369
ITIGALA	KOLONAWA	0	0	6897	1293	6897	1293	8190	*176449
ITIPANE	KOLONAWA	0	0	11036	0	11036	0	11036	*176506
ODDALA	KOLONAWA	0	0	0	0	0	0	0	*176506
T PEDRO	JAFFNA	64554	0	0	0	64554	0	64554	*178472
LGHWELA	KOLONAWA	0	0	49088	465	49088	465	49553	*178905
LGSOWTA	BATICALO	0	0	0	0	0	0	0	*178905
OLGOLLA	PERDNIYA	21115	0	0	0	21115	0	21115	*179160
OLNRUWA	KURNGALA	91876	0	2080	13553	93957	13553	107511	*181318
ONAKERI	KOLONAWA	0	0	0	0	0	0	0	*181318
OONGALA	HAPUTALE	10632	0	0	0	10632	0	10632	*181567
VRSKLAM	KOLONAWA	0	0	0	0	0	0	0	*181567
OTTUVIL	BATICALO	2327	1607	0	13605	2327	15213	17540	*181709
UGODA	KOLONAWA	0	0	9311	0	9311	0	9311	*181752
UJPTIYA	PERDNIYA	17323	0	0	0	17323	0	17323	*181967
ULMODAI	CHINABAY	5514	0	0	3750	5514	3750	9264	*182069
ILOLI	JAFFNA	16651	0	0	0	16651	0	16651	*182561
INDLOYA	KOTAGALA	30083	7609	0	2327	30083	9937	40020	*183264
UNGDTVU	JAFFNA	2164	0	0	18468	2164	18468	20632	*183351
UNNALAI	JAFFNA	7055	0	0	0	7055	0	7055	*183551
UNLKDWN	JAFFNA	35388	512	0	0	35388	512	35901	*184549
UPURESA	PERDNIYA	9656	0	0	0	9656	0	9656	*184681
USELAWA	PERDNIYA	30167	1708	0	0	30167	1708	31876	*185122
USSELLA	KOLONAWA	0	0	21842	0	21842	0	21842	*185319
UTTALAM	KOLONAWA	507	0	111511	6595	112018	6595	118614	*187183
UTKDRPU	KOLONAWA	0	0	0	2922	0	2922	2922	*187187
UTTUR	JAFFNA	2124	0	1149	0	3274	0	3274	*187336
UWKPTYA	KOLONAWA	0	0	1724	0	1724	0	1724	*187346
AGALA	KOTAGALA	17690	0	0	7501	17690	7501	25191	*187755
AGAMA	KOLONAWA	0	0	37821	51	37821	51	37873	*187862
AJAGAMA	KOLONAWA	0	0	0	0	0	0	0	*187862
AJKDLWA	KOLONAWA	0	0	1954	0	1954	0	1954	*187884
AKWANA	RATNPURA	17669	0	13680	0	31350	0	31350	*188367
AMBODA	NEWPERAD	26198	1253	0	0	26198	1253	27451	*188820
AMBDGLA	KOLONAWA	0	0	0	0	0	0	0	*188820
AMBKANA	KOLONAWA	0	0	43455	0	43455	0	43455	*189295
MBKPTYA	KOLONAWA	0	0	0	0	0	0	0	*189295
ANALA	KOLONAWA	0	0	35867	3362	35867	3362	39230	*189419
ANGALLA	NEWPERAD	13785	0	0	1138	13785	1138	14923	*189635
ANNA	KOLONAWA	0	0	0	0	0	0	0	*189635
ATGAMA	KOLONAWA	0	0	4828	2431	4828	2431	7259	*189702
ATMLANA	MATARA	6348	256	387991	103	394339	359	394699	*191059
ATMALE	KOLONAWA	0	0	0	0	0	0	0	*191059

IDIGAMA	KURNGALA	16577	0 (256)	0	0	16577	0	16577	*193325
IDYAGMA	KOLONAWA	0	0	0	0	0	0	0	*193325
IKLGSKD	PERDNIYA	22864	0	0	0	22864	0	22864	*193650
OZELLE	KOLONAWA	2734	0	0	0	2734	0	2734	*193689
UANWELA	KOLONAWA	0	0	31614	1965	31614	1965	33579	*193948
INTHMRY	KOLONAWA	0	0	0	15959	0	15959	15959	*193971
AMNTHRA	BATICALO	1753	2207	0	11381	1753	13588	15341	*194090
ANDLNKW	KOLONAWA	0	0	65297	0	65297	0	65297	*194562
APGHWTA	KOLONAWA	0	0	4598	0	4598	0	4598	*194595
EEDUWA	KOLONAWA	0	0	30340	103	30340	103	30444	*194713
EEPKLAM	KOLONAWA	0	0	0	0	0	0	0	*194713
ILVTURA	ANURPURA	5312	0	0	0	5312	0	5312	*194855
ITNKENI	JAFFNA	10741	0	0	0	10741	0	10741	*195151
ABBOWA	KOLONAWA	0	0	0	0	0	0	0	*195151
ALMANAR	KOLONAWA	0	0	0	0	0	0	0	*195151
ALALLA	KOLONAWA	0	0	0	0	0	0	0	*195151
ALNGAMA	KOLONAWA	0	0	0	0	0	0	0	*195151
ALTUOYA	PERDNIYA	22072	0	0	258	22072	258	22331	*195431
ALWKELE	KOTAGALA	129220	8658	0	22129	129220	30788	160009	*197778
ALWTGDA	KOLONAWA	0	0	18278	0	18278	0	18278	*197839
ALGSWLA	KOLONAWA	0	0	13437	646	13437	646	14084	*198038
ALPE	KOLONAWA	0	0	0	0	0	0	0	*198038
AMBTGMA	ANURPURA	10704	0	0	0	10704	0	10704	*198228
MPLKMAM	KOLONAWA	0	0	0	13941	0	13941	13941	*198247
ANMWILA	MATARA	8277	0	0	0	8277	0	8277	*198475
ANGALLA	MATARA	19087	0	459	41589	19547	41589	61137	*198873
AWALAMA	KOLONAWA	0	0	0	0	0	0	0	*198873
WLNTENE	KOLONAWA	0	0	0	0	0	0	0	*198873
EBUWANA	KOLONAWA	0	0	9311	1060	9311	1060	10372	*198947
ELDNIYA	PERDNIYA	22480	928	0	25038	22480	25966	48447	*199283
ELJWILA	MATARA	0	281	0	0	0	281	281	*199287
ELIPALI	JAFFNA	20679	0	0	0	20679	0	20679	*199862
ENEKBRA	PERDNIYA	25978	0	0	0	25978	0	25978	*200154
ALAGAHA	KOLONAWA	0	0	0	0	0	0	0	*200154
IHAGODA	KOLONAWA	3151	711	0	0	3151	711	3862	*200228
NDMANAR	JAFFNA	20068	0	0	0	20068	0	20068	*200815
UNNUKAI	KOLONAWA	0	0	0	0	0	0	0	*200815
RKTSWRN	ANURPURA	2846	0	0	4914	2846	4914	7760	*200902
RWNKTYA	KOLONAWA	0	0	41845	0	41845	0	41845	*201381
ISMRAMA	MATARA	11307	0	129	76554	11436	76554	87991	*201777
RNCMALE	CHINABAY	130956	0	8897	116299	139853	116299	256153	*203531
UMODARA	KOLONAWA	0	0	0	0	0	0	0	*203531
DHNTENE	KOLONAWA	0	0	0	0	0	0	0	*203531
DAKRWTA	RATNPURA	5126	0	0	0	5126	0	5126	*203594
DPSLAWA	KOTAGALA	39793	0	0	12157	39793	12157	51950	*204598
DAWALWE	KOLONAWA	0	0	0	2327	0	2327	2327	*204602
DISPATU	PERDNIYA	8121	1914	0	0	8121	1914	10035	*204734
DABDAWA	KOLONAWA	0	738	62423	0	62423	738	63162	*205383
DUGAMA	GALLE	15321	786	0	0	15321	786	16108	*205606
DGMPOLA	KOLONAWA	0	0	23451	0	23451	0	23451	*205713
HANA	KOLONAWA	1419	0	0	0	1419	0	1419	*205809
KUWELA	NEWPERAD	2050	0	0	0	2050	0	2050	*205839
LAPANE	NEWPERAD	8133	0	0	0	8133	0	8133	*205952
NDUGODA	KOLONAWA	0	0	574	9234	574	9234	9808	*205971
PCOT	KOTAGALA	57571	0	0	3103	57571	3103	60675	*207049
RALA	GALLE	8270	0	0	0	8270	0	8270	*207150
RAPOLA	KOLONAWA	0	0	10921	0	10921	0	10921	*207216
RUBOKKA	MATARA	8451	0	0	0	8451	0	8451	*207383
RUGALA	PERDNIYA	0	387	0	0	0	387	387	*207387
RGSMNHD	KOLONAWA	0	0	11725	0	11725	0	11725	*207503
RUMPRAI	JAFFNA	4138	0	0	29539	4138	29539	33677	*207664
YLNKLAM	ANURPURA	8519	1192	491	25219	9010	26411	35422	*207956
ADUKODA	KOLONAWA	0	0	0	0	0	0	0	*207956
ALCHENA	BATICALO	22699	109	1008	28219	23708	28329	52037	*208659

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
/AVNKLAM	KOLONAWA	0	0	0	0	0	0	0	*209886
/AVUNIYA	ANURPURA	45269	646	775	86073	46045	86720	132765	*210999
/ELANAI	JAFFNA	3710	490	0	46196	3710	46687	50397	*211180
/EYNGODA	KOLONAWA	0	0	110706	0	110706	0	110706	*211804
/ADAKADA	KURNGALA	5106	0	0	6466	5106	6466	11572	*211874
/ADDUWA	KOLONAWA	0	0	49777	129	49777	129	49907	*212128
/AGA	KOLONAWA	0	0	1149	77	1149	77	1227	*212134
/AHARAKA	KOLONAWA	0	0	1264	5716	1264	5716	6980	*212151
/AIKKAL	KOLONAWA	0	0	18508	0	18508	0	18508	*212265
/ALSGALA	MATARA	15065	0	0	0	15065	0	15065	*212513
/ALSMULA	MATARA	24832	0	3448	0	28281	0	28281	*213066
/ALAWE	MATARA	972	0	0	0	972	0	972	*213091
/ANDRBMA	KOLONAWA	0	0	0	0	0	0	0	*213091
/ARKGODA	KOLONAWA	0	0	5288	0	5288	0	5288	*213135
/ARKPOLA	KOLONAWA	0	0	37592	0	37592	0	37592	*213407
/ARALLA	GALLE	3691	922	0	0	3691	922	4613	*213481
/ARYPOLA	KURNGALA	16773	0	0	42135	16773	42135	58909	*213723
/ASKDUWA	KOLONAWA	0	0	0	4474	0	4474	4474	*213730
/ATAGODA	KOLONAWA	0	0	1600	0	1600	0	1600	*213759
/ATAWALA	KOLONAWA	721	0	0	3052	721	3052	3773	*213773
/ATTALA	KOLONAWA	0	0	63228	0	63228	0	63228	*213906
/ATTGAMA	PERDNIYA	23841	0	1615	1612	25456	1612	27068	*214232
/ATUGDRA	KOLONAWA	0	0	5518	0	5518	0	5518	*214295
/ATUMULA	KOLONAWA	0	569	0	543	0	1112	1112	*214297
/ATRGAMA	KOLONAWA	0	0	11725	0	11725	0	11725	*214348
/ERAGODA	BATICALO	0	731	0	8277	0	9008	9008	*214377
/ERAKTYA	MATARA	15285	0	0	0	15285	0	15285	*214664
/ELIGAMA	GALLE	84040	0	0	0	84040	0	84040	*215754
/ELIKADA	KOLONAWA	0	0	86220	0	86220	0	86220	*215936
/ELIKNDA	KOLONAWA	0	0	0	0	0	0	0	*215936
/ELIMADA	HAPUTALE	83389	0	17244	10061	100634	10061	110695	*218306
/ELIPENE	KOLONAWA	0	0	0	0	0	0	0	*218306
/ELIWRYA	KOLONAWA	0	0	35177	0	35177	0	35177	*218443
/ELLMPTY	KOLONAWA	0	0	117792	0	117792	0	117792	*218650
/ELAWAYA	HAPUTALE	11268	0	0	2379	11268	2379	13647	*218930
/ENAPUWA	KOLONAWA	0	0	34488	1370	34488	1370	35859	*219175
/ERAHERA	KOLONAWA	0	0	5357	0	5357	0	5357	*219194
/ERLGAMA	PERDNIYA	28927	201	0	0	28927	201	29128	*219520
/EWLDNYA	KOLONAWA	0	0	48973	517	48973	517	49490	*219866
/IRAWILA	KOLONAWA	0	0	0	4138	0	4138	4138	*219872
'AKKALA	KOLONAWA	0	0	5403	0	5403	0	5403	*219896
'AKKLMLA	KOLONAWA	0	0	0	0	0	0	0	*219896
'ATAWATA	KOLONAWA	0	0	0	0	0	0	0	*219896
'ATIYANA	MATARA	18045	512	0	3595	18045	4108	22153	*220176
'ATNTOTA	KOLONAWA	0	0	33798	310	33798	310	34108	*220462
'ODKNDYA	KOLONAWA	0	0	0	0	0	0	0	*220462

TOTAL DELIVERIES = 21182769.96

TOTAL COLLECTIONS = 3325496.07

TOTAL DEMAND THROUGHOUT THE COUNTRY IS 24508266.03

FIXED COST OF EXISTING NETWORK = 516850.00

DELIVERY COST OF EXISTING NETWORK = 2124485.88

T OF COLLECTIONS FROM DEPOTS = 36607.19
T OF COLLECTIONS FROM CENTRAL SOURCE = 43527.19

AL COST OF ALL COLLECTIONS = 80134.38

IABLE COST OF EXISTING NETWORK = 2204620.26

AL COST OF EXISTING NETWORK = 2721470.26

PROGRAM WILL ARRANGE SUPPLY FROM THE CENTRAL SOURCE - KOLONAWA
OME OF THE 85 LIKELY DEPOT LOCATIONS TO REDUCE TOTAL DISTRIBUTION
OF THESE, THE FIRST 13 DEPOTS COMPRISE THE EXISTING DISTRIBUTIVE
RK
85 LIKELY DEPOT LOCATIONS ARE:-

OT	OPERATING COST	SUPPLY COST	SOURCE COST	TOTAL COST EX DEPOT
		RUPEES PER IMPERIAL GALLON		
A	0.0186	0.0983	0.0141	0.1310
ALA	0.0107	0.1300	0.0141	0.1548
ALE	0.0164	0.1690	0.0141	0.1995
IYA	0.0083	0.0793	0.0141	0.1017
ALO	0.0163	0.2078	0.0141	0.2382
ALA	0.0125	0.0613	0.0141	0.0879
URA	0.0106	0.1242	0.0141	0.1489
A	0.0124	0.2341	0.0141	0.2606
URA	0.0231	0.0652	0.0141	0.1024
	0.0101	0.0738	0.0141	0.0980
CHY	0.0237	0.1965	0.0141	0.2343
RAD	0.0188	0.0801	0.0141	0.1130
BAY	0.0200	0.0499	0.0141	0.0840
UWA	0.0080	0.0195	0.0141	0.0416
URA	0.0080	0.0234	0.0141	0.0455
WA	0.0080	0.0269	0.0141	0.0490
ARA	0.0080	0.0324	0.0141	0.0545
AMA	0.0080	0.0427	0.0141	0.0648
ODA	0.0080	0.0570	0.0141	0.0791
UWA	0.0080	0.0630	0.0141	0.0851
UWA	0.0080	0.0797	0.0141	0.1018
AMA	0.0080	0.0908	0.0141	0.1129
A	0.0080	0.0196	0.0141	0.0417
BO	0.0080	0.0286	0.0141	0.0507
ILA	0.0080	0.0377	0.0141	0.0598
PE	0.0080	0.0479	0.0141	0.0700
W	0.0080	0.0539	0.0141	0.0760
OYA	0.0080	0.0648	0.0141	0.0869
LAM	0.0080	0.0836	0.0141	0.1057
A	0.0080	0.0163	0.0141	0.0384
HA	0.0080	0.0227	0.0141	0.0448
ODA	0.0080	0.0278	0.0141	0.0499
AMA	0.0080	0.0352	0.0141	0.0573
A	0.0080	0.0443	0.0141	0.0664
WLA	0.0080	0.0491	0.0141	0.0712

HYA	0.0080	0.1391	0.0141	0.1612
IYA	0.0080	0.1527	0.0141	0.1748
LAM	0.0080	0.1787	0.0141	0.2008
ASR	0.0080	0.2054	0.0141	0.2275
I	0.0080	0.2119	0.0141	0.2340
HRY	0.0080	0.2251	0.0141	0.2472
KAM	0.0080	0.2395	0.0141	0.2616
.	0.0080	0.2440	0.0141	0.2661
AWA	0.0080	0.1147	0.0141	0.1368
ANA	0.0080	0.1270	0.0141	0.1491
A	0.0080	0.1368	0.0141	0.1589
LAY	0.0080	0.1536	0.0141	0.1757
MLY	0.0080	0.1768	0.0141	0.1989
KGD	0.0080	0.1465	0.0141	0.1686
UWA	0.0080	0.1563	0.0141	0.1784
NDA	0.0080	0.1712	0.0141	0.1933
HNY	0.0080	0.1904	0.0141	0.2125
R	0.0080	0.2005	0.0141	0.2226
RD	0.0080	0.1638	0.0141	0.1859
KAN	0.0080	0.1712	0.0141	0.1933
R	0.0080	0.1844	0.0141	0.2065
NAR	0.0080	0.1985	0.0141	0.2206
	0.0080	0.0841	0.0141	0.1062
TTA	0.0080	0.0879	0.0141	0.1100
AMA	0.0080	0.0929	0.0141	0.1150
E	0.0080	0.1038	0.0141	0.1259
ANA	0.0080	0.0554	0.0141	0.0775
AWA	0.0080	0.0710	0.0141	0.0931
LA	0.0080	0.0885	0.0141	0.1106
TYA	0.0080	0.0985	0.0141	0.1206
ALA	0.0080	0.1150	0.0141	0.1371
N	0.0080	0.1260	0.0141	0.1481
ELE	0.0080	0.1355	0.0141	0.1576
ODA	0.0080	0.1406	0.0141	0.1627
OYA	0.0080	0.1488	0.0141	0.1709
ELA	0.0080	0.1570	0.0141	0.1791
WLA	0.0080	0.1724	0.0141	0.1945
ARA	0.0080	0.1757	0.0141	0.1978
ELA	0.0080	0.1803	0.0141	0.2024
LA	0.0080	0.1879	0.0141	0.2100
PYA	0.0080	0.0163	0.0141	0.0384
AMA	0.0080	0.0217	0.0141	0.0438
KA	0.0080	0.0259	0.0141	0.0480
ELA	0.0080	0.0399	0.0141	0.0620
GDA	0.0080	0.0552	0.0141	0.0773
ITA	0.0080	0.0621	0.0141	0.0842
ATA	0.0080	0.0810	0.0141	0.1031
IKE	0.0080	0.0848	0.0141	0.1069

TIAL DISTRIBUTION PATTERN - ALL DESTINATIONS SUPPLIED
THE CENTRAL SOURCE (KOLONAWA)

ED COST OF KOLONAWA IS 411000.00
IABLE COST OF SUPPLYING ALL DESTINATIONS FROM KOLONAWA IS 3038759.70

AL COST OF ALL COLLECTIONS = 80134.38

TIAL OVERALL COST = 3529894.08

ERCENTAGE IMPROVEMENT = -29.71

ARA DEPOT WILL ENTER THE BASIS

ROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT MATARA IS 1107024.51

IXED COST OF MATARA IS 7200.00
INITIAL VARIABLE COST OF MATARA IS 249617.47

INITIAL GROSS SAVING BY INCLUSION OF MATARA IN THE BASIS IS 70136.81
ONTRIBUTION TO NETT SAVING BY INCLUSION OF MATARA IS 62936.81

OTS IN BASIS

POT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
ONAWA	20075745.45	411000.00	2719005.42
ARA	1107024.51	7200.00	249617.47

ED COST OF KOLONAWA AND 1 DEPOT/S IS 418200.00
IABLE COST OF KOLONAWA AND 1 DEPOT/S IS 2968622.89

AL COST OF ALL COLLECTIONS = 80134.38

UCED OVERALL COST = 3466957.27

INITIAL NETT SAVING BY INCLUSION OF MATARA IN THE BASIS IS 62936.81

ROVEMENT OVER COST OF PRESENT SYSTEM = -745487.01

ERCENTAGE IMPROVEMENT = -27.39

AGALA DEPOT WILL ENTER THE BASIS

ROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT KOTAGALA IS 1187688.32

IXED COST OF KOTAGALA IS 13000.00
INITIAL VARIABLE COST OF KOTAGALA IS 319932.61

INITIAL GROSS SAVING BY INCLUSION OF KOTAGALA IN THE BASIS IS 40646.09

OTS IN BASIS

POT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
ONAWA	19048827.09	411000.00	2456387.39
ARA	946254.55	7200.00	151656.79
AGALA	1187688.32	13000.00	319932.61

ED COST OF KOLONAWA AND 2 DEPOT/S IS 431200.00
IABLE COST OF KOLONAWA AND 2 DEPOT/S IS 2927976.80

AL COST OF ALL COLLECTIONS = 80134.38

UCED OVERALL COST = 3439311.18

INITIAL NETT SAVING BY INCLUSION OF KOTAGALA IN THE BASIS IS 27646.09

ROVEMENT OVER COST OF PRESENT SYSTEM = -717840.91

ERCENTAGE IMPROVEMENT = -26.38

GALA DEPOT WILL DROP OUT OF THE BASIS. ALL DESTINATIONS ASSIGNED
WILL REVERT TO KOLONAWA FOR RE-ALLOCATION

UTALE DEPOT WILL ENTER THE BASIS

ROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT HAPUTALE IS 986638.60

IXED COST OF HAPUTALE IS 6500.00
INITIAL VARIABLE COST OF HAPUTALE IS 301377.36

INITIAL GROSS SAVING BY INCLUSION OF HAPUTALE IN THE BASIS IS 39740.06
ONTRIBUTION TO NETT SAVING BY INCLUSION OF HAPUTALE IS 33240.06

OTS IN BASIS

POT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
ONAWA	19249876.81	411000.00	2444976.87
ARA	946254.55	7200.00	151656.79
UTALE	986638.60	6500.00	301377.36

AGALA DEPOT HAS DROPPED OUT OF THE BASIS

VARIABLE COST OF KOLONAWA AND 2 DEPOT/S IS 2898011.02

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 3402845.40

INITIAL NETT SAVING BY INCLUSION OF HAPUTALE IN THE BASIS IS 36465.78

IMPROVEMENT OVER COST OF PRESENT SYSTEM = -681375.14

PERCENTAGE IMPROVEMENT = -25.04

PERDNIYA DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

DESTINATION	THROUGHPUT	SOURCE	COST PER GALLON	TRANSPORT COST	
ADALCHNA	0.00	HAPUTALE	0.4444	0.00	
AGALWATA	31499.12	KOLONAWA	0.0933	2938.87	
					SAVE 2890.44 BY SUPPLYING AGRAPTNA FROM PERDNIYA
AGRAPTNA	34885.15	PERDNIYA	0.1105	3854.81	
AHANGAMA	28825.70	MATARA	0.1644	4740.10	
AHUNGALA	3908.65	KOLONAWA	0.0986	385.31	
AKARPATU	11719.60	HAPUTALE	0.4404	5160.80	
AKMIMANA	2050.66	KOLONAWA	0.1582	324.50	
					SAVE 450.65 BY SUPPLYING AKURANA FROM PERDNIYA
AKURANA	14203.48	PERDNIYA	0.1228	1744.47	
AKURESSA	76244.60	MATARA	0.1539	11732.52	
					SAVE 2047.75 BY SUPPLYING ALAVEDDY FROM PERDNIYA
ALAVEDDY	17933.81	PERDNIYA	0.6172	11068.82	
					SAVE 1073.77 BY SUPPLYING ALAWTGDA FROM PERDNIYA
ALAWTGDA	33656.38	PERDNIYA	0.1263	4252.15	
ALAWWA	26325.91	KOLONAWA	0.0792	2085.54	
ALUTGAMA	76103.72	KOLONAWA	0.0810	6162.88	
					SAVE 11.20 BY SUPPLYING ALUTNWRA FROM PERDNIYA
ALUTNWRA	201.18	PERDNIYA	0.1932	38.87	
AMBLGODA	87082.44	KOLONAWA	0.1074	9350.91	
AMBLTOTA	19543.16	MATARA	0.2067	4039.18	
					SAVE 0.00 BY SUPPLYING AMBAWELA FROM PERDNIYA
AMBAWELA	0.00	PERDNIYA	0.1967	0.00	
AMBEPUSA	0.00	KOLONAWA	0.0739	0.00	
AMPARAI	141774.14	HAPUTALE	0.4282	60709.39	
					SAVE 45.30 BY SUPPLYING AMPITIYA FROM PERDNIYA
AMPITIYA	1367.11	PERDNIYA	0.1140	155.88	
ANAMDUWA	0.00	KOLONAWA	0.0739	0.00	
ANDIAMBM	0.00	KOLONAWA	0.0528	0.00	
ANGAMUWA	2069.29	KOLONAWA	0.1472	304.51	
ANGODA	4138.57	KOLONAWA	0.0211	87.49	
ANGRWELA	0.00	KOLONAWA	0.0845	0.00	
ANHTGAMA	360.68	KOLONAWA	0.0757	27.30	
					SAVE 211.29 BY SUPPLYING ANKMBURA FROM PERDNIYA
ANKMBURA	6195.44	PERDNIYA	0.1334	826.35	
ANRDPURA	233028.39	KOLONAWA	0.2610	60826.93	
ARAKWILA	9426.74	KOLONAWA	0.0581	547.69	
ARANAYKA	459.84	KOLONAWA	0.1361	62.57	
ARCHKTWA	0.00	KOLONAWA	0.1305	0.00	
					SAVE 300.33 BY SUPPLYING ARIYALAI FROM PERDNIYA

					SAVE 0.00 BY SUPPLYING ATTABAGE FROM PERDNIYA
ATTABAGE	0.00	PERDNIYA	0.1281	0.00	
					SAVE 2049.32 BY SUPPLYING ATCHUVLY FROM PERDNIYA
ATCHUVLY	17947.52	PERDNIYA	0.6172	11077.28	
ATTNGALA	11381.07	KOLONAWA	0.0599	681.27	
ATTIDIYA	0.00	KOLONAWA	0.0317	0.00	
ATBLSHLA	15979.48	KOLONAWA	0.0880	1406.51	
ATURGRYA	151057.85	KOLONAWA	0.0317	4788.53	
					SAVE 2306.59 BY SUPPLYING AVERNGAL FROM PERDNIYA
AVERNGAL	14485.00	PERDNIYA	0.6249	9051.10	
AVISWELA	179015.19	KOLONAWA	0.0616	11030.92	
BDLKMBRA	5710.97	HAPUTALE	0.2699	1541.39	
BADDGAMA	32752.49	KOLONAWA	0.1398	4577.62	
BADULLA	118139.01	HAPUTALE	0.2400	28351.00	
BADRELYA	15864.52	KOLONAWA	0.1074	1703.53	
BAKIELLA	0.00	HAPUTALE	0.4606	0.00	
BALNGODA	72247.52	KOLONAWA	0.1638	11833.28	
BALAPTYA	23681.83	KOLONAWA	0.1039	2459.59	
BALLKTWA	5016.82	HAPUTALE	0.2347	1177.45	
BAMNPOLA	0.00	KOLONAWA	0.1453	0.00	
BANDRGMA	67021.86	KOLONAWA	0.0563	3776.01	
BANDRWLA	100079.82	HAPUTALE	0.2083	20846.63	
BANGDNYA	0.00	KOLONAWA	0.1127	0.00	
BARMPOLA	0.00	KOLONAWA	0.1398	0.00	
BATAPOLA	11725.95	KOLONAWA	0.1197	1403.60	
					SAVE 11328.38 BY SUPPLYING BATICALO FROM PERDNIYA
BATICALO	113483.49	PERDNIYA	0.3486	39563.52	
BATULUOA	8277.14	KOLONAWA	0.1268	1049.77	
BELIATTA	40740.75	MATARA	0.1697	6914.52	
BELIHLOY	3987.40	KOLONAWA	0.1804	719.41	
BEMMULLA	6667.69	KOLONAWA	0.0493	328.72	
BENDYMLA	21152.69	KOLONAWA	0.0423	893.91	
BENGMUWA	0.00	MATARA	0.1838	0.00	
BENTOTA	0.00	KOLONAWA	0.0810	0.00	
BERAGAMA	0.00	MATARA	0.2137	0.00	
BERLPNTR	0.00	MATARA	0.1996	0.00	
BERUWALA	54836.07	KOLONAWA	0.0739	4054.58	
BIBILE	4249.76	HAPUTALE	0.2963	1259.20	
BINGRIYA	18393.65	KOLONAWA	0.1268	2332.83	
BIYAGAMA	17933.81	KOLONAWA	0.0282	505.37	
BOGWTLWA	27097.75	KOLONAWA	0.1767	4788.82	
BOMBWELA	0.00	KOLONAWA	0.0704	0.00	
BOOSSA	0.00	KOLONAWA	0.1361	0.00	
					SAVE 0.00 BY SUPPLYING BOPTLAWA FROM PERDNIYA
BOPTLAWA	0.00	PERDNIYA	0.2163	0.00	
BOPITIYA	2069.28	KOLONAWA	0.0387	80.16	
					SAVE 0.00 BY SUPPLYING BORAGAS FROM PERDNIYA
BORAGAS	0.00	PERDNIYA	0.1950	0.00	
					SAVE 195.03 BY SUPPLYING BORALNDA FROM PERDNIYA
BORALNDA	4290.60	PERDNIYA	0.2237	959.67	
BORLSGMA	20692.86	KOLONAWA	0.0317	655.96	
BLTKHPTA	11725.95	KOLONAWA	0.0968	1135.31	
BUTTALA	4288.94	HAPUTALE	0.2611	1119.84	
CHDYNTLW	0.00	HAPUTALE	0.4323	0.00	
					SAVE 1244.77 BY SUPPLYING CHANKANI FROM PERDNIYA
CHANKANI	15152.02	PERDNIYA	0.7173	10869.27	
					SAVE 6797.08 BY SUPPLYING CHVKCHRI FROM PERDNIYA
CHVKCHRI	65041.32	PERDNIYA	0.5891	38317.92	
					SAVE 0.00 BY SUPPLYING CHDIKLAM FROM PERDNIYA
CHDIKLAM	0.00	PERDNIYA	0.3345	0.00	
					SAVE 0.00 BY SUPPLYING CHMPNPTU FROM PERDNIYA
CHMPNPTU	0.00	PERDNIYA	0.5636	0.00	
					SAVE 3550.61 BY SUPPLYING CNHKLADI FROM PERDNIYA
CNHKLADI	35568.72	PERDNIYA	0.3304	11752.33	

					SAVE 0.00 BY SUPPLYING CHINABAY FROM PERDNIYA
CHINABAY	0.00	PERDNIYA	0.3385	0.00	
					SAVE 0.00 BY SUPPLYING CHLIPRAM FROM PERDNIYA
CHLIPRAM	0.00	PERDNIYA	0.7232	0.00	
					SAVE 5191.29 BY SUPPLYING CHUNAKAM FROM PERDNIYA
CHUNAKAM	50268.12	PERDNIYA	0.6223	31282.25	
COLOMBO	4143593.80	KOLONAWA	0.0229	94888.30	
DADALLA	0.00	KOLONAWA	0.1601	0.00	
DALWKTWA	15864.53	KOLONAWA	0.0546	865.89	
DAMBDNYA	3448.81	KOLONAWA	0.0845	291.42	
DAMBULLA	22171.34	KOLONAWA	0.1804	4000.15	
DANKTUWA	24946.39	KOLONAWA	0.0669	1668.91	
DEDUGALA	0.00	KOLONAWA	0.1056	0.00	
DEHIOWTA	2212.04	KOLONAWA	0.0704	155.77	
DEHIWELA	99325.71	KOLONAWA	0.0247	2449.37	
DEIYNDRA	7587.38	MATARA	0.1697	1287.73	
DEKATANA	14485.00	KOLONAWA	0.0387	561.15	
DELGODA	6552.73	KOLONAWA	0.0335	219.25	
					SAVE 274.43 BY SUPPLYING DELTOTA FROM PERDNIYA
DELTOTA	8088.72	PERDNIYA	0.1299	1050.40	
DELWALA	0.00	KOLONAWA	0.1435	0.00	
DEMODARA	0.00	HAPUTALE	0.2241	0.00	
DENIPTYA	569.63	MATARA	0.1539	87.65	
DENIYAYA	58180.50	MATARA	0.2032	11819.95	
DERNYGLA	23854.27	KOLONAWA	0.0810	1931.72	
DHRGTOWN	7817.30	KOLONAWA	0.0827	646.80	
DICKOYA	32348.84	KOLONAWA	0.1545	4999.45	
DICKWELA	25982.06	MATARA	0.1539	3998.12	
DIMBULLA	0.00	KOLONAWA	0.1638	0.00	
DIVLPTYA	32188.89	KOLONAWA	0.0563	1813.52	
DIYTLAWA	11110.13	HAPUTALE	0.2083	2314.24	
DODNDUWA	38799.10	KOLONAWA	0.1342	5207.62	
DDNGSLND	2164.06	KOLONAWA	0.1416	306.46	
DONDGODA	9196.82	KOLONAWA	0.0704	647.64	
					SAVE 32.27 BY SUPPLYING DOLSBAGE FROM PERDNIYA
DOLSBAGE	18761.27	PERDNIYA	0.1510	2832.58	
DMBGHWLA	5026.98	HAPUTALE	0.3051	1533.73	
DOMPE	20233.01	KOLONAWA	0.0423	855.05	
DONDRA	39951.10	MATARA	0.1398	5585.16	
DUMLDNYA	17933.81	KOLONAWA	0.0792	1420.72	
DUMLSRYA	12645.63	KOLONAWA	0.1021	1291.12	
					SAVE 1445.12 BY SUPPLYING ELTHMDWL FROM PERDNIYA
ELTHMDWL	9311.79	PERDNIYA	0.6351	5913.62	
EGODUYNA	14485.00	KOLONAWA	0.0387	561.15	
EHLYGODA	39399.82	KOLONAWA	0.0775	3051.91	
EKALA	7587.38	KOLONAWA	0.0387	293.94	
					SAVE 0.00 BY SUPPLYING ELAHERA FROM PERDNIYA
ELAHERA	0.00	PERDNIYA	0.1932	0.00	
ELLE	4380.73	HAPUTALE	0.2189	958.77	
					SAVE 31.31 BY SUPPLYING ELLAMLLA FROM PERDNIYA
ELLAMLLA	569.63	PERDNIYA	0.1615	92.02	
					SAVE 344.95 BY SUPPLYING ELKADUWA FROM PERDNIYA
ELKADUWA	11278.64	PERDNIYA	0.1369	1544.05	
ELPITIYA	61388.81	KOLONAWA	0.1197	7348.24	
EMBLPTYA	28261.13	KOLONAWA	0.2165	6118.53	
EPITWELA	0.00	KOLONAWA	0.0546	0.00	
					SAVE 0.00 BY SUPPLYING EPPAWALA FROM PERDNIYA
EPPAWALA	0.00	PERDNIYA	0.2421	0.00	
					SAVE 0.00 BY SUPPLYING ERAVUR FROM PERDNIYA
ERAVUR	0.00	PERDNIYA	0.3304	0.00	
ETTMPTYA	15174.76	HAPUTALE	0.2241	3401.27	
ETULKOTE	18278.69	KOLONAWA	0.0247	450.75	
					SAVE 347.69 BY SUPPLYING GALGDERA FROM PERDNIYA
GALGDERA	14391.09	PERDNIYA	0.1193	1716.86	
					SAVE 1512.67 BY SUPPLYING GALAHA FROM PERDNIYA
GALAHA	[illegible]	PERDNIYA	[illegible]	[illegible]	

GALBODA	0.00	KOLONAWA	0.1398	0.00	
					SAVE 265.70 BY SUPPLYING GALNBDNW FROM PERDNIYA
GALNBDNW	4138.57	PERDNIYA	0.3183	1317.17	
GALEWELA	31253.01	KOLONAWA	0.1656	5176.62	
GALGMUWA	20242.83	KOLONAWA	0.1878	3801.85	
GALIGMWA	19083.41	KOLONAWA	0.0880	1679.72	
GALLE	579199.89	KOLONAWA	0.1490	86303.10	
					SAVE 0.00 BY SUPPLYING GALOYA FROM PERDNIYA
GALOYA	0.00	PERDNIYA	0.2366	0.00	
GALPATHA	14714.92	KOLONAWA	0.0704	1036.22	
					SAVE 101.67 BY SUPPLYING GAMMDUWA FROM PERDNIYA
GAMMDUWA	2734.22	PERDNIYA	0.1580	432.06	
GAMPAHA	65182.49	KOLONAWA	0.0423	2754.61	
					SAVE 4083.32 BY SUPPLYING GAMPOLA FROM PERDNIYA
GAMPOLA	169011.41	PERDNIYA	0.1193	20163.06	
GANDARA	0.00	MATARA	0.1416	0.00	
GANEGODA	0.00	KOLONAWA	0.1305	0.00	
GANEMULA	23566.87	KOLONAWA	0.0370	871.50	
					SAVE 0.00 BY SUPPLYING GELIOYA FROM PERDNIYA
GELIOYA	0.00	PERDNIYA	0.1105	0.00	
GINGTHNA	21382.61	KOLONAWA	0.1305	2790.94	
					SAVE 6.13 BY SUPPLYING GIRITALE FROM PERDNIYA
GIRITALE	1062.44	PERDNIYA	0.2532	269.05	
GIRIULLA	57595.12	KOLONAWA	0.0775	4461.32	
GODAGAMA	18163.73	KOLONAWA	0.0458	831.54	
GODKWELA	37301.96	KOLONAWA	0.1582	5902.81	
GODPTIYA	0.00	MATARA	0.1380	0.00	
GODIGMWA	21842.46	KOLONAWA	0.0687	1499.70	
GONPNWLA	6207.85	KOLONAWA	0.1324	821.75	
GONAPOLA	4828.33	KOLONAWA	0.0475	229.54	
GONAWELA	22762.14	KOLONAWA	0.0387	881.81	
GOVINNA	1379.53	KOLONAWA	0.0669	92.29	
					SAVE 0.00 BY SUPPLYING GURTLAWA FROM PERDNIYA
GURTLAWA	0.00	PERDNIYA	0.2274	0.00	
HABRDUWA	11725.95	KOLONAWA	0.1638	1920.57	
					SAVE 19.88 BY SUPPLYING HABARANA FROM PERDNIYA
HABARANA	8202.95	PERDNIYA	0.2181	1789.26	
HAKMANA	39322.64	MATARA	0.1592	6258.59	
HALDDWNA	0.00	KOLONAWA	0.0687	0.00	
HALDMULA	9150.79	HAPUTALE	0.2136	1954.43	
					SAVE 1570.53 BY SUPPLYING HALGNOYA FROM PERDNIYA
HALGNOYA	24734.30	PERDNIYA	0.1915	4735.63	
HALIELA	0.00	HAPUTALE	0.2329	0.00	
HAMBTOTA	24598.77	MATARA	0.2190	5387.13	
					SAVE 1272.48 BY SUPPLYING HANGRKTA FROM PERDNIYA
HANGRKTA	35135.81	PERDNIYA	0.1387	4871.93	
HANWELLA	43799.88	KOLONAWA	0.0440	1928.07	
HAPUTALE	115423.43	HAPUTALE	0.2013	23230.12	
HARNKHWA	0.00	KOLONAWA	0.0968	0.00	
					SAVE 630.66 BY SUPPLYING HARSBDDA FROM PERDNIYA
HARSBDDA	8874.57	PERDNIYA	0.1879	1667.89	
HATRLYDA	0.00	KOLONAWA	0.1162	0.00	
HATTON	83762.01	KOLONAWA	0.1490	12480.87	
					SAVE 509.85 BY SUPPLYING HEDENIYA FROM PERDNIYA
HEDENIYA	15386.61	PERDNIYA	0.1140	1754.38	
HEMTGAMA	0.00	KOLONAWA	0.1287	0.00	
HENDALA	26900.71	KOLONAWA	0.0247	663.37	
HENEGAMA	12990.51	MATARA	0.1468	1907.53	
HETIMULA	11036.19	KOLONAWA	0.0968	1068.52	
HETIPOLA	8047.22	KOLONAWA	0.1324	1065.23	
					SAVE 302.31 BY SUPPLYING HEWAHETA FROM PERDNIYA
HEWAHETA	8306.94	PERDNIYA	0.1422	1181.08	
HIKKDUWA	25118.83	KOLONAWA	0.1268	3185.77	
HINGULA	4828.33	KOLONAWA	0.1144	552.46	
					SAVE 427.42 BY SUPPLYING HINGRKGD FROM PERDNIYA

HIRIPTYA	0.00	KOLONAWA	0.1398	0.00	
HITTETYA	0.00	MATARA	0.1345	0.00	
HOMAGAMA	148586.20	KOLONAWA	0.0458	6802.28	
HORMBAWA	0.00	KOLONAWA	0.1127	0.00	
HORANA	138412.21	KOLONAWA	0.0581	8041.75	
HUNGAMA	2873.96	MATARA	0.1926	553.52	
					SAVE 786.16 BY SUPPLYING HUNSGRYA FROM PERDNIYA
HUNSGRYA	22471.86	PERDNIYA	0.1510	3392.80	
HUNUPTYA	30234.56	KOLONAWA	0.0229	692.37	
					SAVE 433.95 BY SUPPLYING HURIKDWA FROM PERDNIYA
HURIKDWA	11725.95	PERDNIYA	0.1175	1378.27	
					SAVE 0.00 BY SUPPLYING HURLWEWA FROM PERDNIYA
HURLWEWA	0.00	PERDNIYA	0.2421	0.00	
IBBGMUWA	25854.78	KOLONAWA	0.1305	3374.67	
IDLGSHNA	8968.49	HAPUTALE	0.2118	1899.71	
					SAVE 26.82 BY SUPPLYING ILLKWELA FROM PERDNIYA
ILLKWELA	6150.99	PERDNIYA	0.1299	798.77	
IMADUWA	22910.30	MATARA	0.1627	3727.05	
IMBLGODA	13105.48	KOLONAWA	0.0387	507.71	
INDURUWA	15749.56	KOLONAWA	0.0863	1358.56	
INGNYGLA	0.00	HAPUTALE	0.3788	0.00	
INGIRIYA	24716.47	KOLONAWA	0.0704	1740.53	
ITTAKNDA	0.00	KOLONAWA	0.1878	0.00	
ITTAPANA	5543.96	KOLONAWA	0.0968	536.77	
JAELA	152839.73	KOLONAWA	0.0317	4845.02	
					SAVE 34060.66 BY SUPPLYING JAFFNA FROM PERDNIYA
JAFFNA	321542.39	PERDNIYA	0.6198	199277.83	
KADAWATA	225667.09	KOLONAWA	0.0282	6359.30	
KADIRANA	2069.28	KOLONAWA	0.0546	112.94	
					SAVE 63.80 BY SUPPLYING KADGNAWA FROM PERDNIYA
KADGNAWA	8574.61	PERDNIYA	0.1123	962.59	
KADUWELA	35999.82	KOLONAWA	0.0282	1014.47	
KAHADUWA	10806.27	KOLONAWA	0.1416	1530.30	
					SAVE 972.91 BY SUPPLYING KHTGSDLY FROM PERDNIYA
KHTGSDLY	17179.44	PERDNIYA	0.2847	4890.16	
KAHAWATA	105276.58	KOLONAWA	0.1416	14908.43	
KAHAWELA	3448.81	KOLONAWA	0.0546	188.24	
					SAVE 0.00 BY SUPPLYING KIKAWELA FROM PERDNIYA
KIKAWELA	0.00	PERDNIYA	0.1387	0.00	
KAKPLIYA	0.00	KOLONAWA	0.0933	0.00	
KALGDHNA	3448.81	KOLONAWA	0.0511	176.10	
KALAWANA	13518.64	KOLONAWA	0.1472	1989.35	
					SAVE 385.47 BY SUPPLYING KALVNCHK FROM PERDNIYA
KALVNCHK	7830.98	PERDNIYA	0.4174	3269.00	
					SAVE 0.00 BY SUPPLYING KALAWEWA FROM PERDNIYA
KALAWEWA	0.00	PERDNIYA	0.2292	0.00	
					SAVE 543.65 BY SUPPLYING KALMUNAI FROM PERDNIYA
KALMUNAI	36912.58	PERDNIYA	0.4357	16084.58	
KALPTIYA	1379.53	KOLONAWA	0.2205	304.25	
KALUTARA	125191.77	KOLONAWA	0.0616	7714.32	
KMBGMUWA	0.00	MATARA	0.1363	0.00	
KMBRPTYA	35487.85	MATARA	0.1504	5335.95	
KANDANA	45294.36	KOLONAWA	0.0299	1356.11	
					SAVE 1182.41 BY SUPPLYING KANDPOLA FROM PERDNIYA
KANDPOLA	25961.88	PERDNIYA	0.1932	5016.35	
					SAVE 19022.32 BY SUPPLYING KANDY FROM PERDNIYA
KANDY	547877.84	PERDNIYA	0.1087	59576.24	
					SAVE 1255.75 BY SUPPLYING KANKSTRA FROM PERDNIYA
KANKSTRA	15220.51	PERDNIYA	0.7232	11006.80	
					SAVE 936.89 BY SUPPLYING KANTALAI FROM PERDNIYA
KANTALAI	124454.29	PERDNIYA	0.2717	33816.22	
KNUKTIYA	3475.30	KOLONAWA	0.1179	409.88	
					SAVE 0.00 BY SUPPLYING KRDIYNRU FROM PERDNIYA
KRDIYNRU	0.00	PERDNIYA	0.3142	0.00	
					SAVE 993.06 BY SUPPLYING KARANAGA FROM PERDNIYA

KARNDPNA	0.00	KOLONAWA	0.0968	0.00	
KATANA	16784.21	KOLONAWA	0.0581	975.16	
KATRGAMA	729.49	MATARA	0.2825	206.11	
					SAVE 128.24 BY SUPPLYING KATNKUDI FROM PERDNIYA
KATNKUDI	1284.68	PERDNIYA	0.3567	458.28	
					SAVE 3586.40 BY SUPPLYING KATGSTTA FROM PERDNIYA
KATGSTTA	102258.28	PERDNIYA	0.1158	11839.46	
					SAVE 203.28 BY SUPPLYING KATKTULA FROM PERDNIYA
KATKTULA	8475.49	PERDNIYA	0.1527	1294.55	
KATKRNDA	20807.81	KOLONAWA	0.0651	1355.42	
KATUNYKA	23279.47	KOLONAWA	0.0493	1147.68	
KATUNRYA	13335.40	KOLONAWA	0.0739	986.02	
KATUPOTA	5518.09	KOLONAWA	0.1074	592.53	
KATUWANA	387.99	MATARA	0.2032	78.82	
KAUDULLA	2188.47	KOLONAWA	0.2185	478.23	
					SAVE 0.00 BY SUPPLYING KAUDPLLA FROM PERDNIYA
KAUDPLLA	0.00	PERDNIYA	0.1527	0.00	
					SAVE 755.62 BY SUPPLYING KAYTS FROM PERDNIYA
KAYTS	9139.07	PERDNIYA	0.7261	6635.51	
					SAVE 0.00 BY SUPPLYING KEBTGLWA FROM PERDNIYA
KEBTGLWA	0.00	PERDNIYA	0.3304	0.00	
KEGALLE	155311.38	KOLONAWA	0.0915	14217.20	
					SAVE 70.77 BY SUPPLYING KEKIRAWA FROM PERDNIYA
KEKIRAWA	17276.77	PERDNIYA	0.2144	3704.62	
KELANIYA	55543.07	KOLONAWA	0.0282	1565.20	
					SAVE 1827.30 BY SUPPLYING KEPTPOLA FROM PERDNIYA
KEPTPOLA	38991.55	PERDNIYA	0.2020	7877.07	
KESBEWA	6437.78	KOLONAWA	0.0405	260.73	
					SAVE 3760.41 BY SUPPLYING KILNOCHI FROM PERDNIYA
KILNOCHI	60824.51	PERDNIYA	0.4678	28452.49	
KIMBLPTY	2299.20	KOLONAWA	0.0581	133.58	
					SAVE 0.00 BY SUPPLYING KINNIYAI FROM PERDNIYA
KINNIYAI	0.00	PERDNIYA	0.3466	0.00	
KIRAMA	0.00	MATARA	0.1961	0.00	
KIRBTGDA	17818.85	KOLONAWA	0.0229	408.05	
KIRIELLA	4943.29	KOLONAWA	0.0863	426.41	
KIRINDA	2069.29	MATARA	0.1539	318.42	
KRNDWELA	23221.98	KOLONAWA	0.0563	1308.33	
KITALAWA	4828.33	KOLONAWA	0.1127	543.96	
KITLGALA	7472.42	KOLONAWA	0.1074	802.39	
KOBEIGNA	2759.04	KOLONAWA	0.1453	400.91	
KOCKKADY	58284.87	KOLONAWA	0.0581	3386.35	
					SAVE 567.28 BY SUPPLYING KODIKMAM FROM PERDNIYA
KODIKMAM	5661.93	PERDNIYA	0.5789	3277.83	
KOGGALA	0.00	MATARA	0.1644	0.00	
					SAVE 0.00 BY SUPPLYING KOLNKLDI FROM PERDNIYA
KOLNKLDI	0.00	PERDNIYA	0.7261	0.00	
KOLONNO	0.00	KOLONAWA	0.1952	0.00	
KOLNNAWA	162657.34	KOLONAWA	0.0159	2579.75	
					SAVE 1889.49 BY SUPPLYING KOPAY FROM PERDNIYA
KOPAY	17914.65	PERDNIYA	0.6172	11056.99	
KOSGAMA	7472.42	KOLONAWA	0.0511	381.54	
KOSLANDA	6345.16	HAPUTALE	0.2294	1455.71	
KOSWT JN	4023.61	KOLONAWA	0.0299	120.47	
KOTDNYWA	0.00	KOLONAWA	0.0687	0.00	
KOTAGALA	50516.35	KOLONAWA	0.1564	7900.56	
KOTAPOLA	2863.66	MATARA	0.1961	561.62	
KOTIKWTA	22302.30	KOLONAWA	0.0194	432.22	
KTYKMBRA	0.00	KOLONAWA	0.0722	0.00	
KOTMALE	56077.41	KOLONAWA	0.1472	8252.13	
KOTNTIVU	2644.09	KOLONAWA	0.1361	359.78	
KOTTAWA	3333.85	KOLONAWA	0.0335	111.55	
KOTTE	3333.85	KOLONAWA	0.0229	76.35	
KOTEGODA	689.76	MATARA	0.1468	101.28	
[illegible]	[illegible]	KOLONAWA	0.0405	[illegible]	

KUCHVELI	0.00	PERDNIYA	0.4129	0.00	
KULYPTYA	47938.45	KOLONAWA	0.1039	4978.89	
					SAVE 150.65 BY SUPPLYING KUNDSALE FROM PERDNIYA
KUNDSALE	4295.47	PERDNIYA	0.1158	497.33	
KURANA	9656.67	KOLONAWA	0.0475	459.08	
KURNGALA	389264.32	KOLONAWA	0.1109	43169.41	
KURUWITA	1073.48	KOLONAWA	0.0951	102.05	
					SAVE 0.00 BY SUPPLYING LABUKELE FROM PERDNIYA
LABUKELE	0.00	PERDNIYA	0.1633	0.00	
LATPNDRA	6322.82	KOLONAWA	0.1021	645.56	
LAXAPANA	0.00	KOLONAWA	0.1749	0.00	
LELOPTYA	0.00	KOLONAWA	0.1268	0.00	
LELWELA	10346.43	KOLONAWA	0.1527	1579.90	
LINDULA	102284.26	KOLONAWA	0.1786	18265.10	
LUNAWA	37247.14	KOLONAWA	0.0335	1246.29	
LUNUGALA	18931.85	HAPUTALE	0.2769	5242.99	
LUNUWILA	44144.76	KOLONAWA	0.0739	3264.06	
MADAMPE	44453.65	KOLONAWA	0.0915	4069.29	
					SAVE 446.60 BY SUPPLYING MADAWALA FROM PERDNIYA
MADAWALA	14990.59	PERDNIYA	0.1211	1814.76	
					SAVE 109.65 BY SUPPLYING MADHU CH FROM PERDNIYA
MADHU CH	1075.50	PERDNIYA	0.3587	385.83	
					SAVE 506.79 BY SUPPLYING MADLKELE FROM PERDNIYA
MADLKELE	13314.06	PERDNIYA	0.1387	1846.13	
MADLSIMA	3293.02	HAPUTALE	0.2734	900.38	
MADRNKLY	8277.14	KOLONAWA	0.1564	1294.51	
MAGGONA	23796.78	KOLONAWA	0.0704	1675.77	
MAHABAGE	13795.24	KOLONAWA	0.0211	291.63	
MAHAEDND	6897.62	KOLONAWA	0.1144	789.23	
MAHAGAMA	1942.94	KOLONAWA	0.0845	164.18	
					SAVE 0.00 BY SUPPLYING MHAILPLM FROM PERDNIYA
MHAILPLM	0.00	PERDNIYA	0.2348	0.00	
					SAVE 263.09 BY SUPPLYING MAHAOYA FROM PERDNIYA
MAHAOYA	2658.53	PERDNIYA	0.2606	692.89	
MAHARA	0.00	KOLONAWA	0.0229	0.00	
MHRAGAMA	177268.80	KOLONAWA	0.0299	5307.43	
					SAVE 69.21 BY SUPPLYING MHVLCHYA FROM PERDNIYA
MHVLCHYA	3980.99	PERDNIYA	0.3102	1234.79	
MAHAWEWA	38971.54	KOLONAWA	0.0863	3361.69	
					SAVE 0.00 BY SUPPLYING MAHYNGNA FROM PERDNIYA
MAHYNGNA	0.00	PERDNIYA	0.1932	0.00	
MAHO	2206.06	KOLONAWA	0.1638	361.33	
MAKOLA	5173.22	KOLONAWA	0.0282	145.78	
MAKLPOTA	0.00	KOLONAWA	0.1675	0.00	
MAKMBURA	15864.52	KOLONAWA	0.1712	2715.69	
MALABE	1149.60	KOLONAWA	0.0352	40.49	
MALIBODA	0.00	KOLONAWA	0.0933	0.00	
MALGWATA	0.00	KOLONAWA	0.0229	0.00	
					SAVE 1374.15 BY SUPPLYING MALLAKAM FROM PERDNIYA
MALLAKAM	12899.46	PERDNIYA	0.6249	8060.36	
MALPTIYA	0.00	KOLONAWA	0.1039	0.00	
MALWANA	0.00	KOLONAWA	0.0335	0.00	
MALWATAI	1530.91	HAPUTALE	0.4282	655.55	
MNGLELYA	0.00	KOLONAWA	0.1305	0.00	
					SAVE 1604.69 BY SUPPLYING MANIPAY FROM PERDNIYA
MANIPAY	15063.53	PERDNIYA	0.6249	9412.60	
					SAVE 1892.51 BY SUPPLYING MANKULAM FROM PERDNIYA
MANKULAM	32856.11	PERDNIYA	0.4312	14166.63	
					SAVE 3403.59 BY SUPPLYING MANNAR FROM PERDNIYA
MANNAR	56090.77	PERDNIYA	0.4357	24441.44	
					SAVE 1941.42 BY SUPPLYING MANTHIKI FROM PERDNIYA
MANTHIKI	18719.33	PERDNIYA	0.6044	11314.79	
					SAVE 0.00 BY SUPPLYING MRDKDWLA FROM PERDNIYA
MRDKDWLA	0.00	PERDNIYA	0.2255	0.00	
MRDGHMLA	48168.37	KOLONAWA	0.0581	2798.58	

MARASANA	0.00	PERDNIYA	0.1351	0.00	
MARAWILA	8966.90	KOLONAWA	0.0792	710.36	
					SAVE 1562.33 BY SUPPLYING MRTHNMDM FROM PERDNIYA
MRTHNMDM	12749.10	PERDNIYA	0.6147	7836.26	
MASKLIYA	63736.25	KOLONAWA	0.1712	10910.37	
MASPOTHA	2734.22	KOLONAWA	0.1179	322.47	
					SAVE 6020.78 BY SUPPLYING MATALE FROM PERDNIYA
MATALE	192030.57	PERDNIYA	0.1351	25951.01	
MATARA	239688.33	MATARA	0.1328	31821.02	
MATTAKA	2759.05	KOLONAWA	0.1490	411.11	
MATUGAMA	132319.32	KOLONAWA	0.0845	11180.98	
MAWANELA	66562.02	KOLONAWA	0.1056	7030.28	
MAWTGAMA	30253.37	KOLONAWA	0.1268	3836.97	
MEDAGAMA	0.00	HAPUTALE	0.2928	0.00	
					SAVE 1696.02 BY SUPPLYING MEDWCHYA FROM PERDNIYA
MEDWCHYA	31463.78	PERDNIYA	0.2828	8898.08	
					SAVE 0.00 BY SUPPLYING MEDAWELA FROM PERDNIYA
MEDAWELA	0.00	PERDNIYA	0.1756	0.00	
MGHETENE	5518.09	KOLONAWA	0.1003	553.69	
MEEGODA	0.00	KOLONAWA	0.0458	0.00	
METYGODA	0.00	KOLONAWA	0.1162	0.00	
MELSRPRA	22798.40	KOLONAWA	0.1453	3312.79	
METKMBRA	0.00	KOLONAWA	0.0951	0.00	
MIDDNIYA	8966.90	MATARA	0.2067	1853.28	
					SAVE 0.00 BY SUPPLYING MIHNTALE FROM PERDNIYA
MIHNTALE	0.00	PERDNIYA	0.2588	0.00	
					SAVE 0.00 BY SUPPLYING MINIPE FROM PERDNIYA
MINIPE	0.00	PERDNIYA	0.2144	0.00	
					SAVE 62.22 BY SUPPLYING MINNRIYA FROM PERDNIYA
MINNRIYA	13717.02	PERDNIYA	0.2403	3296.20	
MINWNGDA	59664.40	KOLONAWA	0.0458	2731.44	
MIRIGAME	42420.35	KOLONAWA	0.0687	2912.58	
MIRISSA	24831.42	MATARA	0.1398	3471.43	
MIRSWTTA	32993.61	KOLONAWA	0.0387	1278.17	
MONRGALE	16411.50	HAPUTALE	0.2840	4660.54	
MONMLDNY	0.00	KOLONAWA	0.1379	0.00	
MORGHENA	0.00	KOLONAWA	0.0616	0.00	
MORAGALA	2759.05	KOLONAWA	0.0986	271.99	
MORATUWA	166405.05	KOLONAWA	0.0352	5860.79	
MORAWAKA	6732.22	MATARA	0.1838	1237.38	
MTLAVNIA	137377.57	KOLONAWA	0.0282	3871.30	
MUDNGODA	13335.40	KOLONAWA	0.0387	516.61	
					SAVE 3327.07 BY SUPPLYING MULATIVU FROM PERDNIYA
MULATIVU	23606.96	PERDNIYA	0.4975	11745.03	
					SAVE 1662.59 BY SUPPLYING MULWALAI FROM PERDNIYA
MULWALAI	12006.68	PERDNIYA	0.4884	5863.73	
MUNDEL	14972.64	KOLONAWA	0.1361	2037.30	
					SAVE 459.24 BY SUPPLYING MURUNKAN FROM PERDNIYA
MURUNKAN	9601.14	PERDNIYA	0.4129	3964.00	
					SAVE 0.00 BY SUPPLYING MURTLAWA FROM PERDNIYA
MURTLAWA	0.00	PERDNIYA	0.1087	0.00	
					SAVE 0.00 BY SUPPLYING MUTTUR FROM PERDNIYA
MUTTUR	0.00	PERDNIYA	0.3304	0.00	
					SAVE 681.19 BY SUPPLYING MYLIDDY FROM PERDNIYA
MYLIDDY	6995.43	PERDNIYA	0.7144	4997.84	
NAGODA	38051.86	KOLONAWA	0.0687	2612.64	
NAGLGODA	0.00	KOLONAWA	0.1361	0.00	
NINAMDMA	11955.87	KOLONAWA	0.0757	905.06	
NAKYDNYA	20731.20	KOLONAWA	0.1804	3740.32	
NAKLGMWA	0.00	MATARA	0.1592	0.00	
					SAVE 0.00 BY SUPPLYING NALANDA FROM PERDNIYA
NALANDA	0.00	PERDNIYA	0.1598	0.00	
					SAVE 2861.64 BY SUPPLYING NALLUR FROM PERDNIYA
NALLUR	23419.21	PERDNIYA	0.6121	14334.90	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

					SAVE 0.00 BY SUPPLYING NANATTAN FROM PERDNIYA
NANATTAN	0.00	PERDNIYA	0.4266	0.00	
					SAVE 1721.87 BY SUPPLYING NANUOYA FROM PERDNIYA
NANUOYA	56299.72	PERDNIYA	0.1879	10580.97	
NARAMALA	33338.49	KOLONAWA	0.0933	3110.48	
NATNDIYA	40810.91	KOLONAWA	0.0845	3448.52	
					SAVE 377.26 BY SUPPLYING NAULA FROM PERDNIYA
NAULA	16517.59	PERDNIYA	0.1668	2755.46	
NAUTDUWA	6322.81	KOLONAWA	0.0968	612.17	
NAWALA	0.00	KOLONAWA	0.0229	0.00	
					SAVE 144.90 BY SUPPLYING NAWLPTYA FROM PERDNIYA
NAWLPTYA	131253.98	PERDNIYA	0.1387	18199.68	
NEBODA	19083.41	KOLONAWA	0.0810	1545.37	
					SAVE 0.00 BY SUPPLYING NEDNKENI FROM PERDNIYA
NEDNKENI	0.00	PERDNIYA	0.4174	0.00	
NEGOMBO	254223.57	KOLONAWA	0.0511	12980.66	
					SAVE 6043.86 BY SUPPLYING NELLIADY FROM PERDNIYA
NELLIADY	58925.36	PERDNIYA	0.6172	36368.97	
NELNDNYA	26210.95	KOLONAWA	0.0827	2168.69	
NELUWA	512.66	KOLONAWA	0.2408	123.44	
NIKWRTYA	44230.47	KOLONAWA	0.1527	6753.99	
					SAVE 0.00 BY SUPPLYING NILDHNNA FROM PERDNIYA
NILDHNNA	0.00	PERDNIYA	0.1791	0.00	
					SAVE 7.26 BY SUPPLYING NINTAVUR FROM PERDNIYA
NINTAVUR	5745.31	PERDNIYA	0.4472	2569.23	
					SAVE 0.00 BY SUPPLYING NIRVELI FROM PERDNIYA
NIRVELI	0.00	PERDNIYA	0.6172	0.00	
NITMBUWA	31499.12	KOLONAWA	0.0528	1663.78	
NIVTGALA	20980.83	KOLONAWA	0.1287	2699.73	
NYNDRPLA	3448.81	KOLONAWA	0.0810	279.28	
NOCHYGMA	18668.56	KOLONAWA	0.2448	4570.74	
NORTBRGE	14998.23	KOLONAWA	0.1398	2096.21	
NORWOOD	32626.73	KOLONAWA	0.1582	5162.98	
NUGEGODA	205778.96	KOLONAWA	0.0247	5074.51	
					SAVE 7762.98 BY SUPPLYING NUWELIYA FROM PERDNIYA
NUWELIYA	169793.88	PERDNIYA	0.1809	30715.71	
					SAVE 9.62 BY SUPPLYING OHIYA FROM PERDNIYA
OHIYA	640.84	PERDNIYA	0.2440	156.36	
OLUVIL	0.00	HAPUTALE	0.4606	0.00	
					SAVE 0.00 BY SUPPLYING OMANTHAI FROM PERDNIYA
OMANTHAI	0.00	PERDNIYA	0.3507	0.00	
OPANAIKE	5810.21	KOLONAWA	0.1472	855.01	
					SAVE 350.75 BY SUPPLYING PADAVIYA FROM PERDNIYA
PADAVIYA	8294.34	PERDNIYA	0.3608	2992.37	
					SAVE 0.00 BY SUPPLYING PADIRUPU FROM PERDNIYA
PADIRUPU	0.00	PERDNIYA	0.4197	0.00	
					SAVE 355.76 BY SUPPLYING PADYPELA FROM PERDNIYA
PADYPELA	9635.95	PERDNIYA	0.1527	1471.80	
PADUKKA	55410.87	KOLONAWA	0.0528	2926.80	
PAYGLALN	517.32	KOLONAWA	0.0669	34.61	
PALAKUDA	6552.74	KOLONAWA	0.1915	1254.90	
PALAMUNA	0.00	HAPUTALE	0.4444	0.00	
					SAVE 1615.39 BY SUPPLYING PALLAI FROM PERDNIYA
PALLAI	16280.26	PERDNIYA	0.5509	8968.01	
					SAVE 0.00 BY SUPPLYING PALLEGMA FROM PERDNIYA
PALLEGMA	0.00	PERDNIYA	0.2348	0.00	
					SAVE 77.77 BY SUPPLYING PALLEPLA FROM PERDNIYA
PALLEPLA	4138.57	PERDNIYA	0.1598	661.26	
PALLEWLA	16175.09	KOLONAWA	0.0563	911.30	
					SAVE 642.80 BY SUPPLYING PALLWTTA FROM PERDNIYA
PALLWTTA	10942.38	PERDNIYA	0.2003	2191.32	
PANADURA	159220.03	KOLONAWA	0.0440	7008.87	
PANAGODA	49211.95	KOLONAWA	0.0475	2339.54	
					SAVE 7659.03 BY SUPPLYING PANDTRPU FROM PERDNIYA
PANDTRPU	51391.83	PERDNIYA	0.6351	32637.31	
PANIKNDA	0.00	MATARA	0.2120	0.00	

(271)

PANKULAM	0.00	PERDNIYA	0.3567	0.00	
PANNALA	8586.04	KOLONAWA	0.0863	740.63	
PANNPTYA	60814.01	KOLONAWA	0.0317	1927.80	
					SAVE 49.02 BY SUPPLYING PANWILA FROM PERDNIYA
PANWILA	1253.18	PERDNIYA	0.1228	153.92	
					SAVE 0.00 BY SUPPLYING PANWLTNE FROM PERDNIYA
PANWLTNE	0.00	PERDNIYA	0.1369	0.00	
PARAKDWA	5633.06	KOLONAWA	0.0845	475.99	
					SAVE 1399.58 BY SUPPLYING PARANTAN FROM PERDNIYA
PARANTAN	21389.77	PERDNIYA	0.4769	10201.47	
PASSARA	42512.60	HAPUTALE	0.2523	10725.93	
PASYALA	8277.14	KOLONAWA	0.0563	466.33	
PATANA	0.00	KOLONAWA	0.1656	0.00	
PELAWATA	11725.95	KOLONAWA	0.1056	1238.49	
PELYGODA	498645.52	KOLONAWA	0.0211	10541.37	
PELMDULA	74439.97	KOLONAWA	0.1342	9991.33	
					SAVE 2320.40 BY SUPPLYING PERDNIYA FROM PERDNIYA
PERDNIYA	71160.55	PERDNIYA	0.1035	7362.27	
					SAVE 0.00 BY SUPPLYING PESALAI FROM PERDNIYA
PESALAI	0.00	PERDNIYA	0.4609	0.00	
					SAVE 529.81 BY SUPPLYING PILMTLWA FROM PERDNIYA
PILMTLWA	26575.30	PERDNIYA	0.1087	2889.80	
PILYNDLA	91175.02	KOLONAWA	0.0370	3371.65	
PITBDARA	8212.76	MATARA	0.1768	1451.69	
PITIGALA	6897.62	KOLONAWA	0.1144	789.23	
PITIPANE	11036.19	KOLONAWA	0.0511	563.51	
PODDALA	0.00	KOLONAWA	0.1601	0.00	
					SAVE 6717.82 BY SUPPLYING PT PEDRO FROM PERDNIYA
PT PEDRO	64554.74	PERDNIYA	0.6070	39184.47	
PLGHWELA	49088.05	KOLONAWA	0.0880	4320.73	
PLGSOWTA	0.00	KOLONAWA	0.0423	0.00	
					SAVE 629.07 BY SUPPLYING POLGOLLA FROM PERDNIYA
POLGOLLA	21115.38	PERDNIYA	0.1211	2556.23	
					SAVE 674.24 BY SUPPLYING POLNRUWA FROM PERDNIYA
POLNRUWA	93957.64	PERDNIYA	0.2680	25182.53	
					SAVE 0.00 BY SUPPLYING PONAKERI FROM PERDNIYA
PONAKERI	0.00	PERDNIYA	0.5585	0.00	
POONGALA	10632.19	HAPUTALE	0.2347	2495.37	
					SAVE 0.00 BY SUPPLYING PVRSKLAM FROM PERDNIYA
PVRSKLAM	0.00	PERDNIYA	0.3507	0.00	
POTTUVIL	2327.65	HAPUTALE	0.3658	851.50	
PUGODA	9311.79	KOLONAWA	0.0458	426.29	
					SAVE 647.19 BY SUPPLYING PUJPTIYA FROM PERDNIYA
PUJPTIYA	17323.16	PERDNIYA	0.1246	2158.12	
					SAVE 298.22 BY SUPPLYING PULMODAI FROM PERDNIYA
PULMODAI	5514.37	PERDNIYA	0.4449	2453.34	
					SAVE 1847.08 BY SUPPLYING PILOLI FROM PERDNIYA
PILOLI	16651.20	PERDNIYA	0.6147	10234.69	
					SAVE 957.13 BY SUPPLYING PINDLOYA FROM PERDNIYA
PINDLOYA	30083.23	PERDNIYA	0.1615	4859.64	
					SAVE 178.92 BY SUPPLYING PUNGDTVU FROM PERDNIYA
PUNGDTVU	2164.06	PERDNIYA	0.7261	1571.24	
					SAVE 557.90 BY SUPPLYING PUNNALAI FROM PERDNIYA
PUNNALAI	7055.57	PERDNIYA	0.7173	5061.30	
					SAVE 3782.33 BY SUPPLYING PUNLKDWN FROM PERDNIYA
PUNLKDWN	35388.53	PERDNIYA	0.6274	22203.19	
					SAVE 241.80 BY SUPPLYING PUPURESA FROM PERDNIYA
PUPURESA	9656.66	PERDNIYA	0.1369	1322.00	
					SAVE 760.71 BY SUPPLYING PUSELAWA FROM PERDNIYA
PUSELAWA	30167.76	PERDNIYA	0.1404	4236.16	
PUSSELLA	21842.46	KOLONAWA	0.0898	1961.02	
PUTTALAM	112018.80	KOLONAWA	0.1656	18554.35	
					SAVE 0.00 BY SUPPLYING PUTKDRPU FROM PERDNIYA
PUTKDRPU	0.00	PERDNIYA	0.4884	0.00	

PUWKPTYA	1724.40	KOLONAWA	0.0581	100.19	
					SAVE 1051.65 BY SUPPLYING RAGALA FROM PERDNIYA
RAGALA	17690.23	PERDNIYA	0.1915	3386.97	
RAGAMA	37821.95	KOLONAWA	0.0282	1065.82	
					SAVE 0.00 BY SUPPLYING RAJAGAMA FROM PERDNIYA
RAJAGAMA	0.00	PERDNIYA	0.4724	0.00	
RAJKDLWA	1954.33	KOLONAWA	0.1127	220.17	
RAKWANA	31350.09	KOLONAWA	0.1619	5076.83	
					SAVE 632.96 BY SUPPLYING RAMBODA FROM PERDNIYA
RAMBODA	26198.72	PERDNIYA	0.1563	4093.81	
RAMBDGLA	0.00	KOLONAWA	0.1453	0.00	
RAMBKANA	43455.00	KOLONAWA	0.1091	4742.68	
RMBKPTYA	0.00	KOLONAWA	0.1342	0.00	
RANALA	35867.62	KOLONAWA	0.0335	1200.13	
					SAVE 451.93 BY SUPPLYING RANGALLA FROM PERDNIYA
RANGALLA	13785.00	PERDNIYA	0.1439	1984.21	
RANNA	0.00	MATARA	0.1856	0.00	
RATGAMA	4828.33	KOLONAWA	0.1324	639.14	
RATMLANA	394339.64	KOLONAWA	0.0299	11806.53	
RATMALE	0.00	KOLONAWA	0.2529	0.00	
RATNPURA	189137.04	KOLONAWA	0.1091	20642.42	
					SAVE 51.80 BY SUPPLYING RATTOTA FROM PERDNIYA
RATTOTA	1413.05	PERDNIYA	0.1475	208.37	
RIDIGAMA	16577.09	KOLONAWA	0.1379	2286.25	
RIDYAGMA	0.00	MATARA	0.2190	0.00	
					SAVE 832.08 BY SUPPLYING RIKLGSKD FROM PERDNIYA
RIKLGSKD	22864.46	PERDNIYA	0.1422	3250.87	
ROZELLE	2734.21	KOLONAWA	0.1435	392.25	
RUANWELA	31614.09	KOLONAWA	0.0810	2560.11	
					SAVE 0.00 BY SUPPLYING SINTHMRT FROM PERDNIYA
SINTHMRT	0.00	PERDNIYA	0.4266	0.00	
SAMNTHRA	1753.35	HAPUTALE	0.4383	768.55	
SANDLNKW	65297.46	KOLONAWA	0.0722	4713.17	
SAPGHWTA	4598.41	KOLONAWA	0.0722	331.91	
SEEDUWA	30340.90	KOLONAWA	0.0387	1175.41	
					SAVE 0.00 BY SUPPLYING SEEPKLAM FROM PERDNIYA
SEEPKLAM	0.00	PERDNIYA	0.2699	0.00	
					SAVE 305.98 BY SUPPLYING SILVTURA FROM PERDNIYA
SILVTURA	5312.20	PERDNIYA	0.4312	2290.47	
					SAVE 1628.31 BY SUPPLYING SITNKENI FROM PERDNIYA
SITNKENI	10741.94	PERDNIYA	0.6325	6794.45	
TABBOWA	0.00	KOLONAWA	0.1823	0.00	
					SAVE 0.00 BY SUPPLYING TALMANAR FROM PERDNIYA
TALMANAR	0.00	PERDNIYA	0.4792	0.00	
TALALLA	0.00	MATARA	0.1433	0.00	
TALNGAMA	0.00	KOLONAWA	0.0282	0.00	
					SAVE 785.78 BY SUPPLYING TALTUOYA FROM PERDNIYA
TALTUOYA	22072.38	PERDNIYA	0.1263	2788.62	
TALWKELE	129220.86	KOLONAWA	0.1712	22120.03	
TALWTGDA	18278.69	KOLONAWA	0.0335	611.60	
TALGSWLA	13437.71	KOLONAWA	0.1472	1977.44	
TALPE	0.00	KOLONAWA	0.1582	0.00	
TAMBTGMA	10704.00	KOLONAWA	0.2286	2447.41	
					SAVE 0.00 BY SUPPLYING TMPLKMAM FROM PERDNIYA
TMPLKMAM	0.00	PERDNIYA	0.3142	0.00	
TANMWILA	8277.15	MATARA	0.2751	2277.41	
TANGALLA	19547.35	MATARA	0.1715	3351.98	
TAWALAMA	0.00	KOLONAWA	0.2327	0.00	
					SAVE 0.00 BY SUPPLYING TWLNTENE FROM PERDNIYA
TWLNTENE	0.00	PERDNIYA	0.1457	0.00	
TEBUWANA	9311.78	KOLONAWA	0.0775	721.29	
					SAVE 804.28 BY SUPPLYING TELDNIYA FROM PERDNIYA
TELDNIYA	22480.92	PERDNIYA	0.1299	2919.37	
TELJWILA	0.00	MATARA	0.1416	0.00	
					SAVE 3134.73 BY SUPPLYING TELTPALT FROM PERDNIYA

					SAVE 906.54 BY SUPPLYING TENEKBRA FROM PERDNIYA
TENEKBRA	25978.34	PERDNIYA	0.1123	2916.33	
TALAGAHA	0.00	KOLONAWA	0.1582	0.00	
TIHAGODA	3151.32	MATARA	0.1416	446.10	
					SAVE 2144.92 BY SUPPLYING TNDMANAR FROM PERDNIYA
TNDMANAR	20068.46	PERDNIYA	0.6274	12591.19	
					SAVE 0.00 BY SUPPLYING TUNNUKAI FROM PERDNIYA
TUNNUKAI	0.00	PERDNIYA	0.4632	0.00	
					SAVE 177.22 BY SUPPLYING TRKTSWRN FROM PERDNIYA
TRKTSWRN	2846.23	PERDNIYA	0.4495	1279.31	
TRWNKTYA	41845.55	KOLONAWA	0.1144	4787.97	
TISMRAMA	11436.67	MATARA	0.2511	2871.98	
					SAVE 4511.13 BY SUPPLYING TRNCMALE FROM PERDNIYA
TRNCMALE	139853.93	PERDNIYA	0.3365	47058.61	
TUMODARA	0.00	KOLONAWA	0.0616	0.00	
					SAVE 0.00 BY SUPPLYING UDHNTENE FROM PERDNIYA
UDHNTENE	0.00	PERDNIYA	0.1351	0.00	
UDAKRWTA	5126.66	KOLONAWA	0.1361	697.57	
					SAVE 1756.31 BY SUPPLYING UDPSLAWA FROM PERDNIYA
UDPSLAWA	39793.24	PERDNIYA	0.2311	9194.63	
UDAWALWE	0.00	KOLONAWA	0.2367	0.00	
					SAVE 279.10 BY SUPPLYING UDISPATU FROM PERDNIYA
UDISPATU	8121.03	PERDNIYA	0.1387	1126.06	
UDABDAWA	62423.45	KOLONAWA	0.1039	6483.30	
UDUGAMA	15321.94	KOLONAWA	0.1915	2934.27	
UDGMPOLA	23451.90	KOLONAWA	0.0458	1073.63	
UHANA	1419.25	HAPUTALE	0.4383	622.10	
					SAVE 58.75 BY SUPPLYING UKUWELA FROM PERDNIYA
UKUWELA	2050.66	PERDNIYA	0.1351	277.13	
					SAVE 185.06 BY SUPPLYING ULAPANE FROM PERDNIYA
ULAPANE	8133.90	PERDNIYA	0.1281	1041.95	
UNDUGODA	574.80	KOLONAWA	0.0986	56.66	
UPCOT	57571.87	KOLONAWA	0.1564	9004.01	
URALA	8270.62	KOLONAWA	0.1730	1431.05	
URAPOLA	10921.23	KOLONAWA	0.0599	653.74	
URUBOKKA	8451.93	MATARA	0.1979	1672.47	
					SAVE 0.00 BY SUPPLYING URUGALA FROM PERDNIYA
URUGALA	0.00	PERDNIYA	0.1422	0.00	
URGSMNHD	11725.95	KOLONAWA	0.0986	1155.94	
					SAVE 427.34 BY SUPPLYING URUMPRAI FROM PERDNIYA
URUMPRAI	4138.57	PERDNIYA	0.6325	2617.71	
					SAVE 530.11 BY SUPPLYING UYLNKLAM FROM PERDNIYA
UYLNKLAM	9010.56	PERDNIYA	0.4197	3782.02	
					SAVE 0.00 BY SUPPLYING VADUKODA FROM PERDNIYA
VADUKODA	0.00	PERDNIYA	0.7173	0.00	
					SAVE 977.54 BY SUPPLYING VALCHENA FROM PERDNIYA
VALCHENA	23708.36	PERDNIYA	0.3527	8361.37	
					SAVE 4202.28 BY SUPPLYING VAVETURI FROM PERDNIYA
VAVETURI	39710.07	PERDNIYA	0.6198	24610.55	
					SAVE 313.67 BY SUPPLYING VASAVLAN FROM PERDNIYA
VASAVLAN	2069.28	PERDNIYA	0.6325	1308.85	
					SAVE 0.00 BY SUPPLYING VAVNKLAM FROM PERDNIYA
VAVNKLAM	0.00	PERDNIYA	0.4541	0.00	
					SAVE 2080.89 BY SUPPLYING VAVUNIYA FROM PERDNIYA
VAVUNIYA	46045.47	PERDNIYA	0.3304	15213.98	
					SAVE 305.46 BY SUPPLYING VELANAI FROM PERDNIYA
VELANAI	3710.32	PERDNIYA	0.7203	2672.37	
VEYNGODA	110706.78	KOLONAWA	0.0563	6237.22	
WADAKADA	5106.45	KOLONAWA	0.0986	503.39	
WADDUWA	49777.81	KOLONAWA	0.0511	2541.65	
WAGA	1149.60	KOLONAWA	0.0475	54.65	
WAHARAKA	1264.56	KOLONAWA	0.0722	91.28	
WAIKKAL	18508.61	KOLONAWA	0.0616	1140.50	
WALSGALA	15065.11	MATARA	0.1644	2477.31	
WALSMULA	28281.78	MATARA	0.1838	5198.19	

WANDRBMA	0.00	KOLONAWA	0.1545	0.00	
WARKGODA	5288.17	KOLONAWA	0.0845	446.85	
WARKPOLA	37592.02	KOLONAWA	0.0722	2713.39	
WARALLA	3691.19	MATARA	0.1908	704.43	
WARYPOLA	16773.56	KOLONAWA	0.1287	2158.35	
WASKDUWA	0.00	KOLONAWA	0.0528	0.00	
					SAVE 2.05 BY SUPPLYING WATAGODA FROM PERDNIYA
WATAGODA	1600.82	PERDNIYA	0.1791	286.77	
WATAWALA	721.35	KOLONAWA	0.1342	96.82	
WATTALA	63228.17	KOLONAWA	0.0211	1336.64	
					SAVE 998.10 BY SUPPLYING WATTGAMA FROM PERDNIYA
WATTGAMA	25456.59	PERDNIYA	0.1246	3171.38	
WATUGDRA	5518.09	KOLONAWA	0.1144	631.38	
					SAVE 0.00 BY SUPPLYING WATUMULA FROM PERDNIYA
WATUMULA	0.00	PERDNIYA	0.1739	0.00	
WATRGAMA	11725.95	KOLONAWA	0.0440	516.18	
WERAGODA	0.00	HAPUTALE	0.3510	0.00	
WERAKTYA	15285.95	MATARA	0.1873	2863.36	
WELIGAMA	84040.37	MATARA	0.1504	12636.31	
WELIKADA	86220.23	KOLONAWA	0.0211	1822.70	
					SAVE 0.00 BY SUPPLYING WELIKNDA FROM PERDNIYA
WELIKNDA	0.00	PERDNIYA	0.3223	0.00	
					SAVE 2226.02 BY SUPPLYING WELIMADA FROM PERDNIYA
WELIMADA	100634.02	PERDNIYA	0.2073	20861.43	
WELIPENE	0.00	KOLONAWA	0.0933	0.00	
WELIWRYA	35177.85	KOLONAWA	0.0387	1362.79	
WELLMPTY	117792.35	KOLONAWA	0.0176	2075.50	
WELAWAYA	11268.27	HAPUTALE	0.2453	2763.66	
WENAPUWA	34488.10	KOLONAWA	0.0704	2428.65	
WERAHERA	5357.15	KOLONAWA	0.0352	188.68	
					SAVE 1009.46 BY SUPPLYING WERLGAMA FROM PERDNIYA
WERLGAMA	28927.74	PERDNIYA	0.1123	3247.43	
WEWLDNYA	48973.09	KOLONAWA	0.0704	3448.68	
WIRAWILA	0.00	MATARA	0.2511	0.00	
YAKKALA	5403.13	KOLONAWA	0.0440	237.85	
YAKKLMLA	0.00	KOLONAWA	0.1693	0.00	
					SAVE 0.00 BY SUPPLYING YATAWATA FROM PERDNIYA
YATAWATA	0.00	PERDNIYA	0.1563	0.00	
YATIYANA	18045.00	MATARA	0.1486	2681.49	
YATNTOTA	33798.33	KOLONAWA	0.0845	2855.96	
YODKNDYA	0.00	MATARA	0.2548	0.00	

INITIAL THROUGHPUT AT PERDNIYA IS 4497880.41

FIXED COST OF PERDNIYA IS 15200.00

INITIAL VARIABLE COST OF PERDNIYA IS 1331642.09

INITIAL GROSS SAVING BY INCLUSION OF PERDNIYA IN THE BASIS IS 240065.13

CONTRIBUTION TO NETT SAVING BY INCLUSION OF PERDNIYA IS 224865.13

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
KOLONAWA	15053456.18	411000.00	985997.67
MATARA	946254.55	7200.00	151656.79
HAPUTALE	685178.82	6500.00	188649.35
PERDNIYA	4497880.41	15200.00	1331642.09

FIXED COST OF KOLONAWA AND 3 DEPOT/S IS 439900.00

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 3177980.27

INITIAL NETT SAVING BY INCLUSION OF PERDNIYA IN THE BASIS IS 224865

IMPROVEMENT OVER COST OF PRESENT SYSTEM = -456510.01

PERCENTAGE IMPROVEMENT = -16.77

BATICALO DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT BATICALO IS 385059.02

FIXED COST OF BATICALO IS 7000.00
INITIAL VARIABLE COST OF BATICALO IS 106827.05

INITIAL GROSS SAVING BY INCLUSION OF BATICALO IN THE BASIS IS 4390
CONTRIBUTION TO NETT SAVING BY INCLUSION OF BATICALO IS 36999.15

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
KOLONAWA	15053456.18	411000.00	985997.67
MATARA	946254.55	7200.00	151656.79
HAPUTALE	524653.92	6500.00	119881.46
PERDNIYA	4273346.29	15200.00	1249583.77
BATICALO	385059.02	7000.00	106827.05

FIXED COST OF KOLONAWA AND 4 DEPOT/S IS 446900.00
VARIABLE COST OF KOLONAWA AND 4 DEPOT/S IS 2613946.74

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 3140981.12

INITIAL NETT SAVING BY INCLUSION OF BATICALO IN THE BASIS IS 36999

IMPROVEMENT OVER COST OF PRESENT SYSTEM = -419510.86

PERCENTAGE IMPROVEMENT = -15.41

MPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT KURNGALA IS 2791521.51

FIXED COST OF KURNGALA IS 9850.00
INITIAL VARIABLE COST OF KURNGALA IS 951893.90

INITIAL GROSS SAVING BY INCLUSION OF KURNGALA IN THE BASIS IS 117662
CONTRIBUTION TO NETT SAVING BY INCLUSION OF KURNGALA IS 107812.15

EPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
OLONAWA	14148061.69	411000.00	836937.03
ATARA	946254.55	7200.00	151656.79
APUTALE	524653.92	6500.00	119881.46
ERDNIYA	2387219.27	15200.00	329088.36
ATICALO	385059.02	7000.00	106827.05
URNGALA	2791521.51	9850.00	951893.90

IXED COST OF KOLONAWA AND 5 DEPOT/S IS 456750.00
ARIABLE COST OF KOLONAWA AND 5 DEPOT/S IS 2496284.59

OTAL COST OF ALL COLLECTIONS = 80134.38

EDUCED OVERALL COST = 3033168.97

INITIAL NETT SAVING BY INCLUSION OF KURNGALA IN THE BASIS IS 107812.

MPROVEMENT OVER COST OF PRESENT SYSTEM = -311698.71

PERCENTAGE IMPROVEMENT = -11.45

NURPURA DEPOT WILL ENTER THE BASIS

MPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT ANURPURA IS 1774556.52

FIXED COST OF ANURPURA IS 6000.00
INITIAL VARIABLE COST OF ANURPURA IS 576921.25

INITIAL GROSS SAVING BY INCLUSION OF ANURPURA IN THE BASIS IS 230106
CONTRIBUTION TO NETT SAVING BY INCLUSION OF ANURPURA IS 224196.52

EPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
KOLONAWA	14148061.69	411000.00	836937.03
MATARA	946254.55	7200.00	151656.79
HAPUTALE	524653.92	6500.00	119881.46
PERDNIYA	2387219.27	15200.00	329088.36
BATICALO	385059.02	7000.00	106827.05
KURNGALA	1016964.99	9850.00	144776.13
ANURPURA	1774556.52	6000.00	576921.25

FIXED COST OF KOLONAWA AND 6 DEPOT/S IS 462750.00
VARIABLE COST OF KOLONAWA AND 6 DEPOT/S IS 2266088.07

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2808972.45

INITIAL NETT SAVING BY INCLUSION OF ANURPURA IN THE BASIS IS 22419

IMPROVEMENT OVER COST OF PRESENT SYSTEM = -87502.18

PERCENTAGE IMPROVEMENT = -3.22

JAFFNA DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT JAFFNA IS 1081888.76

FIXED COST OF JAFFNA IS 9350.00
INITIAL VARIABLE COST OF JAFFNA IS 299824.18

INITIAL GROSS SAVING BY INCLUSION OF JAFFNA IN THE BASIS IS 1257
CONTRIBUTION TO NETT SAVING BY INCLUSION OF JAFFNA IS 116391.04

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
KOLONAWA	14148061.69	411000.00	836937.03
MATARA	946254.55	7200.00	151656.79
HAPUTALE	524653.92	6500.00	119881.46
PERDNIYA	2387219.27	15200.00	329088.36
BATICALO	385059.02	7000.00	106827.05
KURNGALA	1016964.99	9850.00	144776.13
ANURPURA	692667.76	6000.00	151356.04
JAFFNA	1081888.76	9350.00	299824.18

FIXED COST OF KOLONAWA AND 7 DEPOT/S IS 472100.00

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2692581.41

INITIAL NETT SAVING BY INCLUSION OF JAFFNA IN THE BASIS IS 11639

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 28888.86

PERCENTAGE IMPROVEMENT = 1.06

RATNPURA DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT RATNPURA IS 776732.82

FIXED COST OF RATNPURA IS 3000.00
INITIAL VARIABLE COST OF RATNPURA IS 109497.06

INITIAL GROSS SAVING BY INCLUSION OF RATNPURA IN THE BASIS IS 74
CONTRIBUTION TO NETT SAVING BY INCLUSION OF RATNPURA IS 4479.63

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
KOLONAWA	13517805.46	411000.00	750484.09
MATARA	946254.55	7200.00	151656.79
HAPUTALE	378177.33	6500.00	89357.71
PERDNIYA	2387219.27	15200.00	329088.36
BATICALO	385059.02	7000.00	106827.05
KURNGALA	1016964.99	9850.00	144776.13
ANURPURA	692667.76	6000.00	151356.04
JAFFNA	1081888.76	9350.00	299824.18
RATNPURA	776732.82	3000.00	109497.06

FIXED COST OF KOLONAWA AND 8 DEPOT/S IS 475100.00
VARIABLE COST OF KOLONAWA AND 8 DEPOT/S IS 2132867.40

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2688101.78

INITIAL NETT SAVING BY INCLUSION OF RATNPURA IN THE BASIS IS 447

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 33368.48

PERCENTAGE IMPROVEMENT = 1.23

ALLE DEPOT WILL ENTER THE BASIS

MPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT GALLE IS 1076991.91

FIXED COST OF GALLE IS 8850.00
INITIAL VARIABLE COST OF GALLE IS 126549.21

INITIAL GROSS SAVING BY INCLUSION OF GALLE IN THE BASIS IS 39561
CONTRIBUTION TO NETT SAVING BY INCLUSION OF GALLE IS 30711.75

EPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
OLONAWA	12746074.99	411000.00	634979.36
ATARA	640993.11	7200.00	101050.57
APUTALE	378177.33	6500.00	89357.71
ERDNIYA	2387219.27	15200.00	329088.36
ATICALO	385059.02	7000.00	106827.05
URNGALA	1016964.99	9850.00	144776.13
NURPURA	692667.76	6000.00	151356.04
AFFNA	1081888.76	9350.00	299824.18
ATNPURA	776732.82	3000.00	109497.06
ALLE	1076991.91	8850.00	126549.21

IXED COST OF KOLONAWA AND 9 DEPOT/S IS 483950.00
ARIABLE COST OF KOLONAWA AND 9 DEPOT/S IS 2093305.65

OTAL COST OF ALL COLLECTIONS = 80134.38

EDUCED OVERALL COST = 2657390.03

INITIAL NETT SAVING BY INCLUSION OF GALLE IN THE BASIS IS 30711.

MPROVEMENT OVER COST OF PRESENT SYSTEM = 64080.23

PERCENTAGE IMPROVEMENT = 2.35

HINABAY DEPOT WILL ENTER THE BASIS

MPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT CHINABAY IS 365903.61

FIXED COST OF CHINABAY IS 11500.00

INITIAL GROSS SAVING BY INCLUSION OF CHINABAY IN THE BASIS IS 390
CONTRIBUTION TO NETT SAVING BY INCLUSION OF CHINABAY IS 27566.48

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
KOLONAWA	12746074.99	411000.00	634979.36
MATARA	640993.11	7200.00	101050.57
HAPUTALE	378177.33	6500.00	89357.71
PERDNIYA	2387219.27	15200.00	329088.36
BATICALO	385059.02	7000.00	106827.05
KURNGALA	892510.70	9850.00	116127.25
ANURPURA	451218.44	6000.00	90007.57
JAFFNA	1081888.76	9350.00	299824.18
RATNPURA	776732.82	3000.00	109497.06
GALLE	1076991.91	8850.00	126549.21
CHINABAY	365903.61	11500.00	50930.86

FIXED COST OF KOLONAWA AND 10 DEPOT/S IS 495450.00
VARIABLE COST OF KOLONAWA AND 10 DEPOT/S IS 2054239.17

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2629823.55

INITIAL NETT SAVING BY INCLUSION OF CHINABAY IN THE BASIS IS 2756

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 91646.71

PERCENTAGE IMPROVEMENT = 3.37

AMBLGODA DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT AMBLGODA IS 341810.64

CALCULATED INITIAL FIXED COST OF AMBLGODA IS 7341.81
INITIAL VARIABLE COST OF AMBLGODA IS 32125.27

INITIAL GROSS SAVING BY INCLUSION OF AMBLGODA IN THE BASIS IS 76
CONTRIBUTION TO NETT SAVING BY INCLUSION OF AMBLGODA IS 299.62

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST

ATARA	640993.11	7200.00	101050.57
APUTALE	378177.33	6500.00	89357.71
ERDNIYA	2387219.27	15200.00	329088.36
ATICALO	385059.02	7000.00	106827.05
URNGALA	892510.70	9850.00	116127.25
NURPURA	451218.44	6000.00	90007.57
AFFNA	1081888.76	9350.00	299824.18
ATNPURA	776732.82	3000.00	109497.06
ALLE	969285.31	8850.00	113858.85
HINABAY	365903.61	11500.00	50930.86
MBLGODA	341810.64	7341.81	32125.27

IXED COST OF KOLONAWA AND 11 DEPOT/S IS 502791.81
ARIABLE COST OF KOLONAWA AND 11 DEPOT/S IS 2046597.73

OTAL COST OF ALL COLLECTIONS = 80134.38

EDUCED OVERALL COST = 2629523.93

INITIAL NETT SAVING BY INCLUSION OF AMBLGODA IN THE BASIS IS 290.

MPROVEMENT OVER COST OF PRESENT SYSTEM = 91946.34

PERCENTAGE IMPROVEMENT = 3.38

ADAMPE DEPOT WILL ENTER THE BASIS

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MPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT MADAMPE IS 538937.87

CALCULATED INITIAL FIXED COST OF MADAMPE IS 7538.94
INITIAL VARIABLE COST OF MADAMPE IS 53503.20

INITIAL GROSS SAVING BY INCLUSION OF MADAMPE IN THE BASIS IS 1143
CONTRIBUTION TO NETT SAVING BY INCLUSION OF MADAMPE IS 3894.72

EPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
OLONAWA	11985330.06	411000.00	545286.80
ATARA	640993.11	7200.00	101050.57
APUTALE	373927.57	6500.00	88098.50
ERDNIYA	2387219.27	15200.00	329088.36
ATICALO	385059.02	7000.00	106827.05
URNGALA	884463.48	9850.00	115065.82
NURPURA	451218.44	6000.00	90007.57
AFFNA	1081888.76	9350.00	299824.18
ATNPURA	776732.82	3000.00	109497.06
ALLE	969285.31	8850.00	113858.85
HINABAY	365903.61	11500.00	50930.86

ADAMPE	538937.87	7538.94	53503.20	(282)

IXED COST OF KOLONAWA AND 12 DEPOT/S IS 510330.75
ARIABLE COST OF KOLONAWA AND 12 DEPOT/S IS 2035164.08

OTAL COST OF ALL COLLECTIONS = 80134.38

EDUCED OVERALL COST = 2625629.21

INITIAL NETT SAVING BY INCLUSION OF MADAMPE IN THE BASIS IS 3894

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 95841.05

PERCENTAGE IMPROVEMENT = 3.52

ANKULAM DEPOT WILL ENTER THE BASIS

MPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT MANKULAM IS 233958.10

CALCULATED INITIAL FIXED COST OF MANKULAM IS 7233.96
INITIAL VARIABLE COST OF MANKULAM IS 59051.07

INITIAL GROSS SAVING BY INCLUSION OF MANKULAM IN THE BASIS IS 955
CONTRIBUTION TO NETT SAVING BY INCLUSION OF MANKULAM IS 2317.39

EPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
OLONAWA	11985330.06	411000.00	545286.80
ATARA	640993.11	7200.00	101050.57
APUTALE	373927.57	6500.00	88098.50
ERDNIYA	2387219.27	15200.00	329088.36
ATICALO	385059.02	7000.00	106827.05
URNGALA	884463.48	9850.00	115065.82
NURPURA	394215.03	6000.00	72167.44
AFFNA	937790.18	9350.00	257529.30
ATNPURA	776732.82	3000.00	109497.06
ALLE	969285.31	8850.00	113858.85
HINABAY	333047.50	11500.00	42463.45
MBLGODA	341810.64	7341.81	32125.27
ADAMPE	538937.87	7538.94	53503.20
ANKULAM	233958.10	7233.96	59051.07

IXED COST OF KOLONAWA AND 13 DEPOT/S IS 517564.71
ARIABLE COST OF KOLONAWA AND 13 DEPOT/S IS 2025612.73

OTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2623311.82

INITIAL NETT SAVING BY INCLUSION OF MANKULAM IN THE BASIS IS 2317

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 98158.44

PERCENTAGE IMPROVEMENT = 3.61

CHVKCHRI DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT CHVKCHRI IS 535437.35

CALCULATED INITIAL FIXED COST OF CHVKCHRI IS 7535.44
INITIAL VARIABLE COST OF CHVKCHRI IS 144881.19

INITIAL GROSS SAVING BY INCLUSION OF CHVKCHRI IN THE BASIS IS 812
CONTRIBUTION TO NETT SAVING BY INCLUSION OF CHVKCHRI IS 586.07

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
KOLONAWA	11985330.06	411000.00	545286.80
MATARA	640993.11	7200.00	101050.57
HAPUTALE	373927.57	6500.00	88098.50
PERDNIYA	2387219.27	15200.00	329088.36
BATICALO	385059.02	7000.00	106827.05
KURNGALA	884463.48	9850.00	115065.82
ANURPURA	394215.03	6000.00	72167.44
JAFFNA	485626.90	9350.00	129063.56
RATNPURA	776732.82	3000.00	109497.06
GALLE	969285.31	8850.00	113858.85
CHINABAY	333047.50	11500.00	42463.45
AMBLGODA	341810.64	7341.81	32125.27
MADAMPE	538937.87	7538.94	53503.20
MANKULAM	150684.03	7150.68	34514.11
CHVKCHRI	535437.35	7535.44	144881.19

FIXED COST OF KOLONAWA AND 14 DEPOT/S IS 525016.87
VARIABLE COST OF KOLONAWA AND 14 DEPOT/S IS 2017491.23

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2622642.48

INITIAL NETT SAVING BY INCLUSION OF CHVKCHRI IN THE BASIS IS 669

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 98827.78

PERCENTAGE IMPROVEMENT = 3.63

IPUTALE DEPOT WILL DROP OUT OF THE BASIS. ALL DESTINATIONS ASSIGNED
IT WILL REVERT TO KOLONAWA FOR RE-ALLOCATION

ITNPURA DEPOT WILL DROP OUT OF THE BASIS. ALL DESTINATIONS ASSIGNED
IT WILL REVERT TO KOLONAWA FOR RE-ALLOCATION

KAHAWATA DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT KAHAWATA IS 997790.43

CALCULATED INITIAL FIXED COST OF KAHAWATA IS 7997.79
INITIAL VARIABLE COST OF KAHAWATA IS 180721.04

INITIAL GROSS SAVING BY INCLUSION OF KAHAWATA IN THE BASIS IS 1205
CONTRIBUTION TO NETT SAVING BY INCLUSION OF KAHAWATA IS 4055.06

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
KOLONAWA	12260965.76	411000.00	578072.50
MATARA	576407.87	7200.00	86268.76
PERDNIYA	2387219.27	15200.00	329088.36
BATICALO	385059.02	7000.00	106827.05
KURNGALA	884463.48	9850.00	115065.82
ANURPURA	394215.03	6000.00	72167.44
JAFFNA	485626.90	9350.00	129063.56
GALLE	911104.81	8850.00	102832.48
CHINABAY	333047.50	11500.00	42463.45
AMBLGODA	341810.64	7341.81	32125.27
MADAMPE	538937.87	7538.94	53503.20
MANKULAM	150684.03	7150.68	34514.11
CHVKCHRI	535437.35	7535.44	144881.19
KAHAWATA	997790.43	7997.79	180721.04

HAPUTALE DEPOT HAS DROPPED OUT OF THE BASIS

RATNPURA DEPOT HAS DROPPED OUT OF THE BASIS

FIXED COST OF KOLONAWA AND 13 DEPOT/S IS 523514.66
VARIABLE COST OF KOLONAWA AND 13 DEPOT/S IS 2007594.24

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2611243.28

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 110226.98

PERCENTAGE IMPROVEMENT = 4.05

KAHAWATA DEPOT WILL DROP OUT OF THE BASIS. ALL DESTINATIONS ASSIGNED
IT WILL REVERT TO KOLONAWA FOR RE-ALLOCATION

OPANAIKE DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT OPANAIKE IS 718619.55

CALCULATED INITIAL FIXED COST OF OPANAIKE IS 7718.62
INITIAL VARIABLE COST OF OPANAIKE IS 140259.15

INITIAL GROSS SAVING BY INCLUSION OF OPANAIKE IN THE BASIS IS 1088
CONTRIBUTION TO NETT SAVING BY INCLUSION OF OPANAIKE IS 3165.35

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
KOLONAWA	12648029.75	411000.00	648169.63
MATARA	576407.87	7200.00	86268.76
PERDNIYA	2281653.81	15200.00	307110.90
BATICALO	382731.37	7000.00	105984.40
KURNGALA	884463.48	9850.00	115065.82
ANURPURA	394215.03	6000.00	72167.44
JAFFNA	485626.90	9350.00	129063.56
GALLE	911104.81	8850.00	102832.48
CHINABAY	333047.50	11500.00	42463.45
AMBLGODA	341810.64	7341.81	32125.27
MADAMPE	538937.87	7538.94	53503.20
VANKULAM	150684.03	7150.68	34514.11
CHVKCHRI	535437.35	7535.44	144881.19
OPANAIKE	718619.55	7718.62	140259.15

KAHAWATA DEPOT HAS DROPPED OUT OF THE BASIS

FIXED COST OF KOLONAWA AND 13 DEPOT/S IS 523235.49
VARIABLE COST OF KOLONAWA AND 13 DEPOT/S IS 2014409.38

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2617779.25

INITIAL NETT SAVING BY INCLUSION OF OPANAIKE IN THE BASIS IS -6535

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 107424.01

PERCENTAGE IMPROVEMENT = 3.81

IR = 136

MATARA DEPOT WILL REMAIN IN THE BASIS

IMPROVED SUPPLY PATTERN

ADDITIONAL THROUGHPUT AT MATARA IS 114488.59

FIXED COST OF MATARA IS 7200.00
ADDITIONAL VARIABLE COST OF MATARA IS 24324.35

ADDITIONAL GROSS SAVING BY RETENTION OF MATARA IN THE BASIS IS 551
CONTRIBUTION TO NETT SAVING BY RETENTION OF MATARA IS 46449.50

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
KOLONAWA	12533541.16	411000.00	618332.04
MATARA	690896.46	7200.00	110593.11
PERDNIYA	2281653.81	15200.00	307110.90
BATICALO	382731.37	7000.00	105984.40
KURNGALA	884463.48	9850.00	115065.82
ANURPURA	394215.03	6000.00	72167.44
JAFFNA	485626.90	9350.00	129063.56
GALLE	911104.81	8850.00	102832.48
CHINABAY	333047.50	11500.00	42463.45
AMBLGODA	341810.64	7341.81	32125.27
MADAMPE	538937.87	7538.94	53503.20
MANKULAM	150684.03	7150.68	34514.11
CHVKCHRI	535437.35	7535.44	144881.19
OPANAIKE	718619.55	7718.62	140259.15

FIXED COST OF KOLONAWA AND 13 DEPOT/S IS 523235.49
VARIABLE COST OF KOLONAWA AND 13 DEPOT/S IS 2008896.13

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2612266.00

ADDITIONAL NETT SAVING BY RETENTION OF MATARA IN THE BASIS IS 551

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 109204.26

PERCENTAGE IMPROVEMENT = 4.01

RATNPURA DEPOT WILL ENTER THE BASIS

IMPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT RATNPURA IS 548211.10

FIXED COST OF RATNPURA IS 3000.00
INITIAL VARIABLE COST OF RATNPURA IS 67137.16

INITIAL GROSS SAVING BY INCLUSION OF RATNPURA IN THE BASIS IS 590
CONTRIBUTION TO NETT SAVING BY INCLUSION OF RATNPURA IS 2908.08

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
KOLONAWA	11985330.06	411000.00	545286.80
MATARA	690896.46	7200.00	110593.11
PERDNIYA	2281653.81	15200.00	307110.90
BATICALO	382731.37	7000.00	105984.40
KURNGALA	884463.48	9850.00	115065.82
ANURPURA	394215.03	6000.00	72167.44
JAFFNA	485626.90	9350.00	129063.56
RATNPURA	548211.10	3000.00	67137.16
GALLE	911104.81	8850.00	102832.48
CHINABAY	333047.50	11500.00	42463.45
AMBLGODA	341810.64	7341.81	32125.27
MADAMPE	538937.87	7538.94	53503.20
MANKULAM	150684.03	7150.68	34514.11
CHVKCHRI	535437.35	7535.44	144881.19
DPANAYKE	718619.55	7718.62	140259.15

FIXED COST OF KOLONAWA AND 14 DEPOT/S IS 526235.49
VARIABLE COST OF KOLONAWA AND 14 DEPOT/S IS 2002988.04

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2609357.91

INITIAL NETT SAVING BY INCLUSION OF RATNPURA IN THE BASIS IS 2908.

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 112112.35

PERCENTAGE IMPROVEMENT = 4.12

GALLE DEPOT WILL REMAIN IN THE BASIS

IMPROVED SUPPLY PATTERN

ADDITIONAL THROUGHPUT AT GALLE IS 58180.50

FIXED COST OF GALLE IS 8850.00
ADDITIONAL VARIABLE COST OF GALLE IS 11026.37

ADDITIONAL GROSS SAVING BY RETENTION OF GALLE IN THE BASIS IS 79.
CONTRIBUTION TO NETT SAVING BY RETENTION OF GALLE IS 28176.64

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
KOLONAWA	11985330.06	411000.00	545286.80
MATARA	632715.96	7200.00	98773.16
PERDNIYA	2281653.81	15200.00	307110.90
BATICALO	382731.37	7000.00	105984.40
KURNGALA	884463.48	9850.00	115065.82
ANURPURA	394215.03	6000.00	72167.44
JAFFNA	485626.90	9350.00	129063.56
RATNPURA	548211.10	3000.00	67137.16
GALLE	969285.31	8850.00	113858.85
CHINABAY	333047.50	11500.00	42463.45
AMBLGODA	341810.64	7341.81	32125.27
MADAMPE	538937.87	7538.94	53503.20
MANKULAM	150684.03	7150.68	34514.11
CHVKCHRI	535437.35	7535.44	144881.19
OPANAIKE	718619.55	7718.62	140259.15

FIXED COST OF KOLONAWA AND 14 DEPOT/S IS 526235.49
VARIABLE COST OF KOLONAWA AND 14 DEPOT/S IS 2002194.46

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2608564.33

ADDITIONAL NETT SAVING BY RETENTION OF GALLE IN THE BASIS IS 79.

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 112905.93

PERCENTAGE IMPROVEMENT = 4.15

RATNPURA DEPOT WILL DROP OUT OF THE BASIS. ALL DESTINATIONS ASSIGNED
IT WILL REVERT TO KOLONAWA FOR RE-ALLOCATION

OPANAIKE DEPOT WILL REMAIN IN THE BASIS

IMPROVED SUPPLY PATTERN

ADDITIONAL THROUGHPUT AT OPANAIKE IS 277602.38

CALCULATED ADDITIONAL FIXED COST OF OPANAIKE IS 277.60
ADDITIONAL VARIABLE COST OF OPANAIKE IS 37335.93

CONTRIBUTION TO NETT SAVING BY RETENTION OF OPANAIKE IS 3592.86

DEPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
KOLONAWA	12255938.78	411000.00	576103.83
MATARA	632715.96	7200.00	98773.16
PERDNIYA	2281653.81	15200.00	307110.90
BATICALO	382731.37	7000.00	105984.40
KURNGALA	884463.48	9850.00	115065.82
ANURPURA	394215.03	6000.00	72167.44
JAFFNA	485626.90	9350.00	129063.56
GALLE	969285.31	8850.00	113858.85
CHINABAY	333047.50	11500.00	42463.45
AMBLGODA	341810.64	7341.81	32125.27
MADAMPE	538937.87	7538.94	53503.20
MANKULAM	150684.03	7150.68	34514.11
CHVKCHRI	535437.35	7535.44	144881.19
OPANAIKE	996221.93	7996.22	177595.09

RATNPURA DEPOT HAS DROPPED OUT OF THE BASIS

FIXED COST OF KOLONAWA AND 13 DEPOT/S IS 523513.09
VARIABLE COST OF KOLONAWA AND 13 DEPOT/S IS 2003210.27

TOTAL COST OF ALL COLLECTIONS = 80134.38

REDUCED OVERALL COST = 2606857.75

ADDITIONAL NETT SAVING BY RETENTION OF OPANAIKE IN THE BASIS IS 1706.

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 114612.51

PERCENTAGE IMPROVEMENT = 4.21

R = 17

END OF ITERATIONS

OPTIMAL DISTRIBUTION PATTERN

TINATION THROUGHPUT SOURCE COST PER GALLON TRANSPORT COST

SUM OF VARIABLE COSTS TO ALL DESTINATIONS IS 2003210.27

ALLOCATION OF DESTINATIONS TO SOURCES

OURCE	DESTINATION	THROUGHPUT	COST PER GALLON	TRANSPORT COST
.ONAWA	AGALWATA	31499.12	0.0933	2938.87
.ONAWA	ALAWWA	26325.91	0.0792	2085.54
.ONAWA	ALUTGAMA	76103.72	0.0810	6162.88
.ONAWA	AMBEPUSA	0.00	0.0739	0.00
.ONAWA	ANAMDUWA	0.00	0.0739	0.00
.ONAWA	ANDIAMBM	0.00	0.0528	0.00
.ONAWA	ANGODA	4138.57	0.0211	87.49
.ONAWA	ANGRWELA	0.00	0.0845	0.00
.ONAWA	ANHTGAMA	360.68	0.0757	27.30
.ONAWA	ARAKWILA	9426.74	0.0581	547.69
.ONAWA	ARANAYKA	459.84	0.1361	62.57
.ONAWA	ATTNGALA	11381.07	0.0599	681.27
.ONAWA	ATTIDIYA	0.00	0.0317	0.00
.ONAWA	ATBLSHLA	15979.48	0.0880	1406.51
.ONAWA	ATURGRYA	151057.85	0.0317	4788.53
.ONAWA	AVISWELA	179015.19	0.0616	11030.92
.ONAWA	BADRELYA	15864.52	0.1074	1703.53
.ONAWA	BANDRGMA	67021.86	0.0563	3776.01
.ONAWA	BEMMULLA	6667.69	0.0493	328.72
.ONAWA	BENDYMLA	21152.69	0.0423	893.91
.ONAWA	BENTOTA	0.00	0.0810	0.00
.ONAWA	BERUWALA	54836.07	0.0739	4054.58
.ONAWA	BIYAGAMA	17933.81	0.0282	505.37
.ONAWA	BOGWTLWA	27097.75	0.1767	4788.82
.ONAWA	BOMBWELA	0.00	0.0704	0.00
.ONAWA	BOPITIYA	2069.28	0.0387	80.16
.ONAWA	BORLSGMA	20692.86	0.0317	655.96
.ONAWA	BLTKHPTA	11725.95	0.0968	1135.31
.ONAWA	COLOMBO	4143593.80	0.0229	94888.30
.ONAWA	DALWKTWA	15864.53	0.0546	865.89
.ONAWA	DAMBDNYA	3448.81	0.0845	291.42
.ONAWA	DANKTUWA	24946.39	0.0669	1668.91
.ONAWA	DEDUGALA	0.00	0.1056	0.00
.ONAWA	DEHIOWTA	2212.04	0.0704	155.77
.ONAWA	DEHIWELA	99325.71	0.0247	2449.37
.ONAWA	DEKATANA	14485.00	0.0387	561.13
.ONAWA	DELGODA	6552.73	0.0335	219.25
.ONAWA	DELWALA	0.00	0.1435	0.00
.ONAWA	DERNYGLA	23854.27	0.0810	1931.72
.ONAWA	DHRGTOWN	7817.30	0.0827	646.80
.ONAWA	DICKOYA	32348.84	0.1545	4999.45
.ONAWA	DIMBULLA	0.00	0.1638	0.00
.ONAWA	DIVLPTYA	32188.89	0.0563	1813.52
.ONAWA	DONDGODA	9196.82	0.0704	647.64
.ONAWA	DOMPE	20233.01	0.0423	855.05
.ONAWA	DUMLDNYA	17933.81	0.0792	1420.72
.ONAWA	EGODUYNA	14485.00	0.0387	561.15
.ONAWA	EHLYGODA	39399.82	0.0775	3051.91
.ONAWA	EKALA	7587.38	0.0387	293.94
.ONAWA	EPITWELA	0.00	0.0546	0.00
.ONAWA	ETULKOTE	18278.69	0.0247	450.75
.ONAWA	GALPTMDA	0.00	0.0880	0.00
.ONAWA	GALBODA	0.00	0.1398	0.00
.ONAWA	GALIGMWA	19083.41	0.0880	1679.72
.ONAWA	GALPATHA	14714.92	0.0704	1036.22
.ONAWA	GAMPAHA	65182.49	0.0423	2754.61
.ONAWA	GANEMULA	23566.87	0.0370	871.50
.ONAWA	GINGTHNA	21382.61	0.1305	2790.94
.ONAWA	GIRIULLA	57595.12	0.0775	4461.32
.ONAWA	GODAGAMA	[illegible]	[illegible]	[illegible]

.ONAWA	GONAPOLA	4828.33	0.047(5291)	229.54
.ONAWA	GONAWELA	22762.14	0.0387	881.81
.ONAWA	GOVINNA	1379.53	0.0669	92.29
.ONAWA	HALDDWNA	0.00	0.0687	0.00
.ONAWA	HANWELLA	43790.88	0.0440	1928.07
.ONAWA	HARNKHWA	0.00	0.0968	0.00
.ONAWA	HATRLYDA	0.00	0.1162	0.00
.ONAWA	HATTON	83762.01	0.1490	12480.87
.ONAWA	HEMTGAMA	0.00	0.1287	0.00
.ONAWA	HENDALA	26900.71	0.0247	663.37
.ONAWA	HETIMULA	11036.19	0.0968	1068.52
.ONAWA	HINGULA	4828.33	0.1144	552.44
.ONAWA	HOMAGAMA	148586.20	0.0458	6802.28
.ONAWA	HORMBAWA	0.00	0.1127	0.00
.ONAWA	HORANA	138412.21	0.0581	8041.75
.ONAWA	HUNUPTYA	30234.56	0.0229	692.37
.ONAWA	IMBLGODA	13105.48	0.0387	507.71
.ONAWA	INDURUWA	15749.56	0.0863	1358.56
.ONAWA	INGIRIYA	24716.47	0.0704	1740.58
.ONAWA	ITTAPANA	5543.96	0.0968	536.77
.ONAWA	JAELA	152839.73	0.0317	4845.02
.ONAWA	KADAWATA	225667.09	0.0282	6359.30
.ONAWA	KADIRANA	2069.28	0.0546	112.94
.ONAWA	KADUWELA	35999.82	0.0282	1014.47
.ONAWA	KAHAWELA	3448.81	0.0546	188.24
.ONAWA	KALGDHNA	3448.81	0.0511	176.10
.ONAWA	KALAWANA	13518.64	0.1472	1989.35
.ONAWA	KALUTARA	125191.77	0.0616	7714.32
.ONAWA	KANDANA	45294.36	0.0299	1356.11
.ONAWA	KARNDPNA	0.00	0.0968	0.00
.ONAWA	KATANA	16784.21	0.0581	975.14
.ONAWA	KATKRNDA	20807.81	0.0651	1355.42
.ONAWA	KATUNYKA	23279.47	0.0493	1147.68
.ONAWA	KATUNRYA	13335.40	0.0739	986.02
.ONAWA	KATUPOTA	5518.09	0.1074	592.53
.ONAWA	KEGALLE	155311.38	0.0915	14217.20
.ONAWA	KELANIYA	55543.07	0.0282	1565.20
.ONAWA	KESBEWA	6437.78	0.0405	260.73
.ONAWA	KIMBLPTY	2299.20	0.0581	133.58
.ONAWA	KIRBTGDA	17818.85	0.0229	408.05
.ONAWA	KIRIELLA	4943.29	0.0863	426.41
.ONAWA	KRNDWELA	23221.98	0.0563	1308.33
.ONAWA	KITLGALA	7472.42	0.1074	802.30
.ONAWA	KOCKKADE	58284.87	0.0581	3386.35
.ONAWA	KOLNNAWA	162657.34	0.0159	2579.75
.ONAWA	KOSGAMA	7472.42	0.0511	381.54
.ONAWA	KOSWT JN	4023.61	0.0299	120.47
.ONAWA	KOTDNYWA	0.00	0.0687	0.00
.ONAWA	KOTAGALA	50516.35	0.1564	7900.56
.ONAWA	KOTIKWTA	22302.30	0.0194	432.22
.ONAWA	KTYKMBRA	0.00	0.0722	0.00
.ONAWA	KOTMALE	56077.41	0.1472	8252.13
.ONAWA	KOTTAWA	3333.85	0.0335	111.55
.ONAWA	KOTTE	3333.85	0.0229	76.35
.ONAWA	KOTUGODA	8622.02	0.0405	349.10
.ONAWA	KURANA	9656.67	0.0475	459.08
.ONAWA	KURUWITA	1073.48	0.0951	102.05
.ONAWA	LATPNDRA	6322.82	0.1021	645.56
ONAWA	LAXAPANA	0.00	0.1749	0.00
ONAWA	LELOPTYA	0.00	0.1268	0.00
ONAWA	LINDULA	102284.26	0.1786	18265.10
ONAWA	LUNAWA	37247.14	0.0335	1246.20
ONAWA	LUNUWILA	44144.76	0.0739	3264.06
ONAWA	MAGGONA	23796.78	0.0704	1675.77
ONAWA	MAHARAGE	13795.24	0.0211	291.63

LONAWA	MAHARA	0.00	0.0229	0.00
LONAWA	MHRAGAMA	177268.80	0.0299	5307.43
LONAWA	MAKOLA	5173.22	0.0282	145.78
LONAWA	MALABE	1149.60	0.0352	40.40
LONAWA	MALIBODA	0.00	0.0933	0.00
LONAWA	MALGWATA	0.00	0.0229	0.00
LONAWA	MALWANA	0.00	0.0335	0.00
LONAWA	MRDGHMLA	48168.37	0.0581	2798.58
LONAWA	MARAWILA	8966.90	0.0792	710.36
LONAWA	MASKLIYA	63736.25	0.1712	10910.37
LONAWA	MATUGAMA	132319.32	0.0845	11180.98
LONAWA	MAWANELA	66562.02	0.1056	7030.28
LONAWA	MGHETENE	5518.09	0.1003	553.60
LONAWA	MEEGODA	0.00	0.0458	0.00
LONAWA	METKMBRA	0.00	0.0951	0.00
LONAWA	MINWNGDA	59664.40	0.0458	2731.44
LONAWA	MIRIGAME	42420.35	0.0687	2912.58
LONAWA	MIRSWTTA	32993.61	0.0387	1278.17
LONAWA	MORGHENA	0.00	0.0616	0.00
LONAWA	MORAGALA	2759.05	0.0986	271.90
LONAWA	MORATUWA	166405.05	0.0352	5860.79
LONAWA	MTLAVNIA	137377.57	0.0282	3871.30
LONAWA	MUDNGODA	13335.40	0.0387	516.61
LONAWA	NAGODA	38051.86	0.0687	2612.64
LONAWA	NINAMDMA	11955.87	0.0757	905.06
LONAWA	NARAMALA	33338.49	0.0933	3110.48
LONAWA	NATNDIYA	40810.91	0.0845	3448.52
LONAWA	NAUTDUWA	6322.81	0.0968	612.17
LONAWA	NAWALA	0.00	0.0229	0.00
LONAWA	NEBODA	19083.41	0.0810	1545.37
.ONAWA	NEGOMBO	254223.57	0.0511	12980.66
.ONAWA	NELNDNYA	26210.95	0.0827	2168.60
.ONAWA	NITMBUWA	31499.12	0.0528	1663.78
.ONAWA	NIVTGALA	20980.83	0.1287	2609.73
.ONAWA	NYNDRPLA	3448.81	0.0810	279.28
.ONAWA	NORTBRGE	14998.23	0.1398	2096.21
.ONAWA	NORWOOD	32626.73	0.1582	5162.98
.ONAWA	NUGEGODA	205778.96	0.0247	5074.51
.ONAWA	PADUKKA	55410.87	0.0528	2926.80
.ONAWA	PAYGLALN	517.32	0.0669	34.61
.ONAWA	PALLEWLA	16175.09	0.0563	911.30
.ONAWA	PANADURA	159220.03	0.0440	7008.87
.ONAWA	PANAGODA	49211.95	0.0475	2339.54
.ONAWA	PANNALA	8586.04	0.0863	740.63
.ONAWA	PANNPTYA	60814.01	0.0317	1927.80
.ONAWA	PARAKDWA	5633.06	0.0845	475.90
.ONAWA	PASYALA	8277.14	0.0563	466.33
.ONAWA	PATANA	0.00	0.1656	0.00
.ONAWA	PELAWATA	11725.95	0.1056	1238.40
.ONAWA	PELYGODA	498645.52	0.0211	10541.37
.ONAWA	PILYNDLA	91175.02	0.0370	3371.65
.ONAWA	PITIPANE	11036.19	0.0511	563.51
.ONAWA	PLGHWELA	49088.05	0.0880	4320.73
.ONAWA	PLGSOWTA	0.00	0.0423	0.00
.ONAWA	PUGODA	9311.79	0.0458	426.20
.ONAWA	PUSSELLA	21842.46	0.0898	1961.02
.ONAWA	PUWKPTYA	1724.40	0.0581	100.10
.ONAWA	RAGAMA	37821.95	0.0282	1065.82
.ONAWA	RAMBKANA	43455.00	0.1091	4742.68
.ONAWA	RMBKPTYA	0.00	0.1342	0.00
.ONAWA	RANALA	35867.62	0.0335	1200.13
.ONAWA	RATMLANA	394339.64	0.0299	11806.53
.ONAWA	RATNPURA	189137.04	0.1091	20642.42
.ONAWA	ROZELLE	2734.21	0.1435	392.25
ONAWA	RUANWELA	31614.09	0.0810	2540.11

.ONAWA	SAPGHWTA	4598.41	0.0722	331.91
.ONAWA	SEEDUWA	30340.90	0.0387	1175.41
.ONAWA	TALNGAMA	0.00	0.0282	0.00
.ONAWA	TALWKELE	129220.86	0.1712	22120.03
LONAWA	TALWTGDA	18278.69	0.0335	611.60
.ONAWA	TEBUWANA	9311.78	0.0775	721.29
LONAWA	TRWNKTYA	41845.55	0.1144	4787.97
LONAWA	TUMODARA	0.00	0.0616	0.00
LONAWA	UDAKRWTA	5126.66	0.1361	697.57
LONAWA	UDGMPOLA	23451.90	0.0458	1073.63
LONAWA	UNDUGODA	574.80	0.0986	56.66
LONAWA	UPCOT	57571.87	0.1564	9004.01
LONAWA	URAPOLA	10921.23	0.0599	653.74
LONAWA	URGSMNHD	11725.95	0.0986	1155.94
LONAWA	VEYNGODA	110706.78	0.0563	6237.22
LONAWA	WADAKADA	5106.45	0.0986	503.30
LONAWA	WADDUWA	49777.81	0.0511	2541.65
LONAWA	WAGA	1149.60	0.0475	54.65
LONAWA	WAHARAKA	1264.56	0.0722	91.28
LONAWA	WAIKKAL	18508.61	0.0616	1140.50
LONAWA	WARKGODA	5288.17	0.0845	446.85
LONAWA	WARKPOLA	37592.02	0.0722	2713.30
LONAWA	WASKDUWA	0.00	0.0528	0.00
LONAWA	WATAWALA	721.35	0.1342	96.82
LONAWA	WATTALA	63228.17	0.0211	1336.64
LONAWA	WATRGAMA	11725.95	0.0440	516.18
LONAWA	WELIKADA	86220.23	0.0211	1822.70
LONAWA	WELIPENE	0.00	0.0933	0.00
LONAWA	WELIWRYA	35177.85	0.0387	1362.70
LONAWA	WELLMPTY	117792.35	0.0176	2075.50
LONAWA	WENAPUWA	34488.10	0.0704	2428.65
LONAWA	WERAHERA	5357.15	0.0352	188.68
LONAWA	WEWLDNYA	48973.09	0.0704	3448.68
LONAWA	YAKKALA	5403.13	0.0440	237.85
LONAWA	YATNTOTA	33798.33	0.0845	2855.96

FINAL THROUGHPUT AT KOLONAWA IS 12255938.78
FIXED COST OF KOLONAWA IS 411000.00
VARIABLE COST OF KOLONAWA IS 576103.83

TARA	AMBLTOTA	19543.16	0.2067	4039.18
TARA	BELIATTA	40740.75	0.1697	6914.52
TARA	BENGMUWA	0.00	0.1838	0.00
TARA	BERAGAMA	0.00	0.2137	0.00
TARA	BERLPNTR	0.00	0.1996	0.00
TARA	DEIYNDRA	7587.38	0.1697	1287.73
TARA	DICKWELA	25982.06	0.1539	3998.12
TARA	DONDRA	39951.10	0.1398	5585.16
TARA	GANDARA	0.00	0.1416	0.00
TARA	GODPTIYA	0.00	0.1380	0.00
TARA	HAKMANA	39322.64	0.1592	6258.50
TARA	HAMBTOTA	24598.77	0.2190	5387.13
TARA	HITTETYA	0.00	0.1345	0.00
TARA	HUNGAMA	2873.96	0.1926	553.52
TARA	KMBGMUWA	0.00	0.1363	0.00
TARA	KMBRPTYA	35487.85	0.1504	5335.95
TARA	KATRGAMA	729.49	0.2825	206.11
TARA	KATUWANA	387.99	0.2032	78.82
TARA	KIRAMA	0.00	0.1961	0.00
TARA	KIRINDA	2069.29	0.1539	318.47
TARA	KOTEGODA	689.76	0.1468	101.28
TARA	MATARA	239688.33	0.1328	31821.02
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ATARA	NAKLGMWA	0.00	0.1592 (294)	0.00
ATARA	RANNA	0.00	0.1856	0.00
ATARA	RIDY-GMA	0.00	0.2190	0.00
ATARA	TALALLA	0.00	0.1433	0.00
ATARA	TANGALLA	19547.35	0.1715	3351.98
ATARA	TELJWILA	0.00	0.1416	0.00
ATARA	TIHAGODA	3151.32	0.1416	446.10
ATARA	TISMRAMA	11436.67	0.2511	2871.96
ATARA	URUBOKKA	8451.93	0.1979	1672.47
ATARA	WALSGALA	15065.11	0.1644	2477.31
ATARA	WALSMULA	28281.78	0.1838	5108.19
ATARA	WERAKTYA	15285.95	0.1873	2863.36
ATARA	WIRAWILA	0.00	0.2511	0.00
ATARA	YATIYANA	18045.00	0.1486	2681.49
ATARA	YODKNDYA	0.00	0.2548	0.00

FINAL THROUGHPUT AT MATARA IS 632715.96

FIXED COST OF MATARA IS 7200.00

VARIABLE COST OF MATARA IS 98773.16

RDNIYA	AGRAPTNA	34885.15	0.1105	3854.81
RDNIYA	AKURANA	14203.48	0.1228	1744.47
RDNIYA	ALAWTGDA	33656.38	0.1263	4252.15
RDNIYA	ALUTNWRA	201.18	0.1932	38.87
RDNIYA	AMBAWELA	0.00	0.1967	0.00
RDNIYA	AMPITIYA	1367.11	0.1140	155.88
RDNIYA	ANKMBURA	6195.44	0.1334	826.35
RDNIYA	ATTABAGE	0.00	0.1281	0.00
RDNIYA	BOPTLAWA	0.00	0.2163	0.00
RDNIYA	BORAGAS	0.00	0.1950	0.00
RDNIYA	DELTOTA	8088.72	0.1299	1050.40
RDNIYA	DOLSBAGE	18761.27	0.1510	2832.58
RDNIYA	ELLAMLLA	569.63	0.1615	92.02
RDNIYA	ELKADUWA	11278.64	0.1369	1544.05
RDNIYA	GALAHA	42808.06	0.1211	5182.34
RDNIYA	GAMMDUWA	2734.22	0.1580	432.06
RDNIYA	GAMPOLA	169011.41	0.1193	20163.06
RDNIYA	GELIOYA	0.00	0.1105	0.00
RDNIYA	HALGNOYA	24734.30	0.1915	4735.63
RDNIYA	HANGRKTA	35135.81	0.1387	4871.93
RDNIYA	HARSBDDA	8874.57	0.1879	1667.80
RDNIYA	HEDENIYA	15386.61	0.1140	1754.38
RDNIYA	HEWAHETA	8306.94	0.1422	1181.08
RDNIYA	HUNSGRYA	22471.86	0.1510	3392.80
RDNIYA	HURIKDWA	11725.95	0.1175	1378.27
RDNIYA	KADGNAWA	8574.61	0.1123	962.50
RDNIYA	KIKAWELA	0.00	0.1387	0.00
RDNIYA	KANDPOLA	25961.88	0.1932	5016.35
RDNIYA	KANDY	547877.84	0.1087	59576.24
RDNIYA	KATGSTTA	102258.28	0.1158	11839.46
RDNIYA	KATKTULA	8475.49	0.1527	1294.55
RDNIYA	KEPTPOLA	38991.55	0.2020	7877.07
RDNIYA	KUNDSALE	4295.47	0.1158	497.33
RDNIYA	LABUKELE	0.00	0.1633	0.00
RDNIYA	MADAWALA	14990.59	0.1211	1814.76
RDNIYA	MADLKELE	13314.06	0.1387	1846.13
RDNIYA	MAHAOYA	2658.53	0.2606	692.89
RDNIYA	MAHYNGNA	0.00	0.1932	0.00
RDNIYA	MARASANA	0.00	0.1351	0.00
RDNIYA	MATALE	192030.57	0.1351	25951.01
RDNIYA	MINIPE	0.00	0.2144	0.00
RDNIYA	MURTLAWA	0.00	0.1087	0.00

RDNIYA	NILDHNNA	0.00	0.179(E95)	0.00
RDNIYA	NUWELIYA	169793.88	0.1809	30715.71
RDNIYA	PADYPELA	9635.95	0.1527	1471.80
RDNIYA	PALLWTTA	10942.38	0.2003	2191.32
RDNIYA	PANWILA	1253.18	0.1228	153.92
RDNIYA	PANWLTNE	0.00	0.1369	0.00
RDNIYA	PERDNIYA	71160.55	0.1035	7362.27
RDNIYA	PILMTLWA	26575.30	0.1087	2889.80
RDNIYA	POLGOLLA	21115.38	0.1211	2556.23
RDNIYA	PUJPTIYA	17323.16	0.1246	2158.12
RDNIYA	PINDLOYA	30083.23	0.1615	4859.64
RDNIYA	PUPURESA	9656.66	0.1369	1322.00
RDNIYA	PUSELAWA	30167.76	0.1404	4236.16
RDNIYA	RAGALA	17690.23	0.1915	3386.97
RDNIYA	RAMBODA	26198.72	0.1563	4093.81
RDNIYA	RANGALLA	13785.00	0.1439	1984.21
RDNIYA	RATTOTA	1413.05	0.1475	208.37
RDNIYA	RIKLGSKD	22864.46	0.1422	3250.87
RDNIYA	TALTUOYA	22072.38	0.1263	2788.62
RDNIYA	TWLNTENE	0.00	0.1457	0.00
RDNIYA	TELDNIYA	22480.92	0.1299	2919.37
RDNIYA	TENEKBRA	25978.34	0.1123	2916.33
RDNIYA	UDHNTENE	0.00	0.1351	0.00
RDNIYA	UDPSLAWA	39793.24	0.2311	9194.63
RDNIYA	UDISPATU	8121.03	0.1387	1126.06
RDNIYA	UKUWELA	2050.66	0.1351	277.13
RDNIYA	ULAPANE	8133.90	0.1281	1041.95
RDNIYA	URUGALA	0.00	0.1422	0.00
RDNIYA	WATAGODA	1600.82	0.1791	286.77
RDNIYA	WATTGAMA	25456.59	0.1246	3171.38
RDNIYA	WATUMULA	0.00	0.1739	0.00
RDNIYA	WERLGAMA	28927.74	0.1123	3247.43

FINAL THROUGHPUT AT PERDNIYA IS 2281653.81
FIXED COST OF PERDNIYA IS 15200.00
VARIABLE COST OF PERDNIYA IS 307110.90

TICALO	ADALCHNA	0.00	0.3068	0.00
TICALO	AKARPATU	11719.60	0.3104	3637.30
TICALO	AMPARAI	141774.14	0.3086	43751.50
TICALO	BAKIELLA	0.00	0.3368	0.00
TICALO	BATICALO	113483.49	0.2400	27231.50
TICALO	CHDYNTLW	0.00	0.2928	0.00
TICALO	CNHKLADI	35568.72	0.2540	9035.88
TICALO	ERAVUR	0.00	0.2540	0.00
TICALO	INGNYGLA	0.00	0.3297	0.00
TICALO	KALVNCHK	7830.98	0.2664	2085.86
TICALO	KALMUNAI	36912.58	0.2804	10351.76
TICALO	KRDIYNRU	0.00	0.2681	0.00
TICALO	KATNKUDI	1284.68	0.2470	317.32
TICALO	MALWATAI	1530.91	0.2998	458.97
TICALO	NINTAVUR	5745.31	0.2892	1661.77
TICALO	OLUVIL	0.00	0.2998	0.00
TICALO	PADIRUPU	0.00	0.2681	0.00
TICALO	PALAMUNA	0.00	0.3051	0.00
TICALO	RAJAGAMA	0.00	0.3086	0.00
TICALO	SINTHMRT	0.00	0.2804	0.00
TICALO	SAMNTHRA	1753.35	0.2910	510.22
TICALO	UHANA	1419.25	0.3244	460.46
TICALO	VALCHENA	23708.36	0.2734	6481.87

FINAL THROUGHPUT AT BATICALO IS 382731.37
FIXED COST OF BATICALO IS 7000.00
VARIABLE COST OF BATICALO IS 105984.40

IRNGALA	DAMBULLA	22171.34	0.1495	3314.62
IRNGALA	DONGSLND	2164.06	0.1125	243.54
IRNGALA	ELAHERA	0.00	0.1865	0.00
IRNGALA	GALGDERA	14391.09	0.1161	1670.23
IRNGALA	GALEWELA	31253.01	0.1319	4122.27
IRNGALA	GALGMUWA	20242.83	0.1583	3204.44
IRNGALA	GIRITALE	1062.44	0.2117	224.94
IRNGALA	HABARANA	8202.95	0.1724	1414.02
IRNGALA	HINGRKGD	74102.10	0.2117	15688.60
IRNGALA	HIRIPTYA	0.00	0.1108	0.00
IRNGALA	HURLWEWA	0.00	0.2006	0.00
IRNGALA	IBBGMUWA	25854.78	0.1037	2682.17
IRNGALA	ILLKWELA	6150.99	0.1073	659.76
IRNGALA	KALAWEWA	0.00	0.1829	0.00
IRNGALA	KNUKTIYA	3475.30	0.0949	329.94
IRNGALA	KAUDULLA	2188.47	0.1777	388.80
IRNGALA	KAUDPLLA	0.00	0.1460	0.00
IRNGALA	KEKIRAWA	17276.77	0.1689	2917.36
IRNGALA	KOBEIGNA	2759.04	0.1266	349.35
IRNGALA	KURNGALA	389264.32	0.0897	34901.44
IRNGALA	MHAILPLM	0.00	0.1865	0.00
IRNGALA	MAHO	2206.06	0.1354	298.74
IRNGALA	MAKLPOTA	0.00	0.1372	0.00
IRNGALA	MALPTIYA	0.00	0.0949	0.00
IRNGALA	MRDKDWLA	0.00	0.1794	0.00
IRNGALA	MASPOTHA	2734.22	0.0967	264.40
IRNGALA	MAWTGAMA	30253.37	0.1002	3031.90
IRNGALA	MEDAWELA	0.00	0.1653	0.00
RNGALA	MELSRPRA	22798.40	0.1178	2686.11
RNGALA	MINNRIYA	13717.02	0.1917	2630.10
RNGALA	NALANDA	0.00	0.1530	0.00
RNGALA	NAULA	16517.59	0.1601	2643.81
RNGALA	NIKWRTYA	44230.47	0.1319	5834.00
RNGALA	PALLEGMA	0.00	0.2283	0.00
RNGALA	PALLEPLA	4138.57	0.1495	618.75
RNGALA	POLNRUWA	93957.64	0.2265	21281.41
RNGALA	RAMBDGLA	0.00	0.1178	0.00
RNGALA	RIDIGAMA	16577.09	0.1108	1836.41
RNGALA	WARYPOLA	16773.56	0.1090	1828.68
RNGALA	WELIKNDA	0.00	0.2616	0.00
RNGALA	YATAWATA	0.00	0.1372	0.00

FINAL THROUGHPUT AT KURNGALA IS 884463.48
FIXED COST OF KURNGALA IS 9850.00
VARIABLE COST OF KURNGALA IS 115065.82

URPURA	ANRDPURA	233028.39	0.1524	35518.10
URPURA	CHDIKLAM	0.00	0.2087	0.00
URPURA	EPPAWALA	0.00	0.1771	0.00
URPURA	GALNBDNW	4138.57	0.2017	834.75
URPURA	MADHU CH	1075.50	0.2316	249.11
URPURA	MHVLCHYA	3980.99	0.1788	711.88
URPURA	MANNAR	56090.77	0.2709	15193.10
URPURA	MEDWCHYA	31463.78	0.1806	5681.73
URPURA	MIHNTALE	0.00	0.1630	0.00
URPURA	MURUNKAN	9601.14	0.2475	2375.90
URPURA	NANATTAN	0.00	0.2635	0.00
URPURA	NOCHYGMA	18668.56	0.1753	3272.60
URPURA	OMANTHAI	0.00	0.2246	0.00
URPURA	PADAVIYA	8294.34	0.2334	[illegible]

URPURA	RATMALE	0.00	0.1559	0.00
URPURA	SEEPKLAM	0.00	0.1735	0.00
URPURA	SILVTURA	5312.20	0.2672	1419.27
URPURA	TALMANAR	0.00	0.3060	0.00
URPURA	TAMBTGMA	10704.00	0.1771	1895.25
URPURA	TRKTSWRN	2846.23	0.2820	802.51
URPURA	UYLNKLAM	9010.56	0.2527	2277.38

FINAL THROUGHPUT AT ANURPURA IS 394215.03
FIXED COST OF ANURPURA IS 6000.00
VARIABLE COST OF ANURPURA IS 72167.44

FFNA	ALAVEDDY	17933.81	0.2641	4736.68
FFNA	CHANKANI	15152.02	0.2782	4215.20
FFNA	CHLIPRAM	0.00	0.2817	0.00
FFNA	ELTHMDWL	9311.79	0.2712	2524.98
FFNA	JAFFNA	321542.39	0.2624	84339.86
FFNA	KANKSTRA	15220.51	0.2817	4287.92
FFNA	KARANAGA	12036.53	0.2817	3390.93
FFNA	KAYTS	9139.07	0.2800	2558.57
FFNA	KOLNKLDI	0.00	0.2817	0.00
FFNA	KOPAY	17914.65	0.2676	4794.68
FFNA	MANIPAY	15063.53	0.2641	3978.58
FFNA	MRTHNMDM	12749.10	0.2694	3434.61
FFNA	MYLIDDY	6995.43	0.2870	2007.69
FFNA	NALLUR	23419.21	0.2659	6226.70
FFNA	PUNGDTVU	2164.06	0.2817	609.64
FFNA	PUTTUR	3274.48	0.2764	905.20
FFNA	VADUKODA	0.00	0.2747	0.00
FFNA	VELANAI	3710.32	0.2782	1032.21

FINAL THROUGHPUT AT JAFFNA IS 485626.90
FIXED COST OF JAFFNA IS 9350.00
VARIABLE COST OF JAFFNA IS 129063.56

LLE	AHANGAMA	28825.70	0.1209	3484.45
LLE	AKMIMANA	2050.66	0.1086	222.62
LLE	AKURESSA	76244.60	0.1420	10826.73
LLE	DENIPTYA	569.63	0.1332	75.87
LLE	DENIYAYA	58180.50	0.1895	11026.37
LLE	GALLE	579199.89	0.1015	58800.37
LLE	HABRDUWA	11725.95	0.1138	1334.88
LLE	HENEGAMA	12990.51	0.1350	1753.20
LLE	HINIDUMA	0.00	0.1543	0.00
LLE	IMADUWA	22910.30	0.1244	2850.04
LLE	KOGGALA	0.00	0.1156	0.00
LLE	KOTAPOLA	2863.66	0.1825	522.56
LLE	LELWELA	10346.43	0.1033	1068.58
LLE	MAKMBURA	15864.52	0.1209	1917.70
LLE	MORAWAKA	6732.22	0.1702	1145.55
LLE	NAKYDNYA	20731.20	0.1297	2688.42
LLE	NELUWA	512.66	0.1684	86.33
LLE	PITBDARA	8212.76	0.1631	1339.67
LLE	PODDALA	0.00	0.1103	0.00
LLE	TALPE	0.00	0.1086	0.00
LLE	TAWALAMA	0.00	0.1614	0.00
LLE	TALAGAHA	0.00	0.1086	0.00
LLE	UDUGAMA	15321.94	0.1402	2148.75
LLE	URALA	8270.62	0.1226	1014.31
LLE	WANDRBMA	0.00	0.1191	0.00
LLE	WARALLA	3698.10	0.1773	656.00

ILLE	YAKKLMLA	0.00	0.1191	0.00

FINAL THROUGHPUT AT GALLE IS 969285.31
FIXED COST OF GALLE IS 8850.00
VARIABLE COST OF GALLE IS 113858.85

INABAY	CHINABAY	0.00	0.0858	0.00
INABAY	GALOYA	0.00	0.1614	0.00
INABAY	KHTGSDLY	17179.44	0.1702	2924.63
INABAY	KANTALAI	124454.29	0.1262	15711.11
INABAY	KEBTGLWA	0.00	0.1755	0.00
INABAY	KINNIYAI	0.00	0.0910	0.00
INABAY	KUCHVELI	0.00	0.1262	0.00
INABAY	MUTTUR	0.00	0.1790	0.00
INABAY	PANKULAM	0.00	0.1227	0.00
INABAY	PVRSKLAM	0.00	0.2152	0.00
INABAY	PULMODAI	5514.37	0.1738	958.18
INABAY	TMPLKMAM	0.00	0.1051	0.00
INABAY	TRNCMALE	139853.93	0.0963	13470.73
INABAY	VAVUNIYA	46045.47	0.2041	9398.80

FINAL THROUGHPUT AT CHINABAY IS 333047.50
FIXED COST OF CHINABAY IS 11500.00
VARIABLE COST OF CHINABAY IS 42463.45

BLGODA	AHUNGALA	3908.65	0.0897	350.45
BLGODA	AMBLGODA	87082.44	0.0826	7194.75
BLGODA	BADDGAMA	32752.49	0.1073	3513.03
BLGODA	BALAPTYA	23681.83	0.0826	1956.50
BLGODA	BATAPOLA	11725.95	0.0914	1071.90
BLGODA	BOOSSA	0.00	0.1037	0.00
BLGODA	DADALLA	0.00	0.1178	0.00
BLGODA	DODNDUWA	38799.10	0.1020	3956.73
BLGODA	ELPITIYA	61388.81	0.0932	5720.21
BLGODA	GANEGODA	0.00	0.0985	0.00
BLGODA	GONPNWLA	6207.85	0.1002	622.15
BLGODA	HIKKDUWA	25118.83	0.0949	2384.78
BLGODA	KAHADUWA	10806.27	0.1073	1159.08
BLGODA	MAHAEDND	6897.62	0.0879	606.30
BLGODA	MATTAKA	2759.05	0.1161	320.22
BLGODA	METYGODA	0.00	0.0897	0.00
BLGODA	PITIGALA	6897.62	0.1108	764.12
BLGODA	RATGAMA	4828.33	0.1002	483.90
BLGODA	TALGSWLA	13437.71	0.1143	1535.93
BLGODA	WATUGDRA	5518.09	0.0879	485.04

FINAL THROUGHPUT AT AMBLGODA IS 341810.64
REVISED FIXED COST OF AMBLGODA IS 7341.81
VARIABLE COST OF AMBLGODA IS 32125.27

DAMPE	ANGAMUWA	2069.29	0.1158	239.54
DAMPE	ARCHKTWA	0.00	0.1034	0.00
DAMPE	BAMNPOLA	0.00	0.1175	0.00
DAMPE	BANGDNYA	0.00	0.0894	0.00
DAMPE	BARMPOLA	0.00	0.1228	0.00
DAMPE	BATULUOA	8277.14	0.1017	841.62
DAMPE	BIBILE	4249.76	0.2215	941.47
DAMPE	BINGRIYA	18393.65	0.1017	1870.27
DAMPE	CHILAW	138840.49	0.0823	[illegible]

DAMPE	HETIPOLA	8047.22	0.1158	931.59
DAMPE	KAKPLIYA	0.00	0.0753	0.00
DAMPE	KALPTIYA	1379.53	0.1721	237.39
DAMPE	KITALAWA	4828.33	0.1070	516.44
DAMPE	KOTNTIVU	2644.09	0.1087	287.47
DAMPE	KULYPTYA	47938.45	0.0964	4621.27
DAMPE	MADAMPE	44453.65	0.0718	3189.90
DAMPE	MADRNKLI	8277.14	0.1193	987.30
DAMPE	MAHAWEWA	38971.54	0.0753	2933.78
DAMPE	MNGLELYA	0.00	0.1034	0.00
DAMPE	MONMLDNY	0.00	0.1070	0.00
DAMPE	MUNDEL	14972.64	0.1087	1627.83
DAMPE	NAGLGODA	0.00	0.1193	0.00
DAMPE	PALAKUDA	6552.74	0.1598	1046.87
DAMPE	PUTTALAM	112018.80	0.1351	15135.98
DAMPE	RAJKDLWA	1954.33	0.0911	178.08
DAMPE	TABBOWA	0.00	0.1527	0.00
DAMPE	UDABDAWA	62423.45	0.0876	5468.29

FINAL THROUGHPUT AT MADAMPE IS 538937.87
REVISED FIXED COST OF MADAMPE IS 7538.94
VARIABLE COST OF MADAMPE IS 53503.20

NKULAM	CHMPNPTU	0.00	0.2642	0.00
NKULAM	KILNOCHI	60824.51	0.2290	13926.38
NKULAM	MANKULAM	32856.11	0.2026	6655.33
NKULAM	MULATIVU	23606.96	0.2518	5945.18
NKULAM	MULWALAI	12006.68	0.2448	2939.24
NKULAM	NEDNKENI	0.00	0.2395	0.00
NKULAM	PARANTAN	21389.77	0.2360	5047.90
NKULAM	PONAKERI	0.00	0.2624	0.00
NKULAM	PUTKDRPU	0.00	0.2448	0.00
NKULAM	TUNNUKAI	0.00	0.2254	0.00
NKULAM	VAVNKLAM	0.00	0.2184	0.00

FINAL THROUGHPUT AT MANKULAM IS 150684.03
REVISED FIXED COST OF MANKULAM IS 7150.68
VARIABLE COST OF MANKULAM IS 34514.11

VKCHRI	ARIVALAI	2759.04	0.2648	730.59
VKCHRI	ATCHUVLY	17947.52	0.2701	4847.27
VKCHRI	AVERNGAL	14485.00	0.2630	3810.13
VKCHRI	CHVKCHRI	65041.32	0.2490	16192.69
VKCHRI	CHUNAKAM	50268.12	0.2683	13487.94
VKCHRI	KODIKMAM	5661.93	0.2542	1439.49
VKCHRI	MALLAKAM	12899.46	0.2666	3438.48
VKCHRI	MANTHIKI	18719.33	0.2718	5088.66
VKCHRI	NELLIADY	58925.36	0.2806	16536.81
VKCHRI	NIRVELI	0.00	0.2648	0.00
VKCHRI	PALLAI	16280.26	0.2701	4396.97
VKCHRI	PANDTRPU	51391.83	0.2718	13970.36
VKCHRI	PT PEDRO	64554.74	0.2754	17775.79
VKCHRI	PILOLI	16651.20	0.2736	4555.77
VKCHRI	PUNNALAI	7055.57	0.2771	1955.24
VKCHRI	PUNLKDWN	35388.53	0.2718	9620.02
VKCHRI	SITNKENI	10741.94	0.2754	2957.90
VKCHRI	TELIPALI	20679.82	0.2754	5694.40
VKCHRI	TNDMANAR	20068.46	0.2894	5808.62
VKCHRI	URUMPRAI	4138.57	0.2754	1139.60
VKCHRI	VAVETURI	39710.07	0.2736	10864.68
VKCHRI	VASAVLAN	2060.28	0.2754	[illegible]

REVISED FIXED COST OF CHVKCHRI IS 7535.44
VARIABLE COST OF CHVKCHRI IS 144881.19

ANAIKE	BDLKMBRA	5710.97	0.2510	1433.70
ANAIKE	BADULLA	118139.01	0.2196	25946.63
ANAIKE	BALNGODA	72247.52	0.1227	8867.66
ANAIKE	BALIKTWA	5016.82	0.2090	1048.42
ANAIKE	BANDRWLA	100079.82	0.1826	18272.57
ANAIKE	BELIHIOY	3987.40	0.1386	552.57
ANAIKE	BORALNDA	4290.60	0.2215	950.24
ANAIKE	BUTTALA	4288.94	0.2270	973.68
ANAIKE	DEMODARA	0.00	0.1984	0.00
ANAIKE	DIYTLAWA	11110.13	0.1826	2028.40
ANAIKE	DMBGHWLA	5026.98	0.2732	1373.47
ANAIKE	ELLE	4380.73	0.1931	846.00
ANAIKE	EMBLPTYA	28261.13	0.1808	5110.18
ANAIKE	ETTMPTYA	15174.76	0.1984	3010.98
ANAIKE	GODKWELA	37301.96	0.1421	5300.61
ANAIKE	GURTLAWA	0.00	0.2233	0.00
ANAIKE	HALDMULA	9150.79	0.1597	1461.38
ANAIKE	HALIELA	0.00	0.2072	0.00
ANAIKE	HAPUTALE	115423.43	0.1738	20058.28
ANAIKE	IDLGSHNA	8968.49	0.1861	1669.04
ANAIKE	ITTAKNDA	0.00	0.1703	0.00
ANAIKE	KAHAWATA	105276.58	0.1263	13292.22
ANAIKE	KOLONNO	0.00	0.1808	0.00
ANAIKE	KOSLANDA	6345.16	0.1896	1203.17
ANAIKE	LUNUGALA	18931.85	0.2584	4892.67
ANAIKE	MADLSIMA	3293.02	0.2547	838.86
ANAIKE	MEDAGAMA	0.00	0.2751	0.00
ANAIKE	MONRGALE	16411.50	0.2658	4362.64
ANAIKE	NAMNKULA	8538.70	0.2196	1875.34
ANAIKE	OHIYA	640.84	0.2289	146.67
ANAIKE	OPANAIKE	5810.21	0.1087	631.34
ANAIKE	PANIKNDA	0.00	0.1949	0.00
ANAIKE	PASSARA	42512.60	0.2326	9886.90
ANAIKE	PELMDULA	74439.97	0.1192	8874.73
ANAIKE	POONGALA	10632.19	0.2090	2221.92
ANAIKE	POTTUVIL	2327.65	0.3498	814.17
ANAIKE	RAKWANA	31350.09	0.1456	4565.20
ANAIKE	TANMWILA	8277.15	0.2510	2077.93
ANAIKE	UDAWALWE	0.00	0.1984	0.00
ANAIKE	WALAWE	972.65	0.1984	192.90
ANAIKE	WERAGODA	0.00	0.3336	0.00
ANAIKE	WELIMADA	100634.02	0.2037	20499.15
ANAIKE	WELAWAYA	11268.27	0.2055	2315.18

FINAL THROUGHPUT AT OPANAIKE IS 996221.93
REVISED FIXED COST OF OPANAIKE IS 7996.22
VARIABLE COST OF OPANAIKE IS 177595.09

TOTAL FIXED COST OF CENTRAL SOURCE AND SELECTED DEPOTS IS 523513.09
TOTAL VARIABLE COST OF OPTIMAL PATTERN IS 2003210.27

TOTAL COST OF ALL COLLECTIONS = 80134.38

TOTAL OVERALL COST OF OPTIMAL PATTERN IS 2606857.75

IMPROVEMENT OVER COST OF PRESENT SYSTEM = 114612.51

PERCENTAGE IMPROVEMENT = 4.21

FINAL THROUGHPUTS AND COSTS OF SELECTED DEPOTS

(ZERO THROUGHPUT INDICATES NON-UTILISATION OF DEPOT)

DEPOT	FINAL THROUGHPUT	FIXED COST	VARIABLE COST	
KOLONAWA	12255938.78	411000.00	576103.83	
MATARA	632715.96	7200.00	98773.16	
KOTAGALA	0.00	13000.00	0.00	THIS EXISTING DEPOT WILL NOT BE USED
HAPUTALE	0.00	6500.00	0.00	THIS EXISTING DEPOT WILL NOT BE USED
PERDNIYA	2281653.81	15200.00	307110.90	
BATICALO	382731.37	7000.00	105984.40	
KURNGALA	884463.48	9850.00	115065.82	
ANURPURA	394215.03	6000.00	72167.44	
JAFFNA	485626.90	9350.00	129063.56	
RATNPURA	0.00	3000.00	0.00	THIS EXISTING DEPOT WILL NOT BE USED
GALLE	969285.31	8850.00	113858.85	
KILINCHI	0.00	4200.00	0.00	THIS EXISTING DEPOT WILL NOT BE USED
NEWPERAD	0.00	4200.00	0.00	THIS EXISTING DEPOT WILL NOT BE USED
CHINABAY	333047.50	11500.00	42463.45	
MORATUWA	0.00	0.00	0.00	
PANADURA	0.00	0.00	0.00	
WADDUWA	0.00	0.00	0.00	
KALUTARA	0.00	0.00	0.00	
ALUTGAMA	0.00	0.00	0.00	
AMBLGODA	341810.64	7341.81	32125.27	NEW DEPOT LOCATION
HIKADUWA	0.00	0.00	0.00	
HABRDUWA	0.00	0.00	0.00	
WELIGAMA	0.00	0.00	0.00	
JA-ELA	0.00	0.00	0.00	
NEGOMBO	0.00	0.00	0.00	
LUNUWILA	0.00	0.00	0.00	
MADAMPE	538937.87	7538.94	53503.20	NEW DEPOT LOCATION
CHILAW	0.00	0.00	0.00	
BATLUOYA	0.00	0.00	0.00	
PUTTALAM	0.00	0.00	0.00	
RAGAMA	0.00	0.00	0.00	
GAMPAHA	0.00	0.00	0.00	
VEYNGODA	0.00	0.00	0.00	
MIRIGAMA	0.00	0.00	0.00	
ALAWWA	0.00	0.00	0.00	
POLGHWLA	0.00	0.00	0.00	
MAHO	0.00	0.00	0.00	
GALGMUWA	0.00	0.00	0.00	
MADWCHYA	0.00	0.00	0.00	
VAVUNIYA	0.00	0.00	0.00	
MANKULAM	150684.03	7150.68	34514.11	NEW DEPOT LOCATION
EL. PASS	0.00	0.00	0.00	
PALLAI	0.00	0.00	0.00	
CHVKCHRI	535437.35	7535.44	144881.19	NEW DEPOT LOCATION
CHUNAKAM	0.00	0.00	0.00	
K.K.S	0.00	0.00	0.00	

RANA	0.00	0.00	0.00	
YA	0.00	0.00	0.00	
ALAY	0.00	0.00	0.00	
CMLY	0.00	0.00	0.00	
RKGD	0.00	0.00	0.00	
RUWA	0.00	0.00	0.00	
KNDA	0.00	0.00	0.00	
CHNY	0.00	0.00	0.00	
UR	0.00	0.00	0.00	
U RD	0.00	0.00	0.00	
NKAN	0.00	0.00	0.00	
AR	0.00	0.00	0.00	
ANAR	0.00	0.00	0.00	
Y	0.00	0.00	0.00	
STTA	0.00	0.00	0.00	
GAMA	0.00	0.00	0.00	
LE	0.00	0.00	0.00	
KANA	0.00	0.00	0.00	
NAWA	0.00	0.00	0.00	
DLA	0.00	0.00	0.00	
PTYA	0.00	0.00	0.00	
WALA	0.00	0.00	0.00	
ON	0.00	0.00	0.00	
KELE	0.00	0.00	0.00	
GODA	0.00	0.00	0.00	
OYA	0.00	0.00	0.00	
WELA	0.00	0.00	0.00	
RWLA	0.00	0.00	0.00	
DARA	0.00	0.00	0.00	
ELA	0.00	0.00	0.00	
LLA	0.00	0.00	0.00	
YPYA	0.00	0.00	0.00	
GAMA	0.00	0.00	0.00	
KKA	0.00	0.00	0.00	
WELA	0.00	0.00	0.00	
YGDA	0.00	0.00	0.00	
WITA	0.00	0.00	0.00	
WATA	0.00	0.00	0.00	
AIKE	996221.93	7996.22	177595.09	NEW DEPOT LOCATION

NSITIVITY ANALYSIS

ME = 08/01/33

FECT OF DROPPING MATARA DEPOT FROM THE FINAL BASIS

TNPURA DEPOT WILL ENTER THE BASIS

PROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT RATNPURA IS 451065.43

FIXED COST OF RATNPURA IS 3000.00

INITIAL VARIABLE COST OF RATNPURA IS 75362.96

CONTRIBUTION TO NETT SAVING BY INCLUSION OF RATNPURA IS 2482.92

POTS IN BASIS (303)

EPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
LONAWA	12437589.31	411000.00	648522.88
RDNIYA	2281633.81	15200.00	307110.90
TICALO	382731.37	7000.00	105984.40
RNGALA	884463.48	9850.00	115065.82
URPURA	394215.03	6000.00	72167.44
FFNA	485626.90	9350.00	129063.56
TNPURA	451065.43	3000.00	75362.96
LLE	969285.31	8850.00	113858.85
INABAY	333047.50	11500.00	42463.45
BLGODA	341810.64	7341.81	32125.27
DAMPE	538937.87	7538.94	53503.20
VKULAM	150684.03	7150.68	34514.11
VKCHRI	535437.35	7535.44	144881.19
ANAIKE	996221.93	7996.22	177595.09

KED COST OF KOLONAWA AND 13 DEPOT/S IS 519313.09
RIABLE COST OF KOLONAWA AND 13 DEPOT/S IS 2052219.12

TAL COST OF ALL COLLECTIONS = 80134.38

DUCED OVERALL COST = 2651666.60

INITIAL NETT SAVING BY INCLUSION OF RATNPURA IN THE BASIS IS -44808.85

PROVEMENT OVER COST OF PRESENT SYSTEM = 69803.67

PERCENTAGE IMPROVEMENT = 2.56

LE DEPOT WILL REMAIN IN THE BASIS

PROVED SUPPLY PATTERN

DITIONAL THROUGHPUT AT GALLE IS 576407.87

FIXED COST OF GALLE IS 8850.00
DITIONAL VARIABLE COST OF GALLE IS 96238.82

DITIONAL GROSS SAVING BY RETENTION OF GALLE IN THE BASIS IS 39900.57
CONTRIBUTION TO NETT SAVING BY RETENTION OF GALLE IS 68077.22

POTS IN BASIS

POT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST

LONAWA	11985330.06	411000.00	545286.80
RDNIYA	2281653.81	15200.00	307110.90
TICALO	382731.37	7000.00	105984.40
RNGALA	884463.48	9850.00	115065.82
URPURA	394215.03	6000.00	72167.44
FFNA	485626.90	9350.00	129063.56
TNPURA	326916.81	3000.00	42459.65
LLE	1545693.18	8850.00	210097.67
INABAY	333047.50	11500.00	42463.45
BLGODA	341810.64	7341.81	32125.27
DAMPE	538937.87	7538.94	53503.20
NKULAM	150684.03	7150.68	34514.11
VKCHRI	535437.35	7535.44	144881.19
ANAYKE	996221.93	7996.22	177595.09

XED COST OF KOLONAWA AND 13 DEPOT/S IS 519313.09
RIABLE COST OF KOLONAWA AND 13 DEPOT/S IS 2012318.55

TAL COST OF ALL COLLECTIONS = 80134.38

DUCED OVERALL COST = 2611766.02

DDITIONAL NETT SAVING BY RETENTION OF GALLE IN THE BASIS IS -4908.27

PROVEMENT OVER COST OF PRESENT SYSTEM = 109704.24

PERCENTAGE IMPROVEMENT = 4.03

LIGAMA DEPOT WILL ENTER THE BASIS

PROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT WELIGAMA IS 886241.40

CALCULATED INITIAL FIXED COST OF WELIGAMA IS 7886.24
INITIAL VARIABLE COST OF WELIGAMA IS 135277.80

INITIAL GROSS SAVING BY INCLUSION OF WELIGAMA IN THE BASIS IS 12566.9
CONTRIBUTION TO NETT SAVING BY INCLUSION OF WELIGAMA IS 4680.71

POTS IN BASIS

EPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
ONAWA	11985330.06	411000.00	545286.80
DNIYA	2281653.81	15200.00	307110.90
ICALO	382731.37	7000.00	105984.40
NGALA	884463.48	9850.00	115065.82
RPURA	394215.03	6000.00	72167.44
FNA	485626.90	9350.00	129063.56
NPURA	270608.72	3000.00	29096.11
LE	715759.87	8850.00	[illegible]

BLGODA	341810.64	7341.81	32125.27
LIGAMA	886241.40	7886.24	135277.80
DAMPE	538937.87	7538.94	53503.20
NKULAM	150684.03	7150.68	34514.11
VKCHRI	535437.35	7535.44	144881.19
ANAIKE	996221.93	7996.22	177595.09

XED COST OF KOLONAWA AND 14 DEPOT/S IS 527199.33
RIABLE COST OF KOLONAWA AND 14 DEPOT/S IS 1999751.60

TAL COST OF ALL COLLECTIONS = 80134.38

DUCED OVERALL COST = 2607085.32

INITIAL NETT SAVING BY INCLUSION OF WELIGAMA IN THE BASIS IS -227.57

PROVEMENT OVER COST OF PRESENT SYSTEM = 114384.95

PERCENTAGE IMPROVEMENT = 4.20

ANAIKE DEPOT WILL REMAIN IN THE BASIS

PROVED SUPPLY PATTERN

DDITIONAL THROUGHPUT AT OPANAIKE IS 729.49

CALCULATED ADDITIONAL FIXED COST OF OPANAIKE IS 0.73
DDITIONAL VARIABLE COST OF OPANAIKE IS 207.40

DDITIONAL GROSS SAVING BY RETENTION OF OPANAIKE IN THE BASIS IS 0.3
CONTRIBUTION TO NETT SAVING BY RETENTION OF OPANAIKE IS 3592.46

POTS IN BASIS

EPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
ONAWA	11985330.06	411000.00	545286.80
RDNIYA	2281653.81	15200.00	307110.90
TICALO	382731.37	7000.00	105984.40
RNGALA	884463.48	9850.00	115065.82
JRPURA	394215.03	6000.00	72167.44
FFNA	485626.90	9350.00	129063.56
TNPURA	270608.72	3000.00	29096.11
.LE	715759.87	8850.00	75616.46
INABAY	333047.50	11500.00	42463.45
ILGODA	341810.64	7341.81	32125.27
.IGAMA	885511.91	7885.51	135070.07
DAMPE	538937.87	7538.94	53503.20
IKULAM	150684.03	7150.68	34514.11
IKCHRI	535437.35	7535.44	144881.19
INAIKE	996951.42	7996.95	177802.49

XED COST OF KOLONAWA AND 14 DEPOT/S IS 527199.33
RIABLE COST OF KOLONAWA AND 14 DEPOT/S IS 1999751.27

TAL COST OF ALL COLLECTIONS = 80134.38

DUCED OVERALL COST = 2607084.98

DDITIONAL NETT SAVING BY RETENTION OF OPANAIKE IN THE BASIS IS -227.24

PROVEMENT OVER COST OF PRESENT SYSTEM = 114385.28

PERCENTAGE IMPROVEMENT = 4.20

SULTANT DISTRIBUTION PATTERN

TAL FIXED COST = 527199.33
TAL VARIABLE COST = 1999751.27

TAL COST OF ALL COLLECTIONS = 80134.38

TAL OVERALL COST = 2607084.98

NIMUM EXTRA COST IS 227.24

TAGALA DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-

BOPTLAWA	0.00
DIMBULLA	0.00
LINDULA	102284.24
PATANA	0.00
TALWKELE	129220.84
WATAGODA	1600.82

E TOTAL POTENTIAL SAVING IS 573.62

NIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 12426.38

PUTALE DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-
NONE
E TOTAL POTENTIAL SAVING IS 0.00

NIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 6500.00

TRWNKTYA	41845.55
UDAKRWTA	5126.64

E TOTAL POTENTIAL SAVING IS 3615.56

NIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 3656.13

HAWATA DEPOT IS A POTENTIAL SOURCE FOR THE FOLLOWING CENTRES OF DEMAND:-

AMBLTOTA	19543.16
BERAGAMA	0.00
DENIYAYA	58180.50
EMBLPTYA	28261.13
GODKWELA	37301.96
HAMBTOTA	24598.77
ITTAKNDA	0.00
KAHAWATA	105276.58
KATRGAMA	729.40
KOLONNO	0.00
LELOPTYA	0.00
PANLKNDA	0.00
PELMDULA	74439.97
RAKWANA	31350.09
RIDYAGMA	0.00
TISMRAMA	11436.67
UDAWALWE	0.00
WALAWE	972.65
WIRAWILA	0.00
YODKNDYA	0.00

E TOTAL POTENTIAL SAVING IS 6500.01

NIMUM EXTRA COST OF FORCING IT INTO THE BASIS IS 614.48

FECT OF DROPPING OPANAIKE DEPOT FROM THE FINAL BASIS

TARA DEPOT WILL REMAIN IN THE BASIS

PROVED SUPPLY PATTERN

DDITIONAL THROUGHPUT AT MATARA IS 8277.15

FIXED COST OF MATARA IS 7200.00
DDITIONAL VARIABLE COST OF MATARA IS 2277.41

DDITIONAL GROSS SAVING BY RETENTION OF MATARA IN THE BASIS IS 680.02
CONTRIBUTION TO NETT SAVING BY RETENTION OF MATARA IS 44822.54

POTS IN BASIS

EPOT PRESENT THROUGHPUT FIXED COST VARIABLE COST

TARA	640993.11	7200.00	101050.57
RDNIYA	2281653.81	15200.00	307110.90
TICALO	382731.37	7000.00	105984.40
RNGALA	884463.48	9850.00	115065.82
JRPURA	394215.03	6000.00	72167.44
FFNA	485626.90	9350.00	129063.56
LLE	969285.31	8850.00	113858.85
INABAY	333047.50	11500.00	42463.45
BLGODA	341810.64	7341.81	32125.27
DAMPE	538937.87	7538.94	53503.20
NKULAM	150684.03	7150.68	34514.11
VKCHRI	535437.35	7535.44	144881.19

XED COST OF KOLONAWA AND 12 DEPOT/S IS 515516.87
RIABLE COST OF KOLONAWA AND 12 DEPOT/S IS 2054436.94

TAL COST OF ALL COLLECTIONS = 80134.38

DUCED OVERALL COST = 2650088.19

DDITIONAL NETT SAVING BY RETENTION OF MATARA IN THE BASIS IS -43230.44

PROVEMENT OVER COST OF PRESENT SYSTEM = 71382.07

PERCENTAGE IMPROVEMENT = 2.62

PUTALE DEPOT WILL ENTER THE BASIS

PROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT HAPUTALE IS 627656.43

FIXED COST OF HAPUTALE IS 6500.00
INITIAL VARIABLE COST OF HAPUTALE IS 143598.42

INITIAL GROSS SAVING BY INCLUSION OF HAPUTALE IN THE BASIS IS 27144.0
CONTRIBUTION TO NETT SAVING BY INCLUSION OF HAPUTALE IS 20644.05

POTS IN BASIS

EPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
ONAWA	12616227.13	411000.00	631905.71
TARA	640993.11	7200.00	101050.57
PUTALE	627656.43	6500.00	143598.42
RDNIYA	2281653.81	15200.00	307110.90
TICALO	382731.37	7000.00	105984.40
NGALA	884463.48	9850.00	115065.82
JRPURA	394215.03	6000.00	72167.44
FNA	485626.90	9350.00	129063.56
LE	969285.31	8850.00	113858.85
INABAY	333047.50	11500.00	42463.45

ADAMPE	538937.87	7538.94	53503.20
NKULAM	150684.03	7150.68	34514.11
VKCHRI	535437.35	7535.44	144881.19

IXED COST OF KOLONAWA AND 13 DEPOT/S IS 522016.87
ARIABLE COST OF KOLONAWA AND 13 DEPOT/S IS 2027292.89

OTAL COST OF ALL COLLECTIONS = 80134.38

EDUCED OVERALL COST = 2629444.14

INITIAL NETT SAVING BY INCLUSION OF HAPUTALE IN THE BASIS IS -22586.3

IPROVEMENT OVER COST OF PRESENT SYSTEM = 92026.12

PERCENTAGE IMPROVEMENT = 3.38

ERDNIYA DEPOT WILL REMAIN IN THE BASIS

IPROVED SUPPLY PATTERN

ADDITIONAL THROUGHPUT AT PERDNIYA IS 105565.46

FIXED COST OF PERDNIYA IS 15200.00
ADDITIONAL VARIABLE COST OF PERDNIYA IS 21977.46

ADDITIONAL GROSS SAVING BY RETENTION OF PERDNIYA IN THE BASIS IS 2313.1
CONTRIBUTION TO NETT SAVING BY RETENTION OF PERDNIYA IS 64220.43

EPOTS IN BASIS

EPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
LONAWA	12615586.29	411000.00	631739.73
TARA	640993.11	7200.00	101050.57
PUTALE	522731.81	6500.00	119473.75
RDNIYA	2387219.27	15200.00	329088.36
TICALO	382731.37	7000.00	105984.40
RNGALA	884463.48	9850.00	115065.82
URPURA	394215.03	6000.00	72167.44
FFNA	485626.90	9350.00	129063.56
LLE	969285.31	8850.00	113858.85
INABAY	333047.50	11500.00	42463.45
BLGODA	341810.64	7341.81	32125.27
DAMPE	538937.87	7538.94	53503.20
NKULAM	150684.03	7150.68	34514.11
VKCHRI	535437.35	7535.44	144881.19

XED COST OF KOLONAWA AND 13 DEPOT/S IS 522016.87
RIABLE COST OF KOLONAWA AND 13 DEPOT/S IS [illegible]

TAL COST OF ALL COLLECTIONS = 80134.38

DUCED OVERALL COST = 2627130.96

DDITIONAL NETT SAVING BY RETENTION OF PERDNIYA IN THE BASIS IS -20273.21

PROVEMENT OVER COST OF PRESENT SYSTEM = 94339.30

PERCENTAGE IMPROVEMENT = 3.47

TICALO DEPOT WILL REMAIN IN THE BASIS

PROVED SUPPLY PATTERN

DDITIONAL THROUGHPUT AT BATICALO IS 2327.65

FIXED COST OF BATICALO IS 7000.00
DDITIONAL VARIABLE COST OF BATICALO IS 842.65

DDITIONAL GROSS SAVING BY RETENTION OF BATICALO IN THE BASIS IS 8.8!
CONTRIBUTION TO NETT SAVING BY RETENTION OF BATICALO IS 36999.15

POTS IN BASIS

EPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
LONAWA	12615586.29	411000.00	631739.73
TARA	640993.11	7200.00	101050.57
PUTALE	520404.16	6500.00	118622.23
RDNIYA	2387219.27	15200.00	329088.36
TICALO	385059.02	7000.00	106827.05
RNGALA	884463.48	9850.00	115065.82
JRPURA	394215.03	6000.00	72167.44
FFNA	485626.90	9350.00	129063.56
LLE	969285.31	8850.00	113858.85
INABAY	333047.50	11500.00	42463.45
BLGODA	341810.64	7341.81	32125.27
DAMPE	538937.87	7538.94	53503.20
NKULAM	150684.03	7150.68	34514.11
VKCHRI	535437.35	7535.44	144881.19

KED COST OF KOLONAWA AND 13 DEPOT/S IS 522016.87
RIABLE COST OF KOLONAWA AND 13 DEPOT/S IS 2024970.85

TAL COST OF ALL COLLECTIONS = 80134.38

DUCED OVERALL COST = 2627122.11

DDITIONAL NETT SAVING BY RETENTION OF BATICALO IN THE BASIS IS -20264.36

PERCENTAGE IMPROVEMENT = 3.47

ATNPURA DEPOT WILL ENTER THE BASIS

IPROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT RATNPURA IS 776732.82

FIXED COST OF RATNPURA IS 3000.00
INITIAL VARIABLE COST OF RATNPURA IS 109497.06

INITIAL GROSS SAVING BY INCLUSION OF RATNPURA IN THE BASIS IS 7479.6
CONTRIBUTION TO NETT SAVING BY INCLUSION OF RATNPURA IS 4479.63

EPOTS IN BASIS

DEPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
LONAWA	11985330.06	411000.00	545286.80
ITARA	640993.11	7200.00	101050.57
IPUTALE	373927.57	6500.00	88098.50
RDNIYA	2387219.27	15200.00	329088.36
ITICALO	385059.02	7000.00	106827.05
RNGALA	884463.48	9850.00	115065.82
URPURA	394215.03	6000.00	72167.44
FFNA	485626.90	9350.00	129063.56
TNPURA	776732.82	3000.00	109497.06
LLE	969285.31	8850.00	113858.85
INABAY	333047.50	11500.00	42463.45
BLGODA	341810.64	7341.81	32125.27
DAMPE	538937.87	7538.94	53503.20
NKULAM	150684.03	7150.68	34514.11
IVKCHRI	535437.35	7535.44	144881.19

XED COST OF KOLONAWA AND 14 DEPOT/S IS 525016.87
RIABLE COST OF KOLONAWA AND 14 DEPOT/S IS 2017491.23

TAL COST OF ALL COLLECTIONS = 80134.38

DUCED OVERALL COST = 2622642.48

INITIAL NETT SAVING BY INCLUSION OF RATNPURA IN THE BASIS IS -15784.73

IPROVEMENT OVER COST OF PRESENT SYSTEM = 98827.78

PERCENTAGE IMPROVEMENT = 3.63

PROVED SUPPLY PATTERN

INITIAL THROUGHPUT AT KAHAWATA IS 997790.43

CALCULATED INITIAL FIXED COST OF KAHAWATA IS 7997.79
INITIAL VARIABLE COST OF KAHAWATA IS 180721.04

INITIAL GROSS SAVING BY INCLUSION OF KAHAWATA IN THE BASIS IS 12032.8
CONTRIBUTION TO NETT SAVING BY INCLUSION OF KAHAWATA IS 4055.06

POTS IN BASIS

EPOT	PRESENT THROUGHPUT	FIXED COST	VARIABLE COST
LONAWA	11985330.06	411000.00	545286.80
TARA	576407.87	7200.00	86268.76
PUTALE	5026.98	6500.00	1533.73
RDNIYA	2387219.27	15200.00	329088.36
TICALO	385059.02	7000.00	106827.05
RNGALA	884463.48	9850.00	115065.82
URPURA	394215.03	6000.00	72167.44
FFNA	485626.90	9350.00	129063.56
TNPURA	270608.72	3000.00	29096.11
LLE	911104.81	8850.00	102832.48
INABAY	333047.50	11500.00	42463.45
BLGODA	341810.64	7341.81	32125.27
DAMPE	538937.87	7538.94	53503.20
NKULAM	150684.03	7150.68	34514.11
VKCHRI	535437.35	7535.44	144881.19
HAWATA	997790.43	7997.79	180721.04

XED COST OF KOLONAWA AND 15 DEPOT/S IS 533014.66
RIABLE COST OF KOLONAWA AND 15 DEPOT/S IS 2005438.38

TAL COST OF ALL COLLECTIONS = 80134.38

DUCED OVERALL COST = 2618587.42

INITIAL NETT SAVING BY INCLUSION OF KAHAWATA IN THE BASIS IS -11729.67

PROVEMENT OVER COST OF PRESENT SYSTEM = 102882.84

PERCENTAGE IMPROVEMENT = 3.78

SULTANT DISTRIBUTION PATTERN

TAL FIXED COST = 533014.66
TAL VARIABLE COST = 2005438.38

TAL COST OF ALL COLLECTIONS = 80134.38

OTAL OVERALL COST = 2618587.42

INIMUM EXTRA COST IS 11729.67

PLETION TIME = 08/17/47

ND OF JOB