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THE USE OF CAPITAL AND LABOR

IN CONSERVATION DIVISION CONSTRUCTION WORK

Evaluation Prepared for
The Agency for International Development
Under Contract No. AID/AFR-C-1499

by

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Fort Collins, Colorado

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1/ The Ministry of Works provided valuable assistance, as did the firm of Scott, Wilson, Kirkpatrick and Partners.

TABLE OF CONTENTS

		Page
	INTRODUCTION	1
I.	Employment-Population "Problems" in Lesotho	2
II.	Labor Intensive Versus Capital Intensive Cost Comparisons	18
III.	Benefits or Returns to Alternate Technologies	35
IV.	Summary and Conclusions	49

Appendix A: Conservation Division

Appendix B: Thaba Bosiu

Appendix C: Equipment Cost Analysis

Appendix D: Labor Intense Techniques in Conservation

The purpose of this analysis is to evaluate labor intensive and capital intensive techniques of Conservation Division construction of four conservation outputs (e.g., waterways, terraces, diversions and village roads). The analysis which follows compares labor intensive and capital intensive cost differentials, [1/] taking into account "financial" as well as "economic" investment returns. [2/] Additionally, recommendations are set forth regarding the type of resources that can be best employed in conjunction with labor to promote development change in Lesotho.

INTRODUCTION

The information which follows this report consists of summary and data analyses in several appendices. This report considers (Part I) the surplus labor problem in Lesotho; Part II summarizes equipment and labor cost differentials from Appendices A-D; Part III discusses financial and economic returns to alternative technologies; and Part IV is a summary of the conclusions of this evaluation. Detailed Appendix data and analyses are appended to this report on the following subjects:

[1/] Village roads are defined as essentially unimproved access roads that are partially graveled.

[2/] The former reflects pecuniary factors only, while the latter encompasses indirect and socio-economic effects of a nonpecuniary (e.g., employment) nature.

Appendix A: Conservation Division
Appendix B: Thaba Bosiu
Appendix C: Equipment Cost Analysis
Appendix D: Labor Intense Techniques in Conservation

I. EMPLOYMENT-POPULATION PROBLEMS IN LESOTHO

Consideration of labor intensive methods in public works construction merits attention primarily as unemployment and underemployment (surplus or slack labor time) exist.

At the present time, the number of total migrant workers in Lesotho approximates one-quarter million persons, including some 80+ percent of the prime age male labor force. Further, there likely will be a Basotho labor force approximating one million persons by the year 2000. Lastly, the weak demand for labor within Lesotho today is such that one-third to one-half of available labor time over a calendar year as of 1978 is not gainfully employed. [1/] Under such circumstances, it is not difficult to characterize Lesotho as a surplus labor nation. Effectively the situation is one in which:

1. Nearly one-half of the present labor force of some 550,000 persons is employed in the Republic of South Africa on an ambiguous basis that could lead to remigration to Lesotho.
2. At least one-third and perhaps as much as one-half of the domestically engaged labor force is underemployed over a calendar year.

[1/] This situation over the calendar year does not preclude the possibility of a peak load labor shortage. See R. Wykstra. "Farm Labor in Lesotho: Scarcity or Surplus?," LASA Discussion Paper No. 5, September 1978; and Part IV of this report.

3. New entrants to the labor force from the mid-1970's to 2000 will add from no less than 0.4 and likely 0.5 million persons to the labor force.

In short, Lesotho is a situation best characterized as one in which (a) labor absorption is a priority development need and (b) an inappropriate technology is a costly choice that may prove to be intolerable because it can and will lead to greater levels of unemployment and underemployment in the future.

The following pages comment upon the case for devoting more explicit attention to employment absorption in order to increase economic welfare for human resources in Lesotho. Particular attention is given here to select economic aspects of the value of human capital and fuller utilization of labor by adopting the appropriate technology in development project evaluations. [1/] In what follows, we shall briefly comment upon the illusion of economic efficiency (i); the potential magnitude of the employment and manpower problem in Lesotho (ii); economic considerations arguing for absorption of labor (iii); and the argument for placing direct economic values on employment or, alternatively, assigning actual costs to the disemployment arising from capital intense systems of production (iv).

Through whatever means, economic development has one ultimate general end: improvement of individual and national well-being. Sadly, this human end is one that far too frequently is obscurred or even

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[1/] Additional studies are presently being conducted by LASA regarding labor intensity in the private sector of the Lesotho economy.

obliterated. Repeatedly, economic development becomes an obsession with the "trees" and loses perspective of the "forest." Let us see why.

(i) The "Illusion of Efficiency

Preoccupation with a financial cost minimization or technical efficiency criteria which ignores returns to employment often has led to more rather than less underdevelopment. This circumstance arises when the choice of a given technology embodies the view that human capital is an economically valueless and expendable resource; i.e., employment is not overtly valued.

It is generally conceded that increased levels of output and income or enhanced economic welfare represent the rather general purpose of economic development. Further, it is most often assumed implicitly (if not overtly) that development programs which are more efficient or least costly in a technical sense are preferable to others that appear to be less efficient. It is this latter assumption, that an oft-times narrowly perceived form of (technical) economic efficiency is "best," which is illusionary and at issue in what follows. [1/]

Some of the benefit and cost impacts of development progress are economic, of both a direct and indirect nature. Many such economic impacts, however, are <u>not</u> translatable into pecuniary terms. Still other benefits and costs are not economic in nature at all! While this

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[1/] One can also question the former presumption as being an appropriate end (or measure) of development progress, a task which is beyond the point of these remarks.

is a relatively obvious truth, all too often one finds that development projects and programs are justified, judged and implemented upon the basis of naive economic efficiency criteria. That is, apparent least-cost methods or technologies needed to accomplish a goal are selected as superior. The potential dangers here are many.

The first error therein is that economic efficiency is only one, and not the only, or even the paramount, criterion of worth. Secondly, error often arises in that what is measured in pecuniary or economic terms may be measured incompletely, inadequately or even incorrectly. A third type of error is that nonpecuniary impacts, and particularly social or political factors, may not be recognized. Indeed, even when recognized, they very often are given less weighty recognition than pecuniary matter because of their qualitative or more nebulous character.

In short, then, the point simply is this: There may be value to doing things efficiently in a narrowly perceived engineering context; <u>however</u>, the danger that this criteria will be illusionary is large. What is a better or superior system can vary greatly due to analytical distortions. This in turn can lead to policy misdirections and development progress thus may stagnate or perhaps even be retarded.

Such is exactly what has happened far too frequently in developing countries. On the alleged grounds of being most efficient, one repeatedly finds that the "appropriate" technology or method used, let us say to conserve land resources, improve agriculture, or construct roads, is capital intensive or labor saving. At present, this is the precise situation that prevails at the top level of Lesotho's Conservation Division, although there are a few in the Division whose viewpoint

is broader. Sadly, AID's history also is partially characterized similarly, but again there are exceptions, and increasingly so in recent years.

The capital intensity orientation gives an illusion of efficiency in large measure because employed human capital is seen as of zero worth or value. Aside from the rather curious facts that capital intensive methods may be both more familiar to and of more economic benefit to donor nations, potentially serious problems thus arise for developing countries. Preoccupation with an illusionary effiency and hence capital using criteria explicitly assumes unemployment imposes no costs on a society. This is absurd.

In the first place, undue emphasis on capital can be contrary to a developing nation's comparative resource advantages, which clearly is the case for Lesotho. [1/] Secondly, it may well subvert the primary and very basic end of development itself; namely, meeting human needs and enhancing economic welfare. And it is this latter problem which precisely represents the central limitation to many existing development efforts in Lesotho.

[1/] While the argument is much simplified here (and beyond the scope of our purpose as well), two clear observations can be made concerning resource advantages. First, the available evidence rather clearly reveals that developing nations tend to experience serious physical capital shortages and frequently equally as severe labor or human capital surpluses. Second, economists are much prone to advocating, in general terms, that factors most scarce be conserved whereas those most abundant be utilized more fully. Paradoxically, capital intensive technologies precisely reverse this very axiom--with little or no economic explanation.

The employment of Basotho manpower is the fundamental means to meeting the goal of development: enhancing basic human needs, and economic welfare or well-being for both individuals and the nation. Consequently, additional jobs must be seen overtly as a benefit (or recognized as a social cost) when evaluating the appropriate technology. If viable work and hence income earning opportunities are absent or are destroyed, just how economic welfare is affected can be seen by looking at some of its components.

We can (nonexhaustively) define welfare to include some of the following socio-economic factors: (1) improved health and education; (2) social stability of the family unit; (3) greater opportunity equality, inclusive of improved intergenerational opportunities, equality by sex and more equal income distribution; (4) enhanced self-esteem and purpose; (5) clear national identity and political integrity-stability; (6) reasonable rural-urban patterns of population distribution and mobility; (7) stabilized forms of social interaction and security; (8) adequate social goods and public services; and (9) expanding private investments that evolve and develop inter-industry linkages leading to continued employment growth. It is especially factors such as these, as well as increased levels of income and output, which render the end of development progress a worthy objective. And it is employment or jobs for more rather than fewer human resources that generates such benefits.

When the efficiency of labor versus capital intensive technologies is compared, and the comparison ignores the value of employment, the

result is predictable. Capital using methods give the illusion of being superior in a naive least cost sense. If efficiency is going to be used as a real criterion to determine the best way of doing things, it is mandatory that benefit (cost) values be assigned to employed (wasted) human resources. Only through employment are many of the goals of development realized.

(ii) The Basotho Manpower Dilemma

If the basic needs of people are what development is all about, then it is appropriate to consider three groups in Lesotho: the youth who represent future worker-citizens; presently displaced migrant workers; and the vast army of underemployed Basotho left behind in today's economy.

In the year 2000, Lesotho's population will approximate two million persons. At the present time, it is probable that the Basotho labor force will number one million persons by the year 2000, and most of these persons are already born. [1/] This represents a labor force increase of some one-half million persons. That is the minimum number of new job opportunities required in some two decades.

Additionally, an average of about 200,000 Basotho migrant workers are annually employed in the Republic today, and most of these are the males in their most productive (prime-work age) years. At the same time, and likewise of paramount significance, underemployment is

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[1/] LASA Discussion Paper No. 5 (Wykstra, 1978).

extremely serious in Lesotho. Again, on a preliminary basis, it appears that from 30 to as much as 50 percent of Lesotho's supply of agricultural labor is underemployed on an annual basis. [1/]

Absorption of Basotho labor, both that available today and new workers in the future, must be seen as a priority now, and one of the highest importance. Failing that, unmet basic human needs and enormous resource wastes will characterize the future. Avoiding this scenario, and thus positively achieving developmental progress, demands full consideration of labor absorbing (capital saving) approaches to economic development in public works, in agriculture and in the transfer of technology to the modern sector.

The full employment absorption of one million human resources in 2000 A.D., hence the economic welfare problem confronting Lesotho, is enormous! In one sense, it really does not matter greatly what one assumes with respect to future Republic of South Africa growth in migrant employment. Yet, to make matters worse, consider that future migrant-worker employment decreases are probable. Also, substantial and very clear socio-economic costs accompany employment in the Republic. For example, output in Lesotho is not produced or lost because one of Lesotho's most valuable resources, its human capital, is exported abroad. In short, the immediate task is to generate new jobs for about three-fourths of a million Basotho. This will set the economic development, social welfare and political stability "stage" in Lesotho's future.

[1/] At supply levels and migrant work opportunities existing today.

And the future truly is here today. Evaluating alternatives and implementing action policies must be done now in order to meet the needs of an average of some 20,000 to 30,000 net additions yearly to the domestic labor force which can be expected in the future. The present employment situation must be regarded as a most serious and a very current problem, the enormity and present (not future) nature of which can no longer be ignored.

(iii) The Case for Labor Absorption

One very basic observation is in order at this point. It simply is not sufficient to judge the capital-labor content of an appropriate technology on narrow or pure economic efficiency grounds in Lesotho's case. To ignore the economic, social and political value of employment requires that one deny the very worth of economic development (improved well-being) itself! Yet this is precisely what naive economic analysis does in evaluating capital versus labor using techniques. One reason this happens which was noted earlier (section i, page 4) is that least-cost efficiency is seen as the paramount goal. Such an approach can hardly be justified in the case of Lesotho given the un- and under-employment magnitudes noted above--assuming development itself is worthwhile. Indeed, as with the case of using trade controls to protect infant industries, only a divergence from naive least-cost efficiency criteria will likely serve Lesotho's basic needs.

Even if one rather unrealistically assumes that private industry and the public sector grow six to ten percent per year and that migrant labor

employment remains at today's level in the year 2000, some one-half million new workers will need viable jobs. Hence, direct consideration favoring labor absorbing technology is appropriate in all sectors of the economy. And this is nowhere more apparent a need (and perhaps nowhere more ignored) than it is in public sector development projects. Thus we shall concentrate our attention here on the analysis of publicly sponsored programs which all too often claim to be economically efficient, but in fact are not and leave unchanged at best, or even worsen, economic welfare.

It was noted earlier (section i) that pecuniary or economic measures of costs (or benefits) may be inadequately or incorrectly perceived. There are, of course, many potential sources of understandable estimation errors inherent on evaluating, let us say, the costs of road or conservation construction. Labor productivity rates can be over (under) estimated, and capital operating costs also are subject to similar error (or bias). However, let us momentarily assume such errors not to exist or to be self-cancelling. There is yet another fundamental group of measurement errors: Those crudely aggregated here under the umbrella of assuming employment has no economic return.

In evaluating the optimum mix of capital and labor used to produce public goods, economists have, for example, carefully discussed such things as factor market price distortions for labor and capital inputs. Such distortions explain in part why capital intense methods of production appear to have lower costs than labor intense methods.

Factor market price distortions are seen as arising in part because market wages paid to labor overstate the social wage (i.e., the opportunity cost of slack labor to society). Additionally, a variety of implicit and explicit subsidies to capital tend to understate its real price (hence the real costs of a capital intense technology). If such distortions are not recognized, one does indeed encounter a bias toward the introduction and use of capital in developing nations.

In an attempt to adjust for factor price distortions, economists frequently develop a shadow wage for labor; that is, a wage surrogate is used to reflect the social value of using slack labor. Frequently, however, and in spite of seemingly erudite manipulative tactics directed at both theory and data, the conclusive result remains unchanged: capital intense methods "appear" superior. Hence they are adopted, and with a piety akin to Pontius Pilot, economic analysts presume a job well done. In fact, the job has not been well done at all.

Now the point here is not that of attacking often carefully done theoretical and analytical work on shadow wage rates. Nor is it to question philosophically certain capitalistic articles of faith such as economic resource efficiency. The task, frankly, is a much simpler one; namely, to assert that an obvious reality has been obscurred. Inasmuch as jobs are the <u>primary</u> catalyst to developmental ends as those mentioned above, the assertion that employment is a benefit is invalid <u>only if</u> development itself is an invalid end! Employment of more human resources properly yields a real economic return and, conversely, its increased unemployment imposes a real economic and social cost.

Physical capital is unlike human capital. The acquisition costs of equipment generate virtually no direct benefits to a developing (typically capital importing) nation. However, wages paid slack labor are both a cost of production and a direct and immediate return to human resources. [1/] Thus, capital is very unlike labor even though each is a resource input--yet economic analysis typically ignores this beneficiary distinction.

And it further is not sufficient to regard the real cost or shadow wage of labor as at or close to zero (in the extreme case of surplus labor with no opportunity cost). This approach or viewpoint only continues to obscure the employment benefit reality. What is relevant is to value and utilize the unused potential marginal product of labor as an otherwise wasted resource.

Upon observing a dam or a plant operating at one-fourth capacity, one does not meaningfully conclude its marginal product to be equal to zero. The 75 percent unused capacity of physical capital is seen as having a vast opportunity cost; i.e., lost benefits. So too must human capital be regarded.

Moreover, much reluctance would accompany an overt decision to alter the technology of a nation and direct investments to physical capital that

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[1/] This is especially important to developing nations. Unlike physical capital exporting nations, the developing country produces little of its own physical capital. Therefore, the developing nation bears the foreign exchange costs of physical capital imports and fails to generate "induced by" employment benefits that might affect (in part or whole) employment gains forthcoming from a more labor intense production method.

displaced and left unused, say, one-half its existing plant and machinery. The otherwise functional physical capital stock even though not most efficient is much too highly "valued" to permit such nonsense. Yet in a comparable setting, unused human resources are treated as valueless.

Thus, we find human capital erroneously treated as being like physical capital in that no direct return is ascribed to acquiring the use of the resource--when in fact employing labor resources is beneficial. Further, labor is also erroneously seen as being unlike capital equipment in that nonuse of physical capital in place is regarded as untenable and disastrous (e.g., depression) whereas labor subject to massive underutilization is seen and accepted as a norm in developing nations.

Wages paid labor clearly are a cost of production, but employment gains also produce a benefit under surplus labor conditions in much the same way that a physical capital resource such as a dam or reservoir is a benefit (to those able to irrigate farmlands) obtained at a cost.

To see labor as a cost of production in no way precludes considering employment benefits to a developing nation even though it is true that such benefits are not associated with the use of capital, except to the developed nation exporting physical capital. [1/]

[1/] It can be seen, then, that the failure to make this vital distinction between physical and human capital explains gross evaluation errors in comparing labor to capital intense technologies. What has happened quite simply is that the benefits derived from labor use have been underestimated as has the costs of capital intense technologies.

(iv) Conclusions and Policy Implications

The case for adoption of labor intense technologies and implementation of labor absorption policies is vastly greater than normally perceived. What pecuniary "value" one is to assign to incremental gains in employment directly and indirectly derived from a more labor intense technology is a more ambigious and difficult matter. However, given the existence of massive underemployment in Lesotho, one might presume initially that direct wages paid to labor are a market defined benefit or return to using human resources. As a starting assumption (and likely minimum value), we shall use the incremental wage bill as a surrogate value to employment in illustrating and evaluating the comparative efficiency of the capital and labor mix.

Treated thusly, benefit-cost comparisons, and hence the relative economic efficiency of a capital or labor technology, are altered vastly. For example, let us initially ignore employment effects, and assume that the discounted value of the benefits of a labor or capital intense road project have some equal value per Km, defined as B. The comparative costs using two alternative technologies or methods of production, capital (K) and labor (L) are presumed to be respectively: (K) = R 3,200, and (L) = R 5,000 per Km. [1/] Thus, the added or marginal cost (MC) of using a

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[1/] The example used herein is drawn from Lesotho's Basic Agricultural Services Program (BASP) for feeder road construction in Blocks V and VI (Dec. 9, 1977 documents). These cost estimates (adjusted by the author upwards by 20% to reflect inflation factors) are as follows:

Capital Intense Technology Costs			Labor Intense Technology Costs	
Σ (000)	Per Km.		Σ (000)	Per Km.
90	400	.....labor.....	735	3,600
575	2,800	.....capital.....	290	1,400
R 665	R 3,200	.....sum.....	R 1,025	$ 5,000

more labor intense technology is R 1,800 per Km (CL-CK=MC). Naively viewed, the capital intense technology would be regarded as least costly or superior because the ratio

$$\frac{BK}{CK} \quad > \quad \frac{BL}{CL}$$

(i.e., 3,200) (i.e., 5,000)

However, in using these two methods wages paid labor are R 3,600 for method L compared to R 400 for method K. One proxy value for the additional direct employment generated is the incremental wages paid labor of R 3,200 (R 3,600 - R 400). A benefit-cost comparison for a capital versus labor intense technology now is altered: benefits now are higher by the incremental value of employment or +R 3,200 for the more labor intense technology. In this illustration (and many actual instances), the labor intense technology can now be said to be superior. The benefit cost ratio for the capital intense technology is 3,200/3,200 = 1.0, but for the more labor intense method it is higher, or 6,400/5,000 = 1.28. [1/]

[1/] Wages paid using the capital intense (K^W) and labor intense (L^W) technologies are K^W = 400 and L^W = 3,600, or the surrogate value of incremental employment (V) is R 3,200 (i.e., $V = L^W - K^W$). Assume now the benefits of one Km of road are equivalent ($B^K = B^L$) and equal to $ 3,200 in net present value. For the capital intense technology, where CK = 3,200, we have:

$$\frac{B^K}{CK} = \frac{3,200}{3,200} = 1.0 .$$

However, the labor intense technology is valued more highly with inclusion of employment benefits:

$$\frac{B^L + V}{CL} = \frac{B^L + (L^W - L^K)}{CL} = \frac{3,200 + 3,200}{5,000} = \frac{6,400}{5,000} = 1.28 .$$

Even though the labor intensive method costs R 1,800 more per Km of road (5,000-3,200), it also creates more or marginal benefits (MB) in the surrogate amount of R 3,200 (3,600-400). Using the labor intense technology thereby has an <u>incremental</u> impact as follows: $\frac{MB}{MC} = \frac{R\ 3{,}200}{R\ 1{,}800} = R\ 1.77$; thus R.177 benefits accrue for each R 1 added in costs. [1/] Under such circumstances, it does indeed benefit a society to build a road using labor intensive or employment absorbing methods.

In summary, it is clear that how one regards the value of employment of human resources vastly affects the choice of an appropriate technology, and the welfare of nations such as Lesotho. The inclination of this author is to regard employment as having value, in some real measure. Therefore, added employment must be recognized as a tandem benefit to any benefit-cost comparison used to determine the "best" mix of capital and labor.

While the author has equated wages to the value of employment, it must be recognized that work has a great number of other direct and indirect personal, social, political and economic impacts. Whether such benefits are greater (as intuitively felt) or less than the wage bill may not be very material. The larger question is which of two postures is more nearly on the side of the angels: assuming employment is of no benefit; or presuming employment to be a benefit.

[1/] This example continues to assume the use of underemployed labor and that wages paid are a reasonable proxy for the value of employment.

II. LABOR INTENSIVE VERSUS CAPITAL INTENSIVE COST COMPARISONS

Detailed evaluations of estimated cost and output characteristic of conservation activities are presented in Appendices A through D. In what immediately follows, abbreviated summaries are presented of Appendix data for (a) the Conservation Division; (b) the Thaba Bosiu Conservation Project; (c) independently derived estimated equipment rental charges provided by William Niese, Jr. (of the Agency for International Development); and (d) labor intensive cost estimates.

The Conservation Division. The unavailability or poor quality of relevant financial and economic data from the Conservation Division limits the evaluation and analysis which follows. [1/] Presently, the Conservation Division can be characterized as producing conservation works that embody a relatively high capital component, although the equipment in use tends to be oriented to multiple use and is light in nature.

On the basis of equipment owner cost data (Appendix C) and the history of equipment productivity relationships over several years in Thaba Bosiu (Appendix B), it is possible to assess the cost of protecting a typical 650 Ha area. Productivity rates shown below are based upon the same capital intensive methods as used from 1973-78 by Thaba Bosiu. (Equipment input requirements are based upon the "best" productivities experienced by and also shown for 1978 in Thaba Bosiu in

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[1/] The reader should consult Appendix A for further details on the Conservation Division.

Table B-1b.) Equipment charge rates are those derived in Appendix C. Costs are based upon full replacement costs for reasons noted fully on pages C-7 ff. What has happened in Lesotho is an experience of low annual rates of utilization of about 650 hours/year. This situation has prevailed for conservation works for a number of years in Thaba Bosiu and the Conservation Division.

At the time of this study (January 1979), a great deal of investigation as to the actual number of hours of capital equipment utilization per unit per year was conducted. The Conservation Division itself does not maintain records of the hours of equipment use for conservation works, although Mr. Bonnema did indicate that about 700 hours per year was an approximate level of use. This same investigation elicited recognition from Mike Nyquist and Leroy Scherer (Conservation Engineers at Thaba Bosiu and the Conservation Division) that Thaba Bosiu was at least equal to if not superior to the Conservation Division in achieving hourly use per year from its capital equipment.

Engineering data for the five year period and the best year (1978) in Thaba Bosiu also reveal a use achievement of 600 to 700 hours yearly per unit of equipment to be a clear norm (see pages B-6 to B-8). Moreover, plant pool records in the Ministry of Works in Lesotho, a wide variety of working experience in other nations in Africa, as well as other LDC's throughout the world, and equipment manufacturers' manuals confirm these utilization rates to be in the range of achievable norms. In final conferences held with Bonnema, Scherer and Nyquist concerning Conservation Division use rates of capital equipment, 650 hours per year

was agreed upon to be a reasonable norm for this study. Each individual expressed his own opinion that 600 to 700 hours of actual annual use was in fact a reasonable level at these meetings. In view of these men's field experience, the author must rely on their judgment, especially since it seems to be corroborated by other data, as mentioned above.

As to the appropriate cost or equipment charge, it is clear from much precedent work that a replacement cost basis is the only rational comparison basis that can be used. To do otherwise not only vastly understates the cost of the one comparative capital intense technology in Lesotho's near term future; it further places the entire nation in a situation of not having a capital stock to use in future years as undercosted capital consumption mounts (see Appendix C for greater detail on these issues).

What the data below reveal is that a capital intense approach costs the Conservation Division some R 208,000 to treat 650 Ha--an average outlay of about R 320 per Ha of land treated at 1979 price levels. About 11 to 12 percent of this amount represents nonprofessional labor cost expenditures.

Capital Intensive Methods
650 Ha Conservation Protection

	Waterways	Terraces	Diversions	Village Road	Total
i. Km of Output	13	162	4.3	7.7	
ii. Equip Cost in R/Km(a)	2,430	590	1,520	1,920	
iii. Aggregate Equip: Costs in R	31,600	95,580	6,540	14,780	148,500
iv. TOTAL COSTS(a) IN R	44,600	133,400	9,200	20,800	208,000

Includes (iii) plus

A. Labor Costs		32,600
8 Equipment Operators	16,000	
1 Sr. Foreman	2,000	
1 Vehicle Driver	1,000	
2 Conservation Assts.	2,400	
1 Sr. Conserv. Asst.	1,500	
8 Laborers	3,200	
1 Timekeeper	800	
1 Watchman	500	
1/2 Engineer	2,200	
1 Asst. Cons. Officer	3,000	
B. Equipment Mobilization, Materials, etc.		26,900

(a) See page 7. Data are based upon adjusted hourly equipment charges for replacement and use cost shown in Appendix C and machine hour requirements shown in Appendix B.

The cost of protecting 650 Ha shown above is thus about R 208,000. (Protection ratios are 1 Km road : 84 Ha, 1 Km terrace : 4 Ha, 1 Km waterway : 50 Ha, and 1 Km diversion : 150 Ha.) In using this particular resource mix (which is very capital intensive in nature), some 6,500 mandays of employment are required in the aggregate. Employment relative to area protected averages about 10 mandays per Ha and total costs per Ha of area protected are: [1/]

[1/] Table A-1 details Km per Ha of area protected conversion factors.

	Cost in R/Ha
Waterways	68.62
Terraces	205.61
Diversions	14.15
Village Roads	32.00
Total Costs =	R 320.38

The costs shown above also include other site overhead costs approximating less than 20 percent of direct equipment costs. Direct hourly equipment costs constitute some 71 percent of total costs or R 228 per Ha.

Now these data are suggestive of some interesting relationships. With an annual recurrent budget provision approximating R 1 million yearly, the Conservation Division might generate protection for some 3,000 Ha per year. Thus, it would require a period of some 100 years, for example, to provide conservation protection for 300,000 Ha of land in Lesotho at the R 1 million budget level.

Thaba Bosiu Costs and Output. [1/] On the basis of Thaba Bosiu production data (see Appendix Table B-1) and equipment cost (again including capital replacement based upon 650 hours of operating use per year as discussed in Appendix C), it is possible to estimate equipment costs for output in 1978, given the mix of equipment used during this year to build conservation works. They are as follows:

[1/] See Appendix B.

1978 Thaba Bosiu Outputs:	Equipment Costs			
	Waterways	Terraces	Diversions	Village Road
i. Km produced	10.1	164.2	2.57	11.7
ii. Aggregate Hours of Equipment Time (a)	655	2,874	115	530
iii. Total Equipment Costs (b)	R 24,500	R 96,300	R 3,900	R 22,400
EQUIPMENT COST PER KM	R 2,425 (say, 2,430)	R 587 (say,590)	R 1,518 (say, 1,520)	R 1,915 (say, 1,920)

(a) Detailed equipment hours by type are shown in Table B-1b.

(b) Cost charges per operating hour (as adjusted in Appendix C, page C-13) for each type of equipment x total hours of use by equipment type shown in Appendix B-1.

Machine productivity was higher in 1978 than for the entire project period. In 1978 hours required per Km of output averaged 60 to 65 percent of the 1973-78 requirements for all but roads. Thus, equipment costs for 1973-78 would be half again as large as those levels shown above for 1978. The improved productivity levels for 1978 appear to be more representative of standards today. Further, it must be remembered that these data are only cost of equipment; i.e., they do not include site overhead, labor and material costs. Cost data evaluated elsewhere [1/] revealed that equipment charges approximated 71 percent of total costs. On this basis, then, we can estimate total costs for 1978 project output as, say:

[1/] See Appendix pages C-13 ff.

		Total Cost
i.	Waterways:	R 3,430/Km
ii.	Terraces:	R 825/Km
iii.	Diversions:	R 2,140/Km
iv.	Village Roads:	R 2,700/Km

Estimated equipment costs at the lower hourly charge rates, which approximate present rental charges, assume no less than 1,000 hours of use yearly as an expense of ownership of equipment. The earlier noted costs of equipment (e.g., R 2,425 for Waterways) then would approximate total costs because of greater equipment utilization. A lower hourly charge rate (as a result of 1,000 hours annual utilization instead of 650 hours) is close to the same proportions as is the cost differential between total costs and equipment costs (the latter excluding labor, site overhead, materials, etc.). These above costs, to the extent that they reflect known and experienced inputs and outputs, likely provide a more reliable basis for comparison than do those developed in and shown in Appendix C and considered next. 1/

1/ Using the cost data of Appendix C as a comparison basis (at say 25 % overall equipment efficiency levels), results in the following total cost estimates:

i.	Waterways	= R 0.332/M^3 x 1,200 M^3	=	R 398/Km
ii.	Terraces	= R 1.284/M^3 x 2,000 M^3	=	R 2,568/Km
iii.	Diversions	= R 1.284/M^3 x 4,500 M^3	=	R 1,369/Km
iv.	Village Roads	= R 1,268/M^3 x 1,080 M^3	=	R 1,369/Km

These costs differ from those experienced and presented above in the text in part because of differing methods of construction and also because of equipment type differentials (e.g., waterway charges per M^3 reflect a different system of production and use of D-6 Cats). Field conservation engineers in the Conservation Division can best evaluate the feasibility of the production methods inherent in the Niese cost analysis shown in i to iv above and in Appendix C. However, the vast differences in cost by type of output (e.g., waterways) and the uniformity of cost per M^3 in ii, iii and iv above pose questions difficult to answer.

Estimated Rental Charges Per M^3. It is not difficult to understand the Division's aversion to renting capital equipment. The Ministry of Works (and any other private rental agency) requires hourly use and charge minimums. In Lesotho, the Ministry of Works has a 63 hour/week minimum charge/use rate when the renter has an operable machine on short-term hire (page C-49) and 520 hours+ for long-term hire over a 3+ month quarter. If the Division was effective in operating such equipment one-half or two-thirds of the time it was paid for and available, actually hourly cost would rise dramatically. What actually happens in the Conservation Division's costing system is that equipment life is stated at, e.g., 12,000 hours for a Grader or D-4 Dozer (see page A-7). This is totally unrealistic and results in inflated life factors and a fabricated figure understating the cost of equipment (see Appendix C, including pages C-42 ff). There is no point in making capital-labor cost comparisons on a fictitious basis that, by design, states capital costs at half or less the real cost levels incurred.

Appendix C presents engineer cost analysis estimates for select types of capital equipment used in conservation works. [1/] These data as originally constructed (page C-16) did not provide for equipment replacement and have been adjusted for that particular factor (see pages C-6 to C-10). For the major types of equipment used in developing detailed costing sheets by output, inclusion of replacement costs increased depreciation charges by some 61 percent after taking into

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[1/] Provided in their original form by William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

account salvage values. Additionally, the hourly use per year basis for costing conservation works was based upon 650 hours per year. This conforms to the experience of conservation works in Lesotho. Consequently, 5,200 hours of actual use over an effective eight year life is used instead of say 12,000 hours which presumes a 15+ year life that is not probable in developing nations. [1/]

The combined impact of these cost adjustments is to provide for capital recovery (replacement) under use conditions experienced in Lesotho. However, depreciation charges per hour also increased substantially due to these adjustments. Maintenance costs were taken at the normal rate of 100 percent of acqusition costs, however, when spread over an effectively lower work life, [2/] hourly maintenance costs also increased. No additional costs (e.g., overhead or taxes) were included so as to best approximate real owner possessionship costs to the Conservation Division in possessing capital equipment.

These hourly rate charges for four types of equipment used most frequently in conservation construction are as follows:

	Equipment Charge Rates		
	A	B	C
Cat D-6	R 49.68	R 33.67	R 34.20
Scraper (613)	45.16	30.69	30.99
Grader (120G)	40.32	27.48	27.78
Cat D-4	27.14	18.85	n.a.

(A = 650 hrs/year, B = 1,000 hrs/year, and C = estimates of rental rates by Niese excluding replacement costs.)

[1/] Appendix pages C-6 to C-10 and C-42 to C-45 as well as Appendices A and B explain these adjustments in greater detail.

[2/] POL charges are estimated at standard rates and operator costs are included in site labor charges.

Column A is a charge rate based on 650 hours annual use in contrast to 1,000 hours (Column B) and Column C represents estimated rental rates with no replacement of capital.

It also was necessary to evaluate alternative rates of equipment efficiency since the theoretical rates provided by the Caterpillar Handbook greatly overstate machinery productivity. Based primarily upon World Bank studies, the conclusion was reached that a realistic efficiency factor would approximate no less than 20 and no more than 30 percent of the theoretical norm (see pages C-5 and C-6). Indeed, from the information available, it would appear that 20 to 25 percent is most representative of capital equipment efficiency in Lesotho. 1/

The cost of works construction based upon the theoretical costing, and the methods of using equipment inherent in Niese's costing analysis 2/ can be summarized as follows:

At 25% Efficiency	Waterways	Terraces	Diversions	Village Roads
R cost per M^3				
Equip.	.240	.880	.880	.880
Labor & OH	.092	.404	.404	.388
TOTAL	.332	1.284	1.284	1.268
R Cost per Km	398	2,568	5,778	1,369
R Cost per Ha	7.96	642	38.52	16.26

1/ Caterpillar suggests using 32 percent for some of the conditions found in a developing nation (see Appendix C).

2/ See Tables C-2a to C-2f. For example, waterways rely upon two D-6 Cats. Also, the volume of earthworks per Km of output varies from labor intensive methods, particularly for terraces and diversions.

These unit costs would be halved at a 50 percent efficiency level (which is most unlikely to be applicable) and should be increased by 25 percent to depict a 20 percent efficiency factor in Lesotho. Adjustment for the lower hourly equipment rental rate instead of the ownership charge rate is accomplished by taking 80 percent of costs per Km or per Ha shown above. 1/

Taken together, the combined effect of relatively low efficiency rates and higher hourly charge rates increase construction costs significantly for capital intensive methods. However, these are the real-world conditions prevailing in Lesotho, a fact that cannot be avoided. In fact, real hourly equipment costs to the Conservation Division as owner and possessor based upon 650 hours use per year exceed Ministry of Works (MOW) plant pool hourly rental rates. In that sense, it would be less costly to require the Division to rent equipment from outside sources at going rates rather than supply the Division with capital equipment. Of course, since the MOW (or any rental agency) does impose short-term 2/ hire minimums of 63 hours weekly (or 40 hours weekly as a three month+ long-term hire), the total costs of equipment might not be lower to the Conservation Division on a rental basis. This would depend upon management efficiency in reaching effective operating rates achieved during a lease period; and if it was not improved it could be least costly to contract out all actual works construction in the Conservation Division.

1/ See pages C-12 to C-14 of the Appendix.

2/ See Table C-6 of Appendix C (p. C-48).

Labor Construction Unit Costs. The Conservation Division itself does not have realistic past project experiences with labor intense methods of production, thus meaningful cost data do not exist. The very limited prior attempts to work on a more labor intense basis are largely limited to Food for Work projects which are notorious for low productivity and no--or extremely poor--management of labor. The Division itself thus has somewhat of a bias against even considering a movement toward a more labor intense method. Consequently, data related to labor intense projects reviewed below is drawn from a well managed program now extant in Lesotho. [1/]

The Ministry of Works of the Government of Lesotho recently has, on an experimental basis, worked with labor intensive methods through the Labor Construction Unit (LCU). From those projects completed through 1978 (essentially road and airstrip construction), good data are available concerning costs and productivity. Some of the most relevant data estimates taken from Appendix D are as follows:

Labor Intensive Costs	Waterways	Terraces	Diversions	Village Roads	Total
Direct Employment/Km (in mandays)	860	427	2,530	507	
Direct Labor Costs, R/Km	2,064	1,225	6,915	1,904	
Site OH's, R/Km	688	342	2,024	406	
TOTAL COSTS, R/Km	R 2,752	R 1,567	R 8,939	R 2,310	
TOTAL COSTS, R/Ha	55.0	391.8	59.6	27.4	R 533.80 (a)
Employment/Ha (b) (in mandays)	17.2	107.0	16.9	6.0	160 m.d.

(a) Direct costs are R 416/Ha, about R 353 of which is labor cost.

(b) Includes 13 mandays of site OH labor.

[1/] See Appendix D.

The LCU project data shown above cannot be termed strictly a labor intensive technology since the ratio of labor to total cost is about 66 percent (R353 ÷ R534 per Ha). Nonetheless, as an intermediate technology, the LCU approach provides 1,600 percent more employment than the very heavily intense capital methods in the Conservation Division.

During the first four months of 1979, and since the cost-productivity data shown above were collected in January of 1979, the Labor Construction Unit has had more actual works construction experience on conservation projects at Ratau. The result of this experience was a doubling of the overall productivity rate embodied in the data shown above. Mr. J.R. Dawson concluded as a result of this very recent experience that the intermediate labor intense methods used by the Labor Construction Unit can achieve the results shown below. Essentially, total costs per Ha of area protected are now about 25 percent lower than previously projected, or some R 398 per Ha.

(Amended Ratau Productivity from LCU)

Labor Intensive Costs	Waterways	Terraces	Diversions	Village Roads	Total
Direct Employment/Km (in man days)	429	307	1,517	507	
Direct Labor Costs, R/Km	1,030	964	4,483	1,904	
Site OH's, R/Km	343	255	1,213	406	
TOTAL COST, R/KM	R1,373	R1,219	R5,696	R2,310	
TOTAL COST, R/HA	27.5	304.8	38.2	27.4	R 397.90
Employment/Ha (in mandays)	8.6	76.8	10.2	6.0	115 md

Source: J.R. Dawson, Lesotho Ministry of Works, Labor Construction Unit. (See Amendment Table D-1a, D-2a and D-3a of Appendix D.)

The higher productivity rates embodied in the above data (from overall 1.4 M^3 to 2.8 M^3 per manday on waterways) largely are the result of less haulage than was anticipated and much easier excavation than is found in highly compacted roadside environments (6 M^3 per manday excavation task work objectives were set and achieved at Ratau).

The initial estimated cost of R 533.80 per ha of area protected first noted above for labor intensive methods generated some 160 man-days of employment. The more recent LCU costs of R 397.90 per Ha involves estimated employment equal to 115 mandays. Just how these data compare with the costs of using capital intensive methods is shown on the following pages.

		Employment and Costs in Rand Per Ha			
		Direct	Site OH	Total(a)	Mandays Employed(b)
Waterways	CI	48.93	19.69	68.62	2.0
	LI	41.28	13.76	55.04	17.0
(Adj LI.....		20.59	6.86	27.45	8.6)
Terraces	CI	146.60	59.01	205.61	6.5
	LI	306.30	85.50	391.80	107.0
(Adj LI.....		241.00	63.75	304.75	76.8)
Diversion	CI	10.09	4.06	14.15	0.5
	LI	46.13	13.49	59.62	17.0
(Adj LI.....		30.03	8.13	38.16	10.2)
Village RD	CI	22.82	9.12	32.00	1.0
	LI	22.66	4.82	27.48(a)	6.0
AGGREGATE	CI	228.43	91.95	320.38	10
PER HA	LI	416.23	117.57	533.80	160(b)
(Adj LI.....		314.28	83.56	397.84	115)

(a) Site overhead is allocated on mandays of employment which lowers labor intensive road construction costs vis a vis capital intensive methods.

(b) Includes site overhead employing 13 persons for labor intensive. (Capital intensive employment is about one-third site overhead.)

A few observations should be made on certain cost components shown above prior to drawing comparisons.

1. Labor costs relationships originally used were known to be high in that they did not take into account a some 30 to 35 percent productivity increase the Labor Construction Unit anticipated in January of 1979. This was felt in January 1979 to result in reducing aggregate or overall labor intensive costs by some 25 percent to some R 400 per Ha. The adjusted labor intensive cost data now shown as based upon Ratau work clearly support this earlier expectation.
2. Equipment cost estimates (R 320/Ha) are based upon hourly charge rates that assume a continuation of the low annual operating rates (and correspondingly higher cost estimates historically known to apply. If machine utilization could be based on 1,000 annual hours of realized use, overall costs for capital intensive methods would decline to some R 200 to R 220 per Ha of area protected.
3. At the same time, it must be realized that the productivity levels used in this comparison for capital are based on the "best" year for Thaba Bosiu operations. The use of overall 1973-78 Thaba Bosiu productivities, which may best reflect what would occur for a new equipment package, would raise capital intensive costs to some R 480 to 520 per Ha. Additionally, future rises in fuel or rental costs or fuel rationing could impair a capital intensive system of production.

4. The above cost comparisons are purely "financial." They do not reflect relevent economic costs and benefits. In looking ahead toward a growing labor surplus, one might, for example, quite properly use a shadow wage of, say, R 0.80 to R 1 instead of the market price of labor of R 2.40 daily. [1/] This would reduce overall costs of construction by labor intensive methods to something like R 250 to R 280 per Ha, a circumstance which would favor adoption of more labor intensive methods.

We have postulated three basic possible cost level estimates for capital intensive methods, ranging from a low of R 220 per Ha to a high of R 480 per Ha. Since both Thaba Bosiu and the Conservation Division experience a rate of actual equipment use of some 600 to 700 hours/year, the lower estimate of R 220 per Ha based upon 1,000 hours use is fictional and not a reality. No meaningful cost comparisons can be achieved by presuming the Conservation Division will reach an efficiency rate in using capital they have not reached in the past--and one not normally achieved in other developing nations. The higher estimate of R 480 was derived from comparing all five years of equipment hours to total output produced or productivity in Thaba Bosiu. In one context this might best represent capital intensive cost/productivities for the Conservation Division if it engaged in new or expanded construction activities. However, if the Division did <u>achieve</u> the <u>best</u> levels of productivity reached by Thaba Bosiu, the mid-range cost estimate of R 320 per Ha would be a reasonable cost comparison.

[1/] Reflecting, let us say, the opportunity cost in the private sector, or maximum wages paid to subsistence agricultural labor.

Range of Costs in R Per Ha

	Low	Middle	High
Capital Intensive	R 220	R 320	R 480
Labor Intensive	R 265	R 398	R 534
Difference	R 45	R 78	R 64

Regarding the somewhat more labor intensive (66%) methods used on Labor Construction Unit projects, costs are estimated at a low of some R 265 to a high of R 534. The former approximates a shadow wage cost basis which is a well documented and accepted concept in comparing alternative technologies. The higher labor intensive cost level of R 534 is based upon the original estimates related to manday productivities in road construction prior to the Labor Construction Unit's actual waterway construction work in Ratau. The more recent middle cost estimate of R 398 per Ha may be the more realistic labor intensive cost comparison basis; however, this conclusion is deferred for the moment.

Momentarily ignoring the range of cost comparison estimates above, let us simply compare cost differences at like estimation levels. The labor intensive versus capital intensive cost differential ranges from some R 45 to R 78. That is, the more labor intensive approach used by the Labor Construction Unit:

1. May involve increased costs of R 45 to R 78, say R 65 per Ha protected.
2. Generates from 115 to 160 mandays of employment versus ten mandays under the capital intensive technology.

3. Thus a difference of about one-half man-year of additional work per Ha of area protected is produced with labor using methods at an incremental cost of about R 65 per Ha.

Based upon these observations and cost comparisons, it is strongly advised that more intermediate labor using technologies be studied. Unit costs for labor intensive methods might decline dramatically, for example, with the use of ox drawn scrapers, etc. Even though the direct cost differentials above seem to "favor" a capital intensive approach, such a conclusion is premature and unwarranted, as we shall see.

III. BENEFITS OR RETURNS TO ALTERNATE TECHNOLOGIES

Marginal Comparisons. From the cost comparisons noted above, one might reasonably conclude that the moderately labor intense methods used by the Labor Construction Unit would increase cost per Ha by say R 65, or Marginal Cost (MC) = R 65. This presumes, however, that the Division's orientation to and supervision of labor was of a higher quality than experienced in the past and very much competitive with Labor Construction Unit operations in the Ministry of Works. The Marginal Benefits (MB) from such a program are no less than 100 or more mandays of Basotho employment per Ha of area protected.

Thus, if one regards the value of such amounts of additional job opportunities as worth R 65 or more, it is justifiable and preferable to use the more labor intensive technology. Some alternative marginal benefit-marginal cost ratio relationships are presented below:

Marginal Benefit to Marginal Cost Ratio Comparisons

Marginal Benefits (MB) of 100 m.d. Employment	Marginal Costs (MC) of Labor Intense Method			
	$MC_1 = 0$	$MC_2 = 45$	$MC_3 = 65$	$MC_4 = 150$
MB_1 = R 0/m.d.	0	-	-	-
MB_2 = R 0.65/m.d.	0	1.44	1.00	.43
MB_3 = R 1.0/m.d.	0	2.22	1.54	.67
MB_4 = R 2.40/m.d.	0	5.33	3.69	1.60

As can be seen, comparisons involving no additional cost (MC_1) for labor intense methods produce infinite benefits and are thus preferable except when no benefits are postulated as being attached to employment generation as in MB_1. If MB_1 is held to prevail, then labor intense methods never are economical since the MB/MC ratio is negative (or 0). The MB/MC ratios for all reasonably applicable comparisons are positive and exceed 1.0; i.e., $MB_3/MC_3 = 1.54$ or $MB_4/MC_3 = 3.69$. What this means, for example, is that using a labor intense technology produces R 1.54 (or R 3.69) added benefits for every R 1.0 added costs. Thus, the labor intense project is superior to capital intense methods in conservation works.

Present Value and Multiplier Analysis. Since the task of this evaluation is to compare capital intensive to labor intensive methods, and not that of determining conservation benefits, [1/] we shall simply assume that soil conservation and other direct economic benefits due to road use, etc. are R 65 per year per Ha of area protected.

[1/] See the recent soil conservation evaluation for more detail in conservation benefits. K.C. Nobe, et.al., A Reconnaissance Level Evaluation of Soil Conservation Programs and Methods in the Kingdom of Lesotho, U.S. Agency for International Development, July 1978, Chapter IV.

Under these circumstances, and further assuming a 12 percent discount rate into perpetuity [1/] and yearly maintenance costs of R 10 per Ha per year, the discounted net present value (NPV) of conservation benefits (B) is as follows:

Year	Annual Benefit Flow	Annual Maint Cost	NPV of Net Benefits Per Year
1	R 65	R 10	R 55 x .893 = R 49.12
2	65	10	R 55 x .797 = 43.84
3	65	10	R 55 x .712 = 39.16
4	65	10	R 55 x .636 = 34.98
5	65	10	R 55 x .567 = 31.19
6	65	10	R 55 x .507 = 27.89
.	.	.	. .
.	.	.	. .
.	.	.	. .
.	.	.	. .
Σ = N	65	10	55 x 8.333 = R 458

That is, the NPV of direct financial conservation benefits (b) per Ha is R 458. This can be said to be the capitalized present value (at 12 percent), or the level of costs (C) one could incur to derive an annual benefit stream of R 55 yearly. [2/] At costs per Ha of R 458 also, the benefit/cost ratio would be:

$$\frac{B_{NPV}}{C} = \frac{458}{458} = 1.0 .$$

With costs per Ha of area protected as noted earlier and presuming equal benefits to either labor or capital intense methods, we have:

[1/] Land values are most commonly valued in perpetuity, thus land conservation benefits are likewise. See R.C. Suter, The Appraisal of Farm Real Estate, (Interstate Publishers, Inc.: Illinois, 1974), pp. 247 ff.

[2/] The ratio $\frac{B}{i} = \frac{R\ 55}{.12} =$ R 458 capitalized value in perpetuity.

Capital Intensive	Labor Intensive
$\frac{B_{NPV}}{C} = \frac{458}{320} = 1.43$	$\frac{B_{NPV}}{C} = \frac{458}{530} = 0.869$, or $\frac{458}{398} = 1.15$

Thus far, then, the B/C ratio favors capital intensive methods where each R 1 in cost returns a present value of net benefits over time equal to R 1.43. [1/]

The analysis above can be said to reveal a financial rate of return (FRR) for capital intensive methods of 17.2 percent and at the higher labor cost of R 530 per Ha, the rate of return is 10.4 percent. However, this comparison may be misleading if it excludes some economic benefits and costs such as the impact of employment effects. And this is not the economic rate of return (ERR) unless, of course, one makes the untenable presumption that employment is of no benefit to a developing nation which has slack labor time.

Economic Return Comparisons. Including the value of generalizing more employment opportunities completely alters the partial analysis shown above. Our evaluation to date has shown that the cost per Ha of labor intense methods likely is about R 398 and that MB = R 458, plus one must add labor intense employment gains of 105 more direct mandays, plus no less than +10 mandays of indirect employment, or a total of say

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[1/] Alternatively, the internal rate of return equalizing benefits to costs = 17.2% for capital intensive methods $\left(\frac{R55 \div .172}{R320} = \frac{R\ 320}{R\ 320} = 1.0 \right)$

and = 10.4% for labor intensive methods $\left(\frac{55}{.104} = \frac{R\ 530}{R\ 530} = 1.0 \right)$.

115 mandays. [1]

The comparison reflecting this consideration is as follows, where each manday of employment incrementally gained is valued at R 1.40: [2]

		Capital Intensive		Labor Intensive
Benefits to Conservation	=	R 458		R 458
Benefits of Marginal Employment Gain	=	0		R 161 (115 md x R1.40)
TOTAL BENEFITS HA		R 458		R 619
TOTAL COSTS HA		R 320		R 398
	=	1.43	=	1.55

The conclusion quite simply now is that the most cost effective technology is the labor intense system of producing conservation works.

Detailed Multiplier Benefit-Cost Analysis. What follows explains the mechanics of the conclusions noted above in greater detail. It is further assumed here that the cost of labor intense production is the highest level (R 530/Ha) whereas the mid-range estimate (R 320/Ha) is used for capital intense methods.

Previously it was shown that labor intensive methods generated an estimated 160 mandays of total employment per Ha of area protected, including 13 mandays due to site overhead costs. In comparison, capital intensive methods generated some 6,500 mandays of employment for a 650

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[1] The multiplier derivation is explained below for several levels of expenditure leakage. For the evaluation at hand, the 10 mandays of added indirect employment is simply based upon a 85 to 90 percentage leakage rate for direct employment multipliers.

[2] R 1.40 is clearly at or above the standard subsistence wage in Lesotho, and thus denotes one measure of increased worker welfare/consumption.

Ha area--or about 10 mandays per Ha (about one-third of which is attributable to site overhead costs). To derive the ERR and make economic comparisons we must account for the differential of (a) an additional maximum of 150 marginal mandays of direct employment (hence more local consumption) and also (b) indirect-induced employment-consumption impacts. This latter increases income and spending, thus indirect employment increases will stem from and be induced by the use of local labor. 1/

The impact of incremental gains of 150 mandays of direct and an unknown amount of indirect-induced employment is illustrated below under differing employment-output multiplier assumptions. 2/ Thus, Column C shows that in a period of, say one year, 150 incremental mandays of direct employment "create" still another 50 mandays of work (or 150 x K of 1.33 = 50 mandays of indirect employment in year one). Indirect employment is both a result of that induced by suppliers of inputs and

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1/ See E. Costa, et.al., Guidelines for the Organisation of Special Labour-Intensive Works Programmes, International Labor Organization (Geneva: 1977) for greater detail on employment impacts, especially pages I-31 to I-47 and VII-5 to VII-14. Select observations here are that "...for land improvement projects the upstream effects (production of inputs such as seeds, fertilizers, etc.) and the downstream effects (transport, storage and marketing of products) will doubtless be appreciable even in terms of percentages of direct employment," (page I-40) or that "direct productive projects (land improvement, terracing, drainage) can durably increase the volume of employment and income," (p. 39).

2/ Indirect-induced employment varies according to the proportion of new expenditures from the incremental employment gain of 150 mandays that is spent within the Lesotho economy. If we assume that only 33% of the increase in income from added mandays of employment is spent within Lesotho--or a 75% "leakage" factor--the period multiplier (K) is 1.333 as shown in Column C. The generalized explanation and illustration of multiplier impacts which follow are purposely simplified here for clarity purposes. See E. Costa.

also that stemming from increases in incomes and spending. In turn, expenditures from this indirect employment create still more employment in a subsequent period of time, etc. Column A depicts the larger multiplier impact associated with 50 percent of increased income being spent outside a local economy and Column B depicts the smaller period multiplier (K = 1.33) for a 75 percent leakage in expenditures which assumes 25 percent of labor expenditures stay in Lesotho.

A. Direct Gain in Employment →	+150	+150	+150
Time Period Or Year	A $K = \frac{1.0}{.5} = 2.0$	B $K = \frac{1.0}{.75} = 1.3$	C $K = \frac{1.0}{.67} = 1.5$
1	+ 75.0	+ 37.5	+ 50.0
2	+ 37.5	+ 9.4	+ 16.7
3	+ 18.8	+ 2.3	+ 5.6
4	+ 9.4	+ 0.6	+ 1.9
5	+ 4.7	.	+ 0.6
6	+ 2.3	.	.
7	+ 1.2	.	.
8	+ 0.6	.	.
.	.	.	.
.	.	.	.
B. Employment Created = N	+ 150	+ 50	+ 75
Total Employment Change.....	+ 300	+ 200	+ 225

Suppose we assume that new employment created is +75 mandays (Column C), which is associated with a 67 percent leakage of expenditures reasonably

characterizes Lesotho. [1/] If the proxy "value" for newly created employment is taken at the daily wage rate of R 2.40, a labor intensive method of construction will generate an additional +R 180 (75 x R 2.40) in new indirect employment benefits as shown in Column C.

Further, the initial 150 mandays of incremental employment gained via use of a labor intensive method has some value in an increased income-consumption context. If we arbitrarily presume this to be R 1.20, Column B denotes direct employment benefits gained which also have a surrogate value of R 180 (150 x R 1.20).

Year	(A) NPV of Net Conservation Benefits/Year/Ha	(B) Direct Employment of 150 m.d. x R 1.20	(C) Created Employment at R 2.40	(D) Estimated Employment x Benefit	(E) NPV of All Employment Benefits
1	R 49.12	+ R 180	50x2.40=R120	R 300	x.893=R267.9
2	43.84	0	16.7x2.40=40	40	x.797= 31.2
3	39.16	0	5.6x2.40= 13	13	x.712= 9.3
4	34.98	0	1.9x2.40= 5	5	x.636= 3.2
5	31.19	0	0.6x2.40= 1	1	x.567= 0.6
6	27.89	.	.	.	.
.	.	.	.	.	.
Σ=N	R 458	+R 180	75x2.40=+R 180	+R 360	+R 311.20

[1/] A large proportion of Lesotho incomes are spent abroad. However, since the data herein are primarily illustrative and also because most authorities argue that the period multiplier in developing nations rarely is less than 1.5, the assumption herein likely is reasonable. Also estimated final consumption expenditures approximated R 267 million in 1977/78 while net imports adjusted for business-government services and purchases of equipment approximated 150-180. Thus a reasonable proportion of consumption likely does not leak out of the domestic economy. See "Lesotho's Agriculture: A Review of Existing Information," LASA, October 1978, pp. 1-5 and 10-12.

As a consequence of so "valuing" employment, the previously illustrated benefit-cost comparisons between capital intensive and labor intensive methods is altered significantly. Incremental employment gains of +225 added mandays of employment has present value, say, of R 310. Thus, total benefits are R 768 (R 458 + Column E or 310). These employment gained benefits can now be factored into our comparison of alternative technologies. The respective B/C ratios now are about equal as is shown below:

Capital Intensive	Labor Intensive
$\frac{B_{NPV}}{C} = \frac{458}{320} = 1.43$	$\frac{B_{NPV}}{C} = \frac{768}{530} = 1.45$.

The nature of the above illustrative data and analysis is now such that an economic rate of return can be said to be derived (in part). Inclusion of employment as an economic reality as well as an end of development has altered the former "financial" conclusion that the capital intensive method is "best." [1/] On the basis of the economic information above, then, the ERR of the labor intensive method is equivalent to 17.39 percent annually as compared to a financial return of 17.19 percent for the capital intensive method.

Using these benefit-cost relations and the 650 Ha area treated "model" discussed on page 21, we would produce 13 Km of waterway, 162 Km

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[1/] Actually one might also adjust labor intensive costs of R 530 for a shadow wage, which has the effect of favoring still further the labor intensive technology.

of terrace, 4.3 Km of diversions and 7.7 Km of village roads. Benefits and costs vary as a result of inclusuion of the employment impact discussed above.

	Capital Intense	Labor Intense	Difference
Costs			
No Ha Protected	650	650	0
Total Cost R/Ha	R 320	R 530	+R 210
Aggregate Total Cost	R 208,000	R 344,500	+R 136,500
NPV Marginal Cost of Labor Intense			R 136,500
			R 210/Ha
Benefits			
Annual Conservation/Ha	R 55	R 55	0
NPV Benefits/Ha	R 458	R 458	0
NPV Cons. Aggregate Benefits	R 297,000	R 297,000	0
Employment in m.d./Ha	10	160	150
Total Employment on 650 Ha	9,750	156,000	146,250
Direct Employment	6,500	104,000	97,500
Indirect Employment	3,250	52,000	48,750

NPV Marginal Benefit of Labor Intense Method:..... R 201,500
(R 310/Ha)

Added Employment = 146,250 m.d.
Rand Value of Direct Employment R 1 per m.d. = R 97,500
Rand Value of Indirect Employment R 2.40/m.d.= R117,000
(NPV based upon 12% discount rate and 146.250 m.d. x R 1.378/m.d.)

Total Benefits $R\ \frac{297,000}{208,000} = 1.43$ $R\ \frac{498,500}{344,500} = 1.45$.

While financial marginal costs (MC) are higher by MC = R 136,500 in a cost comparison admittedly unfair to labor intensive methods, the economic marginal benefits (MB) are still greater in the amount of marginal benefits ($M_{B)}$ = R 201,500 for the labor intensive technology. Total benefits in an absolute context also are greater in using labor intensive methods.

In conclusion, the comparison just shown suggests that labor intensive methods likely generate marginal economic benefits sufficiently

large enough to counter the impact of their higher marginal financial costs. Because the labor intensive M_B/M_C exceeded the overall B/C ratio, labor intensive methods are most appropriate. Total benefits in an absolute context also are greater in using labor intensive methods.

Other "Economic" Returns. Clearly the benefits of employment discussed above are an important economic return. There are a number of social and indirect benefits to labor intensive works programs which tend to be excluded in a purely financial evaluation of project rates of return. These socio-economic factors overwhelmingly argue against the continued heavy use of relatively scarce capital resources in a surplus labor economy, particularly if capital intensive production leads to labor displacement. A move toward more labor intensive methods of works construction in Lesotho generates the following eight categories of benefits that cannot be readily identified in pecuniary terms.

1. Increased capacity in agriculture. Local interest in agricultural pursuits (and land conservation) is enhanced by the fact that workers have a supplementary employment option on their own, or their village, farm lands. Such an interest can be especially important to works maintenance and to increased farm output objectives.
2. Avoiding urban migration costs. Migration to urban areas in the future may be mitigated with more labor intensive works in the Conservation Division. Generally speaking, a somewhat balanced dispersal of population tends to minimize social costs attendant to a burgeoning urban population.

3. Social stability. The evolution of a potentially satisfied populace and socio-family solidarity is enhanced as supplementary nonfarm employment options are made available. Political, social and family benefits of a nonpecuniary nature stem from greater opportunities for domestic employment. The push of recent decades toward migrant labor in the Republic of South Africa, as well as the hidden effect of disemployment (due in part to using capital intensive methods) are destabilizing influences in Lesotho.
4. Human resource worth. Local employment generates benefits in the form of an enhanced sense of personal worth; learning by doing, or the accretion of additional skills over time; and ultimately increases the productivity of Basotho labor. In a very real sense, then, the stock of human capital available in Lesotho grows as a by-product of labor intensive projects.
5. Intergeneration effects. There is a difficult to enumerate but important intergeneration impact stemming from higher levels of health, education and consumption possible through employment in labor intensive systems of production. Future as well as present workers benefit from jobs, and the reality or a reasonable expectation of future employment being available within Lesotho likewise is important. In contrast, adverse intergeneration effects are associated with fewer jobs.

6. International vulnerability. The present level of reliance on the Republic of South Africa for nonfarm work carries with it a high degree of political and economic vulnerability to powers and events external to Lesotho. Any change away from this posture, whether due to the result of labor intensive production systems or to the adoption of import substitution policies, for example, may be construed as beneficial to the Lesotho economy.

7. Crisis potential. There is present today a prospective reemployment crisis, due to past heavy reliance on migrant employment and also due to future probable labor force growth. The option value of experience now with labor intensive programs may be enormous to the Government of Lesotho. By way of contrast, capital intensive methods intensify the potential severity of such a crisis. The significance of labor absorption policies is particularly important because Lesotho's labor force will grow by several hundred thousand additional workers in the next two decades.

8. Interindustry growth. A labor intensive orientation to Conservation Division works programs also can benefit the Lesotho economy by prompting or inducing expansion in investment in and consumption via industry linkages. (These sectoral growth effects will be all the more positive if accompanied by selective import substitution policies.) In contrast, lesser interindustry growth impacts accompany

capital intensive and primarily imported systems of conservation works production.

These eight types of largely nonpecuniary impacts are of substantial importance. Unfortunately, it is not possible to quantify such economic benefits financially and one can only suggestively imply their significance.

As a surrogate value for such factors, the above inclusion of direct and indirect employment impacts as an explicit benefit to labor intensive methods appears to be reasonable. Moreover, it should be remembered that labor costs were not evaluated on a shadow wage basis; rather market wages were used in the economic rate of return analysis. This results in an overstatement of the costs of labor intensive projects. If a shadow wage were used, the economic rate of return would further favor labor intensive methods of works construction in the Conservation Division.

Ultimately, a pure financial or least cost efficiency comparison standard must encounter trade offs and competing objective functions. Thus, any comparison of labor intensive versus capital intensive systems is, in the end, a judgmental, matter. However much merit there may appear to be in pursuing technical or least cost efficiency, it can ultimately run counter to the essence of economic development. Because capital intensive methods do displace potential working people, they are indeed costly. Therefore, the case for building employment benefits into comparative benefit-cost analysis is considerable.

IV. SUMMARY AND CONCLUSIONS

COST SUMMARY

The data shown below summarize probable cost comparisons in Rand per output unit (in Km and Ha area protected) for labor intensive and capital intensive methods. The former are presented both as originally derived (LI-A) and on the basis of more recent 1979 data (LI-B). While revealing financial cost advantages for capital intensive methods overall, financial cost data alone clearly reveal only one-half of the picture.

	Waterway	Terrace	Diversion	Village Roads	(Per Ha Protected)
CAPITAL INTENSE (CI)					
TOTAL COST/KM	3,430	825	2,140	2,700	320
Equipment Only	2,430	590	1,520	1,920	228
OH and Labor	1,000	235	620	780	92
LABOR INTENSE (LI)					
LI-A: TOTAL COST/KM	2,750	1,570	8,940	2,310	534
Labor Only	2,060	1,225	6,915	1,904	416
OH & Equipment	690	345	2,025	406	118
LI-B: TOTAL COST/KM	1,370	1,220	5,700	2,310	398
Labor Only	1,030	960	4,480	1,904	314
OH & Equipment	340	260	1,220	406	84

BENEFIT SUMMARY

The essential difference in benefits is that of employment and its value. Labor intense methods generate hundreds of additional mandays of employment above capital intensive methods as we have seen. The comparison is shown below per Km for capital intensive versus labor intensive--A, and capital intensive versus labor intensive--B:

	Waterway	Terrace	Diversions	Village Roads	(Per Ha Protected)
CI Employed Mandays	107	26	67	84	10
LI-A Employed Mandays	860	427	2,530	507	160
Gain in LI Employment:	+ 753	+ 401	+ 2,463	+ 423	+ 150
LI-B Employed Mandays	429	307	1,517	507	115
Gain in Employment:	+ 322	+ 281	+ 1,450	+ 423	+ 105

All things considered, the conclusion reached here is that labor intensive methods are more cost effective and thus deserving of wider adoption. The MB/MC ratio for labor likely is 1.5 to 3.7 (p. 36). The total B/C ratios appear to be CI = 1.4 and LI = 1.55 (p. 39). However, this does presume a high quality of program supervision for the Conservation Division. Additionally, several other labor intense program components deserve careful consideration.

PROGRAM COMPONENTS OF LABOR INTENSIVE WORKS

Construction programs designed to operate at more labor intensive levels within the Conservation Division should incorporate certain components. There are seven major components of a labor intensive construction program worthy of further consideration:

1. Employment of Basotho labor at nonpeak seasonal times.
2. Use of task work or incentive pay systems.
3. Continued cost and output monitoring systems.
4. Rehabilitation in lieu of reconstruction for selected arable land areas.
5. Development of equal employment opportunities in the use of female labor.
6. Experimentation with a combined wage and in-kind payment system.
7. Explicit plans for maintenance of works.

Because each of these is critical to the use of a labor intensive approach they are discussed further below.

1. Employing Off-Peak Labor Supply. Great care must be taken to avoid employing labor which otherwise would engage in crop farming, thereby reducing agricultural inputs and outputs. The agricultural labor force in Lesotho does have "slack" time over an entire calendar year and, in that context, surplus labor can be said to exist. Elsewhere [1/] it has been tentatively estimated that this form of underemployment may approximate 10 million more mandays, or one-third to one-half of available Basotho labor time over a yearly period. There is little doubt that there is an amount of significant labor surplus, or slack labor time especially when one considers that these estimates do not include (a) current migrant workers or (b) future new entrants to the labor force.

At the same time it is strongly recommended, however, that Conservation Division programs of the labor intensive nature hire men with great care during peak load seasonal times for crop farming. This is particularly true during the plough-plant period (generally Oct.-Dec.) insofar as male workers are concerned. Furthermore, since weeding is largely a female farm task, employment of women should be also limited or monitored during those seasonal peak periods (generally Dec.-Feb.).

Existing data are not in clear agreement with respect to the nature of a farm labor shortage that might exist at present in Lesotho

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[1/] R. Wykstra, "Farm Labor in Lesotho, Scarcity or Surplus?," LASA Discussion Paper No. 5, September 1978, pp. 36 ff.

during peak load periods. What information we do have ranges from a probabilistic farm labor seasonal shortage of a significant nature (about 30%) to other estimates that indicate the likelihood of no labor shortage--that is, a full employment level not exceeded during peak crop farm periods. 1/

In the aggregate, the potential seasonal labor scarcity does suggest that Conservation Division programs emphasizing labor absorption should primarily be restricted to a period of time no longer than eight months of a calendar year. This does not remove, however, the possibility of a nonfarm work-income substitution effect. That is, a relative farm labor shortage (reduced farm labor inputs) could prevail because of improved opportunities for nonfarm income sources from labor intensive programs conducted by the Conservation Division. At the present time, the extent to which such work-income substitution might occur simply is not known.

In short, even though slack labor clearly exists annually, disruption of the flow of farm labor must be avoided by the Conservation Division to avoid conflict with peak-load agricultural labor demand. If this is not done, the costs of a labor intensive program rise greatly, perhaps to the point of being uneconomic vis a vis capital intensive methods. Of course, such circumstances are subject to change over time as (a) migrant workers return to the Basotho labor force and (b) growth in the size of the labor force occurs.

1/ LASA Agricultural Sector Review, October 1978, Section VI.

2. Task-Work or Incentive Pay Schemes. Far too much evidence exists today to continue a work or pay scheme that fails to relate to labor productivity. Therefore it is recommended that wage payments be tied to worker output levels, or that task-work quotas tied to given levels of output be established.

The Labor Construction Unit in Lesotho has, for example, experienced productivity rates equal to or in excess of its target of two to three M^3 daily since adoption of a task-work wage system. 1/ Initially, for example, labor productivity rates doubled as task-work quotas were established on the project for the Mazenod-Mokema-Moitsupeli Road. 2/ Productivity rates for ordinary ground excavation are now exceeding 2.5 to 3.0 M^3 per manday.

Labor productivity rates elsewhere have also been found to relate to pay schemes dramatically. In its survey of 42 irrigation and dam construction sites (in India, Kenya, Honduras and Indonesia), the International Bank for Reconstruction and Development has reached similar conclusions regarding task-work (or piece rate) payment systems. 3/ In general, these studies attribute 70 to 100+ percent gains in productivity as due to such pay systems.

1/ See Ministry of Works, Labor Construction Unit 1st, 2nd and 3rd Six Month Financial and Technical Reports to the Coordinating Committee (Nov, 1977, May 1978 and Nov. 1978). More recently rates of 6 M^3 have been reached.

2/ Ibid., p. 8 of 2nd Report.

3/ World Bank productivity studies are summarized in I.K. Sud, et.al., Scope for the Substitution of Labor and Equipment in Civil Construction (New Delhi, International Bank for Reconstruction and Development Progress Report, 1976), p. 7 ff.

Further, unskilled labor output rates of some 2.5 M^3 per manday earth moving is an easily reached output norm (for moderately compact dirt excavation). 1/

A large number of additional variables such as nutrition, climate, site and soil conditions, quality of tools, specific nature of a task, and management quality also have a significant impact on labor productivity. Several of these variables are important to both labor intensive and capital intensive methods of construction. They generally have a quantitative impact upon productivity gains comparable to those associated with incentive pay schemes. 2/

Finally, on behalf of the importance of incentive pay schemes, such systems of payment likely contribute in a positive way in the long run to work attitudes and patterns of industry that are required in modernizing an economy. In contrast, a daily pay rate system, and especially in combination with fair to poor supervision practices, tends to encourage wastes. In short, work habits and customs that enhance labor productivity also enhance the value of labor. For that reason, a labor intensive approach with an output-payment relationship will have a positive development impact. In contrast, use of a labor intense technology may <u>not</u> be economic and will appear to be inappropriate if a daily pay wage system is continued by the Conservation Division.

1/ Ibid., pp. 7, 8 and 43 ff. Also see: <u>Men or Machines, A Philippines Case Study of Labor-Capital Substitution</u> (Geneva, International Labor Organization, 1974) and W.A. McCleary, <u>et.al.</u>, <u>Equipment vs. Employment</u> (Geneva, International Labor Organization, 1977).

2/ See above references.

3. Continual Output-Cost Monitoring. A third and vital need for future Conservation Division programs is the monitoring and evaluation of output, productivity and costs of construction programs--regardless of whether a labor intensive or a capital intensive approach is used. This is an even more important need, however, once a given resource combination is adopted. Resource supply or factor cost-benefit changes in the future can greatly affect the appropriateness of whatever might have prevailed in the past. Additionally, it is vital that the Conservation Division have a staff capability and an orientation to cost effectiveness in its operations that does not exist today. [1/]

It would not be totally unfair to say that consideration of additional future expenditures for the Conservation Division are out of order until the cost accountability problem is remedied. The requisite manpower required to establish a responsible and systematic financial and cost accounting orientation is very modest. The Conservation

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[1/] The cooperation and willingness of the Conservation Division in obtaining available cost, output and economic information for this evaluation could not have been greater. In spite of the fact that the above mentioned staff also are much overextended and have responsibilities which preclude anyone currently meeting this need, the present situation is untenable. Currently, economic evaluation information and particularly a systematic accounting for production, cost and financial data is, at best, sporadic and available on a very partial basis from various persons. These conditions should not be continued even with the present orientation toward a capital intensive works-construction method. Moreover, consideration of labor intensive systems of production, can involve even greater wastes. At the moment it is not possible to determine the actual hourly inputs of equipment to Conservation Division construction; realistic cost data needed for evaluation are not available; and a cost analysis of labor versus equipment charges does not have an established basis. Such circumstances should not be continued for any government agency with a budget level and responsibility comparable to that of the Conservation Division.

Division should, if present circumstances prevail in the future, be required to utilize Ministry of Works capital equipment on a normal rental basis.

4. Rehabilitation of Prevailing Conservation Systems. At the present time, there is potential (to an unknown degree) to rehabilitate portions of existing conservation works on arable cropland.

The extent to which the Conservation Division has been able to provide land protection at recent funding levels is such that it will literally require hundreds of years to complete the task on a full or new construction basis. At present funding levels, the Conservation Division budgets a little more than R 1 million yearly. If construction costs of conservation approximate R 300/ha of area protected, something like 100 years will be required to protect 300,000 Ha (or R 300 million in expenditure yearly). This is one compelling reason to consider rehabilitation. Additionally, it is feasible to use more labor intensive systems to rehabilitate because of the selective application of labor as opposed to capital resources. For these reasons, and in spite of the fact that rehabilitation may yield less than a perfect or optimum solution in a conservation engineering context, a rehabilitation orientation to future resource request seems to be in order.

Consequently, it is strongly urged that methods for rehabilitating existing structures be evaluated and implemented where feasible. [1/]

[1/] The general posture prevailing today appears to be that existing structures are not worth redeeming by assumption. This is not defensible as a presumptive reality. Indeed, quite the reverse proposition is most likely to be the case, especially if rehabilitation is more clearly attuned to both technical and economic realities in Lesotho today.

5. Equal Employment Opportunities by Sex. A planned use of more labor resources by the Conservation Division will further require that attention be paid to the sex distribution of employment. For short-term availability and also equality reasons, fuller utilization of the female labor force cannot be ignored.

A large number of households in Lesotho, no less than one-third and perhaps as many as one-half, are headed by females. If females are implicitly excluded from consideration as workers on labor intensive projects, [1/] this discriminatory policy will likely lead to a greater maldistribution of income. Also, a very large amount of the existing supply of surplus or slack labor today in Lesotho is female. Further, Basotho women have a demonstrated ability and custom of productive work in agriculture. Any differential male-female productivity levels which may prevail are immaterial to the Conservation Division if payment is based upon task-work or piece-rate payment systems, and the abysmal productivity experiences of food-aid labor must be ignored.

In short, as one component of a greater labor intensive orientation in the Conservation Division, careful consideration must be given to the use of female workers. This is not to imply that there is a reduced need to employ male workers on an off-peak seasonal basis, nor is it suggestive of ignoring the need to reemploy migrant male workers domestically. Rather, the recommendation is simply that of giving

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[1/] The case in the Labor Construction Unit today.

careful consideration to equality of employment opportunities and income distribution impacts.

6. Combining Cash and In-Kind Labor Payments. The Conservation Division should carefully consider and experiment with a portion of labor wages (e.g., 10 to 20%) being paid in-kind in the form of inputs to crop farming.

One crucial factor is that payment in-kind be an acceptable alternative to workers and while consumption related payments may be acceptable in some measure because of historical experience, they must be tied to productivity. The Conservation Division may then have an opportunity to totally reorient the existing food-aid labor program away from its present welfare form which bears no relation to work productivity. In spite of the clearly positive social and personal benefits of the food-aid program in general, as presently administered the program is detrimental to a labor intensive operation in the Conservation Division.

An alternative form of in-kind payment to labor might be payment in the form of farm inputs such as fertilizer, tools and implements, or seeds. This may have the added incentive feature of encouraging workers to devote efforts to crop farming during those seasonal periods when labor is not engaged by labor intensive construction teams. Potentially, that may have a crop farm output (and consumption) increasing impact which, in the final analysis, is the ultimate object of land conservation programs.

7. Structure Maintenance Programs. Presently there is some evidence that Conservation Division outputs (such as terraces) may be maintained at little expense at the farmer or village level. This evidence, however, is neither consistent nor complete and, in any event, public sector support is likely to be required in some measure for maintenance purposes.

Road maintenance particularly seems suited to continued government assistance and, additionally, provides an opportunity for an expanded labor intensive profile within the Conservation Division. For these reasons then, an active maintenance program is another crucial component to implementation of a more general orientation toward a labor intensive construction program.

A more exhaustive list of program components might be attached to this endorsement of labor intensive techniques. However, the above seven points are very vital to this evaluation and to realization of returns associated with a labor intensive approach to public works.

APPENDIX A: CONSERVATION DIVISION

Data on the output of primary construction works available for the 1.5 years ending December 1978 are shown below for the Conservation Division.

Aggregate Outputs	18 months 7-77/12-78	6 months 7-78/12-78
Km Village Roads	40.0	7.4
Km Diversions	4.8	0.1
Km Terraces	74.8	40.8
Km Waterways	124.5	26.4

Source: Table A-1 of this Appendix.

These primary outputs were generated during a time period when aggregate budget outlays approximated R 1.5 million, two-thirds of which represent recurrent budget provisions and one-third of which represents capital committed (see Table A-2 of this Appendix for detailed data). Conservation Division expenditures do provide more than simply physical works construction, however, even though soil conservation is the ultimate object of Division activities.

Unfortunately data on equipment input by hours or type of output are not available from the Conservation Division for this time period. What is known is that works construction such as that detailed above relied almost exclusively on the use of numerous tractors with tandem scoops across several project areas the Conservation Division was working in during this period of 1.5 years. Apparently terrace construction relied upon available motorgrader capacity and some Cat D-4 capacity also was available to the Conservation Division during this time period.

Additionally, the Conservation Division does cost out its use of existing equipment on a replacement value basis using the +12 percent compound factor for inflation and insurance charges also used by the Ministry of Works plant pool. However, hourly cost charges are based upon twice (1,400 hrs) the actual experienced operating hours yearly which average about 700 hours. Similarly, equipment life is costed at about twice effective life (e.g., 12,000 hours for graders and D-4 dozers or some 17 years at 700 hours yearly use). Conservation Division equipment charge rates depart downward in further ways from the plant pool (or other standard costing) charges (e.g., no minimum monthly charge, say 120 hours). Appendix Table A-3 which follows provides the costing sheet used by the Conservation Division.

The Conservation Division has used food-aid labor fairly regularly and also has some experience with labor intense works at Matsieng Morija and Lipetu. In the former case, a dam was built involving difficult haul length and compaction problems in which output averaged 0.5 M^3 per manday. At Lipetu, waterway construction was involved for a 50 man crew for hauls exceeding 100 M and output rates approximated 0.1 M^3 per manday. [1/] These are not representative of labor construction productivity achievements, however, for various reasons (e.g., site condition and daily pay systems--see Appendix D).

Based upon experience in conservation engineering from both the Conservation Division and Thaba Bosiu, estimated site overhead labor

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[1/] Leroy Scherer, Conservation Division, Government of Lesotho.

requirements were derived for a "package" of output consisting of 650 ha of "area protected." [1/] The components of these site overhead charges are as follows for a capital intensive technique:

1 Sr. Foreman	1 Timekeeper
1 Vehicle Driver	1 Watchman
2 Conservation Assts	1/2 Engineer
1 Sr. Conservation Asst	1 Asst Conservation Officer
8 Laborers	8 Equipment Operators

Source: Leroy Schreer and Mike Nyquist, Conservation Engineers.

The above noted labor inputs typically would serve a project of some 550 Ha of area protected. Additional site overhead charges for materials, equipment mobilization, etc. are incurred under capital intensive methods, however. [1/] (See text Section II for these details.)

Using cost rates [2/] per Km of works constructed in combination with equipment and productivity levels achieved in Thaba Bosiu (see Appendix B), [3/] it is possible to reconstruct an estimated total equipment cost-value for the levels of output achieved by the Conservation Division for the 18 months ending January 1979. Over the last 1.5 years, works constructed by the Conservation Division consisted of the following:

[1/] The Km of output required (see Note h to Table A-1) are 7.7 Km village roads, 162 Km terraces, 13 Km waterways and 4.3 Km diversions.

[2/] Page C-13.

[3/] These cost rates represent charges for capital equipment based upon available input data for Thaba Bosiu. Such data on operating hours were not available for the Conservation Division.

	Output in Km	Equipment Cost in R
Waterways	124.5	302.500
Terraces	74.8	44.100
Diversions	4.8	7.300
Village Roads	40.0	108.000
	244.1	R 461.900

It must be remembered, however, that this does not include site overhead costs (some R 188,700). Further, due to the unavailability of equipment operating hours from the Conservation Division the "equipment costs" values estimated above are based upon productivity relations experienced by Thaba Rosiu and not the Conservation Division.

TABLE A-1

Major Construction Items and Area Protected
Conservation Division, July 1977 to December 1978

	Km Length	Ha Protected (b)
Roads (Village)		
7-77/7-78	32.6	2,700
7-78/1-79	7.4	600
To Date (a)	40.0	3,368
Terraces		
7-77/7-78	34.0	136
7-78/1-79	40.8	163
To Date (a)	74.8	299
Waterways		
7-77/7-78	98.1	4,906
7-78/1-79	26.4	1,320
To Date (a)	124.5	6,226
Diversions		
7-77/7-78	4.7	705
7-78/1-79	0.1	15
To Date (a)	4.8	720

(a) Period prior to 7-77 excluded.

(b) Estimated basis 84.2 ha = 1 km roads; 4.0 ha = 1 km terraces; 50 ha = 1 km waterways; and 150 ha = 1 km diversions. Data do not include some 130 km of road maintained.

Source: Mr. Leroy Scherer, Conservation Division, Government of Lesotho.

TABLE A-2

Conservation Division
Estimated Financial Outlays
July 1977-December 1978
(in 000 R)

	July 1, 1977-June 30, 1978 (a)	July 1, 1978-Dec 31, 1978	18 Mo Total
Recurrent Budget Provisions (b)	561.2	460.0	1,021.2
Capital Committed (c)	384.0	149.1	533.1
TOTAL			1,554.3

(a) Based on April 1, 1977 to March 31, 1978.

(b) The recurrent budget is based upon the provision amount which typically is +/- 1% of the total active spent.

(c) The capital budget committed is based upon the balance of funds committed for the 7-78 to 12-78 six months period; however, for the period July 1, 1977 to June 30, 1978 capital outlays represent those funds approved for April 1, 1977 to March 31, 1978 as the approximate estimated capital cost. Capital cost includes temporary casual labor but excludes skilled operator labor costs.

Source: Peter Bonnema of the Conservation Division, Government of Lesotho.

TABLE A-3

Replacement Costs
Conservation Equipment

Description	C Price 1978	L Est Life in Hrs	A Cost 1979/80	1.1 x A Cost 1980/81	1.21 x A Cost 1981/82
D4D	R 33,400	12,000	6.21	6.83	7.51
Grader	57,000	12,000	10.60	11.66	12.83
Ford 4000	8,461	11,200	1.63	1.79	1.97
Ford 5000/6600	9,887	11,200	1.90	2.09	2.30
MF 188	10,657	11,200	2.05	2.25	2.48
Ford 8000	21,870	11,200	4.21	4.63	5.09
I.D. 760	68,000	12,000	12.64	13.90	15.29
STD 8	32,800	10,000	6.70	7.37	8.11
Compressor	14,720	14,000	2.55	2.80	3.08
Tandem Scoops	5,323	14,000	.92	1.01	1.11
Tipping Trailers	3,400	20,000	.51	.56	.62
Flat Trailer	2,300	14,000	.40	.44	.48
Water Trailer	12,000	20,000	1.79	1.97	2.17
County 754	16,682	11,200	3.21	3.53	3.83
County 1124	23,796	11,200	4.58	5.04	5.54

Plant pool formula used:

$$\frac{1.1 \times C}{L} + \frac{0.132 \times C}{1,400} = A$$

Source: Conservation Division.

APPENDIX B: THABA BOSIU

The Thaba Bosiu Project represents one of the more intense and integrated conservation efforts undertaken in Lesotho. The information which follows is a compilation of available relevant data on costs and production from its inception in 1973 to the end of 1978 for this project.

During the period of time from project inception to the end of 1978 estimated conservation works output were as follows.

Aggregate Output	Entire Period 1973-78	1 Year 1978
Km Village Roads	45.0	11.7
Km Diversions	6.0	2.6
Km Terraces	324.2	164.2
Km Waterways	46.5	10.1

Source: Table B-1 of this Appendix.

During this same period of time (up through September 1978 only), the Agency for International Development's portion of Thaba Bosiu expenditures aggregated R 767,700, some R 208,800 of which was earmarked for soil conservation. 1/

Aggregate hours of operating time of heavy equipment used for construction of conservation works for these same time periods averaged about 600 to 700 hours of operation yearly. This can be seen by examination of the data below, which includes rental time for two graders of some 600 hours each in 1978.

1/ See Table B-2.

Heavy Equipment	Hours of Operation Entire Period 1973-78	1 Year 1978
2 D-4 Cats	5,864	993
1 Scraper	2,982	651
4 Graders 1/	7,926	2,609
TOTAL	16,772	4,253

1/ Two rental units used only in 1978 some 600 hours each.

Source: Table B-1 of this Appendix.

Project officers indicated that equipment was operated virtually as many hours as it was available and not in need of repair. 1/ Additionally, it should be recognized that because of delivery lags in equipment, the earlier period of project activity did not include significant equipment operating time. 2/

Productivity rates in the Thaba Bosiu project for the entire period from 1973 to 1978 in comparison to the last year of 1978 show marked improvement in terraces, waterways and diversion construction. Generally speaking, each machine hour of input produced upwards of 50 percent more of these outputs measured in Km of production. For example, during the entire five year period, an average of 27 hours of mixed scraper-grader-dozer time was used to construct one Km of terrace over the entire 1973-78 period. In contrast, for 1978, 17.5 aggregate

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1/ Michael Nyquist, Conservation Engineer, Thaba Bosiu.

2/ Excluded from the above is data concerning maintenance and road construction of other than village roads which, relatively speaking, was insignificant (see Table B-1 following).

machine hours were required on the average, as is shown in the illustration below:

	Average Hours of Scraper-Grader-Dozer Required [1/]		
	(a)	(b)	(a÷b)
	1978	1973-78	1978 as % of Overall Hours Req
1 Km Village Road req:	45.3 hrs.	47.2 hrs.	96.0 %
1 Km Terrace req:	17.5 hrs.	27.0 hrs.	64.8 %
1 Km Diversion req:	44.7 hrs.	68.3 hrs.	65.4 %
1 Km Waterway req:	64.9 hrs.	108.6 hrs.	59.7 %

[1/] The equipment "package" actually in use consisted of 1 scraper, 4 graders and 2 dozers.

Source: Table B-1 of this Appendix.

This improved level of productivity was explained largely as due to the experience gained by equipment operators and project management, including lead time gained in design and planning.

Table B-1 of this Appendix is the original project estimate of output by Km and machine hour inputs by type of equipment. This document contains comparable information concerning village road maintenance, field roads and terrace maintenance which is not considered above because of its relative insignificance. Additionally, data concerning cost per unit of output (Km or M^3) are not fully reflective of real equipment cost because of the understated hourly rate hypothetically charged. Charged rates cannot be based upon actual hours operated when they average two to three hours daily since even long-term lease rates normally require a greater level of

capital recovery based upon long-term possession of equipment. Typically, such capital charge rates average about 60 percent of short-term rates, which in turn are tied to charges for 45 or more hours of use weekly--based on a 2,000+ hour per year cost norm. [1/]

Exhibit B-2 which follows is a summary of cumulative expenditure disbursements through September 1978 applicable to the Agency for International Development. The first budget item (Staff and Operation) is approximately one-third of total expenditures and is as representative of general overhead expenditures as can be determined for this conservation effort.

[1/] Actual available operating hours cannot be expected to exceed 1,000 to 1,200 hours yearly, and Swaziland experienced an average of only 22% use of a theoretical 2,000 hour year (see Soil Conservation Cost Effectiveness Study, U.S. Agency for International Development, September 1977, pp. 107-09.

TABLE B-1

SAVINGRAM

FROM: Conservation Engineer

RECEIVED DATE STAMP

TO: Ron Wykstra, CCO/ TBCS, CCO/ MOA, Levoy Scherer

REF. NO. CR 5/3

SIGNED: M Nyquist
(Full Signature)

NAME: M. Nyquist
(Typed)

FILE NO.:
(Receiving Min./Dept.)

DATE: 8 January, 1979.

GPL 2551/78 - 10m Pds

Re: Conservation Costs

The following pages show estimated costs for construction of conservation measures in the Thaba Bosiu Conservation Section.

Figure 1 shows total construction to date at the top of the page. This is followed by total heavy equipment operating hours and an estimate of hours spent on each type of work, that is - waterways, terraces, village roads, etc. Estimated cost per unit construction for each conservation measure is given at the bottom of the page.

Equipment rates in Rands per hour are based upon hire rates locally charged by both commercial firms and by the government plant pool. Rates are given in the figures based on actual operating hours, rather than being based on an 8 hour day. Actual operating rates for our equipment average about 2-3 hours per day.

Figure 2 shows the same information as figure 1 but for 1978 only. It can be seen that costs per unit construction are much lower when compared to previous years. This is attributable mainly to the increased skills of operators and technicians.

Figure 3 gives estimated costs of construction for waterways, terraces and diversions shown as dollars per cubic yard.

"Operating hours" includes such non-productive time as idling, road and travel time, warm-up, etc.

MN/OD.

TABLE B-1a

THABA BOSIU OUTPUT-COST ANALYSIS
Total to Date

Constructed

Field roads	26.35 Km
Field road maintenance	12.47 Km
Diversions	6.00 Km
Terraces	342.20 Km
Terraces maintenance	7.00 Km
Waterways (total = 112)	46.50 Km
Village roads	45.00 Km
Village road maintenance	10.00 Km
VDP roads	35.00 Km

A. Total Machine Hours, 1973-78

Type	Hours	W/way	Terraces	Diversions	Village Roads	Field Roads	VR Maint	VDP Roads
Scraper	2,982	830	1,100	80	902	10	20	40
Grader No. 1	3,351	1,200	1,380	100	520	51	20	80
Grader No. 2	3,372	1,220	1,380	80	520	72	20	80
Cat D-4	2,966	900	1,846	100	100	0	0	20
Cat D-4	2,898	900	1,844	50	84	0	0	20
Grader No. 3*	600	0	600	0	0	0	0	0
Grader No. 4*	602.5	0	602.5	0	0	0	0	0

B. Estimated Rates

W/Way Cost	Hours	Rate	Rands	R/Ha	Total R/Unit Of Output	Mach Hrs/Unit Of Output
Scraper	830	30	24,900	669.35		
Graders	2,420	28	67,760	1,821.51	3,942.49/Ha	
Cats	1,800	30	54,000	1,451.61	3,154.84/Km	108.6/Km
Terrace Cost						
Scraper	1,100	30	33,000	101.79		
Graders	3,962.5	28	110,950	342.23	785.48/Km	27.0/Km
Cats	3,690	30	110,700	341.46		
Diversion Cost						
Scraper	80	30	2,400	400.00		
Graders	180	28	5,040	840.00	1,990.00/Km	68.3/Km
Cats	150	30	4,500	750.00		

*Rented graders.

(Continued on next page)

TABLE B-1a (Continued)

B. Estimated Rates (Continued)

Type	Hours	Rate	Rands	R/Ha	Total R/Unit Of Output	Mach Hrs/Unit Of Output
Village Road Cost						
Scraper	902	30	27,060	601.33		
Graders	1,040	28	29,120	647.11	1,371.11/Km	47.2/Km
Cats	184	30	5,520	122.67		
Field Road Cost						
Scraper	10	30	300	11.39		
Graders	123	28	3,444	130.70	142.09/Km	
VDP Road Cost						
Scraper	40	30	1,200	34.29		
Graders	160	28	4,480	128.00	196.58/Km	
Cats	40	30	1,200	34.29		
Village Road Maintenance						
Scraper	20	30	600	60		
Grader	40	28	1,120	112	172.00/Km	

TABLE B-1b

COST 1978 ONLY (Calendar Year)

	Constructed
Waterways	10.10 Km
Terraces	164.20 Km
Diversions	2.57 Km
Village roads	11.70 Km
Field roads	15.75 Km
Village road maintenance	5.00 Km

A. Total Machine Hours, 1978

Type	Total Hours	W/Way	Terraces	Diversion	Village Road	Field Road	VR Maint
Scraper	651	155	176	10	300	0	10
Grader No. 1	736	200	381	25	100	20	10
Grader No. 2	571	100	316	25	100	20	10
Grader No. 3*	600	0	600	0	0	0	0
Grader No. 4*	602.5	0	602.5	0	0	0	0
Cat No. 1	293	50	218	15	10	0	0
Cat No. 2	790	150	580	40	20	0	0

B. Estimated Rates

Type	Hours	Rate	Rands	R/Km	Total R/Unit Of Output	Mach Hrs/Unit Of Output
W/Way Cost						
Scraper	155	30	4,650	574.78		
Graders	300	28	8,400	1,038.32	1,886.14/Km	64.9/Km
Cats	200	30	6,000	741.66		
Terrace Cost						
Scraper	176	30	5,280	32.16		
Graders	1,899.5	28	53,186	323.91	501.87/Km	17.5/Km
Cats	798	30	23,940	145.80		
Diversion Cost						
Scraper	10	30	300	116.73		
Graders	50	28	1,400	544.75	1,303.50/Km	44.7/Km
Cats	55	30	1,650	642.02		
Village Road Cost						
Scraper	300	30	9,000	769.23		
Graders	200	28	5,600	478.63	1,324.78/Km	45.3/Km
Cats	30	30	900	76.92		
Field Road Cost						
Graders	40	28	1,120	71.11	71.11/Km	
Village Road Maintenance Cost						
Scraper	10	30	300	60		
Graders	20	28	560	112	172.00/Km	

*Rented graders.

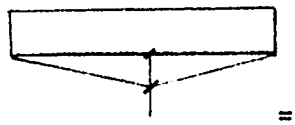
TABLE B-1c

ANALYSIS OF MACHINE COST BY VOLUME

Waterway

Estimated Vol/Km = ½ (8x.3x1,000)

= 1,200 M^3



= 1.2 M^3/1m

1973-1978

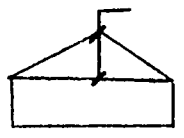
R 3,942.47/Ha = R 2.63 per M^3

1978 only

R 1,886/Km = R 1.57 M^3

Terrace

Estimated Vol/Km = ½ (1)(4)(1,000) = 2,000 M^3



= 2 M^3/1m

1973-1978

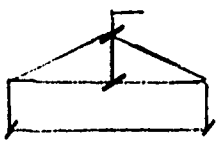
R 785.48/Km = R 0.39 per M^3

1978 only

R 501.87/Km = R 0.25 per M^3

Diversion

Estimated Vol/Km = ½ (1.5)(6)(1,000) = 4,500 M^3



= 4.5 M^3/1m

1973-1978

R 1,990/Km = R 0.44 per M^3

1978 only

R 1,303.50/Km = R 0.29 per M^3

Village Road

Estimated Vol/Km = 1,080 M^3 combined excavation and gravel

1973-78

R 1,371.11/Km = R 1.27 per M^3

1978 only

R 1,324.78/Km = R 1.22 per M^3

TABLE B-2

1. Project/Activity No. 690-11-120-031

2. Agreement No. 73-L-8

Thaba Bosiu Rural Development Project,
Private Bag, Maseru.

To: A.I.D. Operations Officer
c/o American Embassy, Maseru, Lesotho

From: Project Manager

Request No. 17

Subj: Request for Reimbursement

Date of Request 30th September, 1978

Pursuant to the provisions of the above-mentioned Project Agreement, the Thaba Bosiu Rural Development Authority requests reimbursement in the amount of R 5,589-71 as itemized and certified on the attached statement, bearing the same number and date as this request. The commodities and services for which payment is requested have been received and applied for the purposes specified in the Project Agreement. They are appropriate for such purposes, and the costs and terms of purchases thereof are reasonable and consistent with the provisions of the above-specified Project Agreement and any revisions issued to date pursuant to said Project Agreement.

The Thaba Bosiu Rural Development Authority hereby warrants that it has not heretofore applied for or received reimbursement for the costs of any of the items for which reimbursement is requested in this application, and will not obtain such reimbursement out of the proceeds of any other loan, credit, or grant available to the Government of Lesotho.

AfterAID enters the dollar equivalent in Section C of the attachment, please return an acknowledged copy of this request to the Project Manager, Thaba Bosiu Rural Development Authority. Please make the check payble to Thaba Bosiu Rural Development Project A/C No. 09010 and mail it to the following address: Private Bag, Maseru

(Signature)

G. L. MOCHOCHOKO
(Name Typed)

TABLE B-2a

THABA BOSIU RURAL DEVELOPMENT PROJECT EXPENDITURE REPORT
(for local costs eligible for reimbursement under the AID Grant)
LEOSTHO Project No. 690-11-120-031
Statement No. 17 dated 9-30-78

A. ELIGIBLE COSTS (local costs applied to project)

ITEMS B U D G	BUDGET AMOUNT E T	CUMULATIVE THRU.PREV.PERIOD 3-31-78	THIS PERIOD C O S T S	CUMULATIVE THRU.THIS PERIOD 9-30-78
STAFF & OPERATION				
Salaries & Wages	151,445	229,428-20	2,085-73	231,513-93
Miscel. Supplies	11,000	3,456-97	-	3,456-97
Overhead Costs	28,000	35,022-91	1,409-15	36,432-06
VEHICLES & EQUIPMENT				
Running Costs Parts	60,640	73,516-21	6-08	73,522-29
Gas & Oil	29,000	30,452-53	-	30,452-53
Maintenance	-	-	-	-
BUILDINGS				
Materials	-	-	-	-
Contract Services	245,085	176,078-57	1,233-47	177,312-04
Maintenance	2,500	1,031-41	-	1,031-41
Furniture	7,500	4,153-25	-	4,153-25
SOIL CONSERVATION				
Roads & Conserv. Costs	256,568	204,504-68	725-78	205,230-46
Trees	2,000	-	-	-
Fertilizer	3,500	3,671-87	-	3,671-87
Maintenance Operation Machinery	5,500	788-17	129-50	917-67
Totals as of this Date	802,738	762,104-77	5,589-71	767,694-48

Less: Previous amounts requested from A.I.D. ..... R 762,104-77

Amount now due ..... R 5,589-71

(Continued on next page)

TABLE B-2b (Continued)

B. CERTIFICATE OF PERFORMANCE AND ELIGIBILITY

The undersigned certify that:

This statement fairly sets forth, as of the date indicated, the local costs of commodities and services paid for by the Government of Lesotho incorporated into the project or included in project inventories under the control of the Thaba Bosiu Rural Development Authority, that the services have been satisfactorily rendered, and that the commodities are appropriate and required for the Project; that the above costs meet all the requirements in the AID agreement to qualify as local costs eligible for reimbursement; that prior reimbursement has neither been applied for nor received from AID nor from proceeds of any other loan, credit, or grant available to the Government of Lesotho; that documentation to support the costs claimed herein for reimbursement is on file at Thaba-Bosiu Rual Development Project and will be made available to A.I.D. upon request by an authorized representative of A.I.D.; and that the amount due as indicated above is properly payble;

FOR THE THABA BOSIU RURAL DEVELOPMENT AUTHORITY

SIGNATURE G.L. Mochochoko

NAME TYPED G.L. Mochochoko

TITLE PROJECT MANAGER

FOR THE MINISTRY OF FINANCE

SIGNATURE

NAME TYPED A.M. Mapetla

TITLE Permanent Secretary

FOR THE THABA BOSIU RURAL DEVELOPMENT PROJECT

SIGNATURE P.M. Mabathoana

NAME TYPED P.M. Mabathoana

TITLE Chairman

APPENDIX C: EQUIPMENT COST ANALYSIS

INTRODUCTION

Because capital cost is both an important part of this analysis and a subject involving considerable data, a brief comment on the organization which follows is in order.

Part A of this Appendix discusses equipment cost in the form of engineering cost data provided by project participant William Niese, Jr., Regional Engineer Advisor to the Agency for International Development. This base data prepared by Niese and included as Tables C-1 to C-5 at the end of this section is as follows: [1/]

Table C-1: Equipment Charge Rates

Tables C-2a to C-2f depict detailed cost analyses by input components as follows:

- Table C-2a: Waterways
- Table C-2b: Terraces & Diversions
- Table C-2c: Village Road-No Compaction
- Table C-2d: Village Road-With Compaction
- Table C-2e: Village Road-With Gravel, No Compaction
- Table C-2f: Village Road-With Gravel and Compaction

Table C-3: Section Layouts for Conservation Works

Table C-4: Niese Replacement Cost Commentary

Table C-5: Labor and Equipment Operator Rates

Table C-6: Plant Pool Charge Basis

[1/] Additional data prepared by Niese are not produced here but are available from the author on a modified costing rate basis. These data, which reflect some 60% of the equipment rate charge shown in Tables C-2a to C-2f as depicting long-term lease costs, are not included here primarily because (a) the hourly rate is applicable essentially on a full-use (1,500+ hour) annual basis only and (b) replacement costs are not included (see commentary below).

Part B is an evaluation of real capital equipment costs under Lesotho conditions, inclusive of low annual utilization rates experienced, equipment replacement and existing operating efficiency conditions. The final section (Part C) of this Appendix summarizes key observations regarding capital equipment charges.

A. EQUIPMENT COST AND EFFICIENCY

Table C-1 details equipment hourly rental charge estimates exclusive of operator time charges. The hourly charge rates for related equipment are as follows:

Cat D-6	R 34.20
Scraper (150 hp)	R 30.99
Grader (125 hp)	R 27.78

The cost analyses presented in Tables C-2a to C-2f [1/] enumerate total estimated costs at five different "technical effiency levels" for equipment ranging from 30 to 100 percent. The standard rates in such analyses also used here is that of Caterpillar Tractor, Inc. Aside from providing a useful costing framework which the Conservation Division advantageously might use--material, labor, equipment and site as well as organizational overhead costs, are separately estimated. These cost estimates provided by William Niese, Jr. are based on hourly rates and then on cost per unit of output measured as a M^3 of earthwork involved in the production of each conservation output.

[1/] All data were provided by William Niese, P.E., Regional Engineer Advisor, REDSO/EA.

It was thus possible for Niese to estimate construction costs for capital intensive methods by multiplying total cost per M^3 of earthwork (as shown on the final page of Tables C-2a to C-2f) by the earthwork quantities required for each product. The following is a summary of equipment only costs and also of total cost taken from Tables C-2a to C-2f prepared by Niese and attached to this Appendix:

	Total Cost R per M^3		Equip Cost in R per M^3	
Efficiency Factor =	40%	80%	40%	80%
Output of:				
Diversions	0.752	0.376	0.384	0.192
Terraces	0.752	0.376	0.384	0.192
Waterways	0.186	0.099	0.102	0.051
Village Road*	0.741	0.368	0.384	0.192

*Unimproved, no compaction.

Using the above data in conjunction with earthwork quantities required for each Km of output, Niese derived estimates of total cost at alternate effiency levels as follows:

Cost Comparison Chart in Rand per Km at Various Efficiency Levels

Description	Quantity per Km		Based on Hourly Equip Charge of Table C-1 % Efficiency 20	40	60	80
ROAD (VILLAGE) (No cross drainage or compaction)						
Earthwork	750 M^3		1,112	556	369	276
Gravel	330 M^3		2,480	1,240	827	620
TOTAL		R	3,592	1,796	1,196	896
ROAD (IMPROVED GRAVEL) (With drainage & compaction)						
Earthwork	1,872 M^3		2,566	1,283	858	643
Gravel	1,080 M^3		6,368	3,184	2,132	1,593
Culverts	4 ea		7,504	3,752	3,382	3,197
TOTAL		R	16,438	8,219	6,372	5,433
WATERWAY						
Earthwork	1,200 M^3	R	448	224	151	119
TERRACE						
Earthwork	2,000 M^3	R	3,008	1,504	1,006	752
DIVERSIONS						
Earthwork	4,500 M^3	R	6,768	3,384	2,264	1,692

Source: William Niese, Jr., P.E.. Regional Engineer Advisor, REDSO/EA.

A column at 20 percent technical operator efficiency levels has been added to the original work of Niese, in reflection of less than "excellent" or 100 percent operator efficiency factors likely prevailing in Lesotho. [1/]

[1/] Based upon .75, the standard correction factor used to adjust from excellent to average operator. See International Bank for Reconstruction and Development, World Bank Study of the Substitution of Labor and Equipment in Civil Construction, Supplement to Technical Memorandum No. 7, August 1975, p. 5; and International Bank for Reconstruction and Development, World Bank Study of the Substitution of Labor and Equipment in Civil Construction, Technical Memorandum No. 7, May 1975.

It is extremely difficult to determine the appropriate level of "technical efficiency" to use in cost analysis of capital equipment since a great many factors are involved. For example, a differential haul distance of five to 50 meters alone alters Cat D-6 dozer productivities from some 1,200 M^3 to 150 M^3 per hour. 1/ Some of the more obvious variables lowering Capterpillar ideal (100%) technical efficiency norms in addition to the above noted operator skill factors and haul distance are soil conditions, work site, job layout, daily versus incentive pay, customs and traditions, quality of supervision, climate and weather, terrain and grade. Also, time factors such as start up-shut down, hourly rest and idling, breakdown frequency, travel to site, maintenance needs, and part availability and repair delays.

Detailed and well documented studies of some of these many variables recently have been exhaustively analyzed by the World Bank and others. 2/ World Bank studies generally have found the percent efficiency or productivity to be somewhat lower than given in the Caterpillar Handbook (overall of 32%). Suggested correction factors are: 3/

1/ William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

2/ International Bank for Reconstruction and Development, World Bank Study of the Substitution of Labor and Equipment in Civil Construction, Technical Memorandum No. 7, May 1975; International Bank for Reconstruction and Development, World Bank Study of the Substitution of Labor and Equipment in Civil Construction, Supplement to Technical Memorandum No. 7, August 1975; and P.A. Green and P.D. Brown in Indian Roads Congress Papers of 37th Annual Session, December 1976, pp. 35-74.

3/ International Bank for Reconstruction and Development, World Bank Study of the Substitution of Labor and Equipment in Civil Construction, Supplement to Technical Memorandum No. 7, August 1975, p. 5; and P.A. Green and P.D. Brown in Indian Roads Congress Papers of 37th Annual Session, December 1976, pp. 46 ff.

average operator	.75
soil	.70
45 min. hr.	.75
grade 10%	.80
overall =	.32%

The general recommendations reached in these World Bank analyses are broadly based and reasonably uniform in concluding that, e.g., dozer and scraper productivity approximates "25 to 40 percent of published Caterpillar Handbook (technical efficiency) productivity at 100 percent time and operator efficiency." [1/] These latter two variables typically are subject each to a 75 percent adjustment factor (reflective of effectively a 45 minute work hour and average operator skill level); thus the joint correction factor of .563 (.75 x .75) exists. Combined technical efficiency levels thus appear to approximate 20 percent as they range downward from (40% x .563 =) 22.5 percent to, let us say, as low as (25% x .563 =) 14.1 percent.

In conclusion, then, it seems that something on the order of a 20 percent efficiency factor perhaps might be expected in Lesotho.

B. EQUIPMENT USE AND REAL COST CHARGES

Practical rates of technical operating efficiency are only one problem in determining the cost of capital intensive methods. Another and equally critical matter is establishment of an appropriate real

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[1/] See International Bank for Reconstruction and Development, World Bank Study of the Substitution of Labor and Equipment in Civil Construction, Technical Memorandum No. 7, May 1975, p. 21.

hourly (annual) cost or charge rate which characterizes realities existing in developing nations. One factor which must be reflected is capital recovery or replacement costs (not included in the Niese data of Part A above or Tables C-1 and C-2). Further, hourly rates based upon more hours than are achieveable can lead to understating capital cost of operating time which is, in fact, considerably less.

The Conservation Division presently uses a 12 percent annual cost escalation factor which would appear to be a minimum charge, especially considering that it reflects insurance costs also. The impact and meaning of a 12 percent capital recovery factor over an eight year life can be illustrated by closer examination of, say, the Cat D-6 dozer at current prices of R 90,600 FOB Lesotho. At these cost escalation rates, the estimated replacement price in eight years approximates R 224,300, and the required annual capital recovery charge is R 18,200. 1/ This generates an equivalent life charge of capital replacement over eight years of R 145,600 (R 18,200 x 8). Capital recovery at this charge rate annually earning 12 percent per year for eight years will allow equipment replacement of some R 224,300. 2/

A more realistic but equivalent interpretation of capital recovery charges is required under Lesotho conditions, however, since (a) equipment

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1/ Note that it is not appropriate to develop an annual charge of R 224,300 ÷ 8 = R 28,000, however (see below).

2/ The capital recovery factor is equal to $i + \frac{i}{(1 + i)^N - 1}$ where i = 12 percent and N = 8 years.

retains some salvage value and (b) a much lower social interest return than 12 percent (e.g., some 6%) is probable. Presuming the equipment to be in good condition (because of both the low hourly use rates prevailing in Lesotho and 100 percent maintenance) generates likely full replacement cost inclusive of salvage value estimated as follows:

i. R 18,200 annual use charges for eight years = R 145,900.

ii. Interest earnings at six percent for eight years = R 34,600. 1/

iii. Salvage value (approximately 45-50% cost) = R 44,800.

REPLACEMENT COST OF CAT D-6 DOZER = R 224,300.

In short, then, to allow for replacement of capital equipment, depreciation charges inclusive of escalated replacement costs must be charged (on an annual and hourly basis). Further, the evidence available from equipment operating hours both in the Conservation Division and the Thaba Bosiu Project rather clearly suggests that relatively new equipment operates 600-700 hours yearly, and that the most likely heavy equipment eight year life operating use rate would be approximately 650 or so hours per year, or some 5,200 hours over an eight year life. 2/ This represents what is about two-thirds of effective full hourly life

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1/ Based upon net capital recovery of 180,500 at i = 6 % annual interest earnings over N = eight years or the annuity factor $\frac{(1 + i)^{N-1}}{i}$, plus R 44,700 salvage value.

2/ See appendices A and B.

(7,500 to 8,000 hours) for capital equipment in developing nations; [1] a fact that corroborates the relatively high salvage values used in the example above. [2] Lower hourly operating rates do not correspondingly lower maintenance costs or increase expected life, however. As observed elsewhere, "...deterioration and corrosion due to inclement weather may reduce lifetime factors more than normal wear and tear in use...and increase operating costs." [3]

The equipment cost basis used in comparing labor intensive to capital intensive construction in this analysis is that provided in Table C-1 [4] adjusted as described above for depreciated replacement cost or capital recovery less salvage values. Because dozers, scrapers and graders largely are relevant to the waterways, terraces, diversions and village road outputs evaluated herein, the below summary of cost of capital is presented only for these four units of equipment.

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[1] See William Niese data, Appendix Table C-1. Also, a recent study of Lesotho construction observed an average plant pool life of 7,200 hours (Louis Berger, International, Techno-Economic Feasibility Study of the Lesotho Southern Perimeter Road, Vol. III, March 1978, p. D-4.

[2] Norms of 45-50% of initial costs were obtained from Jack A. Hasten, Manager of Sales Development, Caterpillar Tractor, Inc., General Office, (Peoria, Il.) for developing nation auction resales by Forke Bros., Nebraska.

[3] International Labor Organization, Men or Machines, Geneva, 1978, p. 87.

[4] Provided by William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

	Cat D-6 Dozer (W/Ripper)	Scraper Cat 613	Motorgrader Cat 120G	Cat D-4 Dozer (W/Ripper)
A. Price FOB Lesotho	R 90,600	R 82,000	R 72,800	R 47,200
B. Required Replacement Costs	R 224,300	R 203,000	R 180.3	R 116,900
less interest earn	R 34,600	R 31,300	R 27,800	R 18,100
salvage value	R 43,800	R 39,600	R 35,300	R 22,800
C. 8 YEAR DEPREC COST				
i. Total	R 145,900	R 132,100	R 117,200	R 76,000
ii. Annual (8 Yrs)	R 18,200	R 16,500	R 14,650	R 9,500
iii. Hrly (650/Yr)	R28.06/Hr	R25.40/Hr	R22.54/Hr	R14.62/Hr

Maintenance charges in the data above are based upon those shown also in Table C-1 (over equipment life equal to 90 percent plus five percent), or essentially 100 percent of initial cost. [1/] This is a rather standard costing procedure as is the treatment of petrol-oil-fuel or POL charges. As can be seen from the summary data below, operator labor rates are not included nor are overhead charges included (nor are separate tax, insurance and tire charges individually identified). [2/]

Essentially, those charges denoted in "Part A" of the data below represent ownership possession expenses based upon two operating time factors.

[1/] Niese uses effectively 97.5 percent.

[2/] Overheads are included by Niese in his estimates of equivalent rental charge rates while other costs are not separately identified.

	Replace Deprec	+ Repairs& Maint(a)	+ POL(b)	= Hourly Charge Rate(c)
A. Operating Life of 8 Yrs at 650 Hr/Yr				
Cat D-6	28.06	17.42	4.20	R 49.68
Scraper	25.40	15.77	3.99	R 45.16
Grader	22.54	14.00	3.78	R 40.32
Cat D-4	14.62	9.07	3.45	R 27.14
B. Operating Life of 8 Yrs at 1,000 Hrs/Yr				
Cat D-6	18.20	11.27	4.20	R 33.67
Scraper	16.50	10.20	3.99	R 30.69
Grader	14.65	9.05	3.78	R 27.48
Cat D-4	9.50	5.90	3.45	R 18.85

(a) Estimated at 100% of price FOB Lesotho over 8 years with no cost escalation.
(b) See Table C-1.
(c) Niese rates are R 34.20, R 30.99 and R 27.78 respectively.

Source: Calculation and Table C-1 of this Appendix.

The hourly costs data presented are based upon both an operating time experienced (650 hour/year) and a higher target hourly rate dependent upon full life charge-outs for equipment possession and utilization of 1,000 hours annually. These latter hypothetical charge rates do correspond rather closely with the estimated rental rates derived in Table C-1 and also with present Ministry of Works plant pool charges. However, Ministry of Works charge rates must be adjusted upwards to reflect 1979-1980 cost-price factors which are likely to be recognized in the next year. It also must be recognized that to realize the lower hourly charge rates shown in "Part B" of the above data as owner and possessor demands operating levels of no less than 1,000 hours

annually. Charge rates at these lower levels cannot be realized if operating time is based upon low use; instead charges then must revert to those shown in Part A which reflect a "time of possession" hourly rate basis in which deadline time can be below the industry norm. 1/

C. SUMMARY OF COSTS OF CAPITAL EQUIPMENT

There are two very significant factors influencing a pragmatic estimate of probable equipment costs not developed in the Appendix data following. These are likely technical efficiency or productivity factors and probable hourly charge rates for operating time on various types of capital equipment.

First, one might conclude at the high probable level that, when in actual operation under average conditions, technical efficiency rates on the order of 30 to 40 percent of theoretical efficiency norms are attainable as demonstrated in developed nation conditions and generally alleged by engineer handbooks such as Caterpillar. 2/ At the lower probable efficiency level somewhat more representative of developing

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1/ See the comments of William Niese (Table C-4) and also Ministry of Works plant pool regulations concerning long-term hire rates which are 64% of short-term minimum time charges (Table C-6 of this Appendix).

2/ See International Bank for Reconstruction and Development, World Bank Study of the Substitution of Labor and Equipment in Civil Construction, Technical Memorandum No. 7, May 1975, pp. 5-26; and International Bank for Reconstruction and Development, World Bank Study of the Substitution of Labor and Equipment in Civil Construction, Supplement to Technical Memorandum No 7, August 1975, pp. 11 ff.

nation conditions, the World Bank recommended rates of 20 to 25 percent, which may be more reasonable in Lesotho's case.

Recognition of (a) the periodic need to replace owned and possessed equipment and (b) the historical annual operating hours attained for capital usage in conservation works in Lesotho tend to confirm that the appropriate owner cost hourly charge rates are the higher of those shown above in Part A, namely:

Cat D-6, R 49.68/Hr	Grader, R 40.32/Hr
Scraper, R 45.16/Hr	Cat D-4, R 27.14/Hr

These rates provide for capital recovery and they reflect low operating use time; thus they are greater than the estimated rental rates of Table C-1. These latter are close to the Ministry of Works plant pool charges (that presume higher annual operating hours of use than is obtained by the Conservation Division). [1/] Assuming operating hours in the Conservation Division could more nearly approximate the long-term cost minimum of 1,000 hours yearly, capital equipment utilization would achieve very significant economies in works construction.

Equipment costs estimated by Niese, adjusted for low use and thus higher hourly rates noted above, are increased as follows: for (a) terraces, diversions and unimproved village roads from R 0.154/M^3 to R 0.220/M^3 at 100 percent theoretical efficiency; and (b) for waterways from R 0.041/M^3 to R 0.060/M^3. Other costs, excluding headquarters or organizational overhead shown in Tables C-2a to C-2f, are derived as labor and site overheads and are shown below for various efficiency levels:

[1/] Plant pool rates inclusive of fuel are about 70 to 75 percent of the above recommended charge rates.

Adjusted Costs Per M^3 Earthwork	Cost Components: Equip	Labor	Mat'ls& Site OH	Total(a)
Waterways				
100% effic, R per M^3	.060	.003	.020	.083
25% effic, R per M^3	.240	.012	.080	.332
20% effic, R per M^3	.300	.015	.100	.415
Terraces & Diversions				
100% effic, R per M^3	.220	.026	.075	.321
25% effic, R per M^3	.880	.104	.300	1.284
20% effic, R per M^3	1.100	.130	.375	1.605
Village Roads (unimproved)				
100% effic, R per M^3	.220	.024	.073	.317
25% effic, R per M^3	.880	.096	.292	1.268
20% effic, R per M^3	1.100	.120	.365	1.585

(a) Excludes 20% organizational overhead shown in Niese estimates.

If the Conservation Division did use and cost capital at the 1,000 hour per year level total costs for waterways would decline to some 77 percent of the levels shown above (e.g., to R 0.32 per M^3 at the 20 percent efficiency level). Similarly, costs would decline to 80 percent of the levels shown for terrace, diversions and village roads. This effect is relatively comparable to an increase in operating efficiency from 20 to 25 percent.

The technique of equipment utilization, particularly the use of two Cat D-6 dozers in tandem for waterway construction, has a very significant impact on costs. Provided that conservation engineer field experience confirmed these estimates as approximately correct,

the Conservation Division could effect very sizeable economies by using the equipment in that fashion. This is true even at the lowest efficiency levels.

TABLE C-1

Equipment Charge Rates
(Based on Price in Rand 1-16-1979)

Description 1/	Purchase Price FOB-Leostho(R)	Hourly Rate Depr.	90% Maint	5% Cont	= Owner Expense	+ Over Head	+ Rent Cont	= Total	Recom Min Rental Rate	Fuel Cons in L	Cost @ R 0.20	Lub as 5% Fuel	Cost POL	Hourly Operating Cost (Less Operator)
Dozer W/Ripper-Cat D-6 (140 HP)	90,600.00	11.33	10.19	1.08	22.59	4.52	2.71	29.82	30.00	20	4.00	0.20	4.20	34.20
Elevating Wheeled Scraper Cat-613 (150 HP)	82,000.00	10.25	9.23	0.97	20.45	4.09	2.45	26.99	27.00	19	3.80	0.19	3.99	30.99
Motorgrader-Cat 120G (125 HP)	72,800.00	9.10	8.19	0.86	18.15	3.63	2.18	23.96	24.00	18	3.60	0.18	3.78	27.78
Wheel Loader-Cat 920 (80 HP)	48,000.00	6.00	5.40	0.57	11.97	2.39	1.44	15.80	16.00	12	2.40	0.12	2.52	18.52
Compactor-Cat 815 (170 HP)	103,500.00	12.94	11.64	1.23	25.81	5.16	3.10	34.07	34.50	34	6.80	0.34	7.14	41.64
Compactor-3 wheeled 6-8 Ton							estimated at		10.00		3.00	0.15	3.15	13.15
Disc. (Rome Trc 12-36)	22,608.00	2.26	2.03	0.21	4.51	0.90	0.54	5.95	6.00	-	-	-	-	6.00
Dump Truck (5 M^3)	18,000.00	3.75	3.38	0.36	7.48	1.50	0.90	9.87	10.00	15	3.00	0.15	3.15	13.15
Water Truck (5,000L)	18,000.00	3.75	3.38	0.36	7.48	1.50	0.90	9.87	10.00	15	3.00	0.15	3.15	13.15
Pickup Truck Mech Equipped	24,000.00	5.00	4.50	0.48	9.98	2.00	1.20	13.17	13.50	Varies	-	-	-	14.00
Concrete Mixer (16S)	12,000.00	2.00	1.80	0.19	3.99	0.80	0.48	5.27	5.50	6	1.20	0.06	1.26	6.75
Water Pump 4"Q Discharge	5,500.00	1.83	1.65	0.17	3.66	0.73	0.44	4.83	5.00	1.5	0.30	0.02	0.32	5.32
Water Pump 2"Q Discharge	3,500.00	1.17	1.05	0.11	2.33	0.47	0.28	3.07	3.50	1.0	0.20	0.01	0.21	3.71
Generator, Electric Power (3 Kw)	5,000.00	1.67	1.50	0.16	3.33	0.67	0.40	4.39	4.50	1.75	0.35	0.02	0.37	4.87
Vibrators, Concrete Elec-Motor in Head	1,100.00	0.55	0.55	0.06	1.16	0.23	0.14	1.52	2.00	-	-	-	-	2.00

1/ Items 1 through 6 basic costs; others estimated.

Source: William Niese, Jr., Regional Engineer Advisor, REDSO/EA.

TABLE C-2a

I. Project: Waterway

II. Work Description: Earthwork

III. Cost Element: Equipment

A. Description	No. Reqd	Standard 8,000 Hr Life Rate, No Replacement R/Hour	Extension
Dozer D-6	2	34.20	68.40
Motorgrader, Cat 120G	1	27.78	27.78
Pickup Truck (Foreman)	1	1.79	1.79
Total Cost Per Hour			R 97.97

B. Unit Price Efficiency: Estimated 100% efficiency = 1,200 M^3 per dozer hour, or 2 dozers = 2,400 M^3.

C. Efficiency of:	30 %	40 %	60 %	80 %	100 %
in M^3/hour:	720	960	1,440	1,920	2,400
IV. 1/ Cost in R Per M^3, No Replacement:	R 0.137	R 0.102	R 0.068	R 0.051	R 0.041

1/ Obtained by dividing total cost per hour by various efficiency rates of earth moved in M^3 per hour.

Source: Prepared by William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

(Continued on next page)

TABLE C-2a (Continued)

I. Project: Waterway

II. Work Description: Earthwork

III. Cost Element: Labor

A. Description	No. Reqd	Standard 8,000 Hr Life Rate, No Replacement R/Hour	Extension
Foreman	1	1.35	1.35
Equipment Operators	3	1.00	3.00
Light Truck Driver	1	0.47	0.47
Laborers	6	0.38	2.28
Total Cost Per Hour			R 7.10

B. Unit Price Efficiency: Estimated 100% efficiency = 1,200 M^3 per dozer hour, or 2 dozers = 2,400 M^3.

C. Efficiency of:	30 %	40 %	60 %	80 %	100 %
in M^3/hour:	720	960	1,440	1,920	2,400
IV. 1/ Cost in R Per M^3, No Replacement:	R 0.010	R 0.007	R 0.005	R 0.004	R 0.003

1/ Obtained by dividing total cost per hour by various efficiency rates of earth moved in M^3 per hour.

Source: Prepared by William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

(Continued on next page)

TABLE C-2a (Continued)

I. Project: Waterway

II. Work Description: Earthwork

III. Cost Element: Site Job Overhead

A. Description	No. Reqd	Standard 8,000 Hr Life Rate, No Replacement R/Hour	Extension
Job Superintendent	1	2.00	2.00
Engineer	1	1.70	1.70
Surveyor	1	1.04	1.04
Rodman	4	0.46	1.84
Mechanic	1	1.35	1.35
Mechanic Helper	1	0.85	0.85
Timekeeper	1	0.63	0.63
Watchman	1	0.44	0.44
Light Truck Driver	1	0.47	0.47
Laborers	6	0.38	2.28
Equipment:			
Mechanic Truck	1	14.00	14.00
Light Truck (Sup't)	2	1.79	3.58
Total Cost Per Hour			R 30.18

B. Unit Price Efficiency: Estimated 100% efficiency = 1,200 M^3 per dozer hour, or 2 dozers = 2,400 M^3.

C. Efficiency of:	30 %	40 %	60 %	80 %	100 %
in M^3/hour:	720	960	1,440	1,920	2,400
IV. 1/ Cost in R Per M^3, No Replacement:	R 0.042	R 0.031	R 0.021	R 0.016	R 0.012

1/ Obtained by dividing total cost per hour by various efficiency rates of earth moved in M^3 per hour.

Source: Prepared by William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

(Continued on next page)

91

TABLE C-2a (Continued)

I. Project: Waterway

II. Work Description: Earthwork

III. COST SUMMARY: Standard 8,000 Hr Life Rate in R per M^3

Description	at Efficiency Factors of 30 %	40 %	60 %	80 %	100 %
a. Material	0.001	0.001	0.001	0.001	0.001
b. Equipment(a)	0.137	0.102	0.068	0.051	0.041
c. POL	-	-	-	-	-
d. Labor	0.010	0.007	0.005	0.004	0.003
e. Site Job OH	0.042	0.031	0.021	0.019	0.012
f. Org OH(b)	0.038	0.028	0.019	0.015	0.011
g. SUBTOTAL	0.228	0.169	0.114	0.090	0.068
h. +10% Contngcy	0.023	0.017	0.011	0.009	0.007
i. TOTAL COST IN RAND PER M^3	0.251	0.186	0.125	0.099	0.075

(a) See Table C-1 for hourly cost data.

(b) Estimated 20% of above cost elements covering supplies, office training, transportation, personnel and other general nonallocable costs.

Source: Prepared by William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

TABLE C-2b

I. Project: Terraces & Diversions

II. Work Description: Earthwork

III. Cost Element Equipment

A. Description	No. Reqd	Standard 8,000 Hr Life Rate, No Replacement R/Hour	Extension
Motorgrader, Cat 120G	1	27.78	27.78
Pickup (Foreman)	1	1.79	1.79
Total Cost Per Hour			R 29.57

B. Unit Price Efficiency: Estimated 100% efficiency = 192.5 M^3 per hour.

C. Efficiency of:	30 %	40 %	60 %	80 %	100 %
in M^3/hour:	57.75	77.00	115.50	154.00	192.50

IV. 1/ Cost in R Per M^3, No Replacement:	R 0.512	R 0.384	R 0.256	R 0.192	R 0.154

1/ Obtained by dividing total cost per hour by various efficiency rates of earth moved in M^3 per hour.

Source: Prepared by William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

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TABLE C-2b (Continued)

I. Project: Terraces & Diversions

II. Work Description: Earthwork

III. Cost Element: Labor

A. Description	No. Reqd	Standard 8,000 Hr Life Rate, No Replacement R/Hour	Extension
Foreman	1	1.35	1.35
Equipment Operator	1	1.00	1.00
Light Truck Driver	1	0.47	0.47
Laborers	6	0.38	2.28
Total Cost Per Hour			R 5.10

B. Unit Price Efficiency: Estimated 100% efficiency = 192.5 M^3 per hour.

C. Efficiency of:	30 %	40 %	60 %	80 %	100 %
in M^3/hour:	57.75	77.00	115.50	154.00	192.50
IV. 1/ Cost in R Per M^3, No Replacement:	R 0.088	R 0.066	R 0.044	R 0.033	R 0.026

1/ Obtained by dividing total cost per hour by various efficiency rates of earth moved in M^3 per hour.

Source: Prepared by William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

(Continued on next page)

TABLE C-2b (Continued)

I. Project: Terraces & Diversions

II. Work Description: Earthwork

III. Cost Element: Site Job Overhead

A. Description	No. Reqd	Standard 8,000 Hr Life Rate, No Replacement R/Hour	Extension
Job Superintendent	1	2.00	2.00
Surveyor	1	1.04	1.04
Rodman	2	0.46	0.92
Mechanic Helper	1	0.85	0.85
Timekeeper	1	0.63	0.63
Light Truck Driver	1	0.47	0.47
Laborers	3	0.38	1.14
Equipment:			
Light Truck	1	1.79	1.79
Total Cost Per Hour			R 8.84

B. Unit Price Efficiency: Estimated 100% efficiency = 192.5 M^3 per hour.

C. Efficiency of:	30 %	40 %	60 %	80 %	100 %
in M^3/hour:	57.75	77.00	115.50	154.00	192.50
IV. 1/ Cost in R Per M^3, No Replacement:	R 0.153	R 0.115	R 0.077	R 0.057	R 0.046

1/ Obtained by dividing total cost per hour by various efficiency rates of earth moved in M^3 per hour.

Source: Prepared by William Niese, Jr., P.E.. Regional Engineer Advisor, REDSO/EA.

(Continued on next page)

TABLE C-2b (Continued)

I. Project: Terraces & Diversions

II. Work Description: Earthwork

III. COST SUMMARY: Standard 8,000 Hr Life Rate in R per M^3

Description	at Efficiency Factors of 30 %	40 %	60 %	80 %	100 %
a. Material	0.005	0.005	0.004	0.003	0.002
b. Equipment(a)	0.512	0.384	0.256	0.192	0.154
c. POL	-	-	-	-	-
d. Labor	0.088	0.066	0.044	0.033	0.026
e. Site Job OH	0.153	0.115	0.077	0.057	0.046
f. Org OH(b)	0.152	0.114	0.076	0.057	0.046
g. SUBTOTAL	0.910	0.684	0.457	0.342	0.274
h. +10% Contngcy	0.091	0.068	0.046	0.034	0.027
i. TOTAL COST IN RAND PER M^3	1.001	0.752	0.503	0.376	0.301

(a) See Table C-1 for hourly cost data.

(b) Estimated 20% of above cost elements covering supplies, office training, transportation, personnel and other general nonallocable costs.

Source: Prepared by William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

10

TABLE C-2c

I. Project: Village Road

II. Work Description: Earthwork-no compaction

III. Cost Element: Equipment

A. Description	No. Reqd	Standard 8,000 Hr Life Rate, No Replacement R/Hour	Extension
Motorgrader, Cat 120G	1	27.78	27.78
Light Truck (Foreman)	1	1.79	1.79
Total Cost Per Hour			R 29.57

B. Unit Price Efficiency: Estimated 100% efficiency = 192.5 M^3 per hour.

C. Efficiency of:	30 %	40 %	60 %	80 %	100 %
in M^3/hour:	57.75	77.00	115.50	154.00	192.50
IV. 1/ Cost in R Per M^3, No Replacement:	R 0.512	R 0.384	R 0.256	R 0.192	R 0.154

1/ Obtained by dividing total cost per hour by various efficiency rates of earth moved in M^3 per hour.

Source: Prepared by William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

(Continued on next page)

TABLE C-2c (Continued)

I. Project: Village Road

II. Work Description: Earthwork-no compaction

III. Cost Element: Labor

A. Description	No. Reqd	Standard 8,000 Hr Life Rate, No Replacement R/Hour	Extension
Foreman	1	1.35	1.35
Equipment Operator	1	1.00	1.00
Light Truck Driver	1	0.67	0.67
Laborers	4	0.38	1.52
Total Cost Per Hour			R 4.54

B. Unit Price Efficiency: Estimated 100% efficiency = 192.5 M^3 per hour.

C. Efficiency of:	30 %	40 %	60 %	80 %	100 %
in M^3/hour:	57.75	77.00	115.50	154.00	192.50
IV. 1/ Cost in R Per M^3, No Replacement:	R 0.079	R 0.059	R 0.039	R 0.029	R 0.024

1/ Obtained by dividing total cost per hour by various efficiency rates of earth moved in M^3 per hour.

Source: Prepared by William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

(Continued on next page)

TABLE C-2c (Continued)

I. Project: Village Road

II. Work Description: Earthwork-no compaction

III. Cost Element: Site Job Overhead

A. Description	No. Reqd	Standard 8,000 Hr Life Rate, No Replacement R/Hour	Extension
Superintendent	1	2.00	2.00
Timekeeper	1	0.63	0.63
Mechanic	1	1.35	1.35
Rodman	2	0.46	0.92
Light Truck Driver	1	0.47	0.47
Laborers	4	0.38	1.52
Equipment:			
Light Truck (Sup't)	1	1.79	1.79
Total Cost Per Hour			R 8.68

B. Unit Price Efficiency: Estimated 100% efficiency = 192.5 M^3 per hour.

C. Efficiency of:	30 %	40 %	60 %	80 %	100 %
in M^3/hour:	57.75	77.00	115.50	154.00	192.50
IV. 1/ Cost in R Per M^3, No Replacement:	R 0.150	R 0.113	R 0.075	R 0.056	R 0.045

1/ Obtained by dividing total cost per hour by various efficiency rates of earth moved in M^3 per hour.

Source: Prepared by William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

(Continued on next page)

TABLE C-2c (Continued)

I. Project: Village Road

II. Work Description: Earthwork-no compaction

III. COST SUMMARY: Standard 8,000 Hr Life Rate in R per M^3

Description	at Efficiency Factors of 30 %	40 %	60 %	80 %	100 %
a. Material	0.006	0.005	0.003	0.002	0.001
b. Equipment(a)	0.512	0.384	0.256	0.192	0.154
c. POL	-	-	-	-	-
d. Labor	0.079	0.059	0.039	0.029	0.024
e. Site Job OH	0.150	0.113	0.075	0.056	0.045
f. Org OH(b)	0.149	0.112	0.075	0.056	0.045
g. SUBTOTAL	0.896	0.673	0.447	0.335	0.269
h. +10% Contngcy	0.090	0.067	0.045	0.033	0.027
i. TOTAL COST IN RAND PER M^3	0.986	0.741	0.492	0.368	0.296

(a) See Table C-1 for hourly cost data.

(b) Estimated 20% of above cost elements covering supplies, office training, transportation, personnel and other general nonallocable costs.

Source: Prepared by William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

TABLE C-2d

I. Project: Village Road-improved

II. Work Description: Earthwork-compacted

III. Cost Element: Equipment

A. Description	No. Reqd	Standard 8,000 Hr Life Rate, No Replacement R/Hour	Extension
Motorgrader, Cat 120G	1	27.78	27.78
Dozer D-6	1	34.20	34.20
Compactor, 8-10 Ton	1	13.15	13.15
Water Trucks (5,000 L)	2	13.15	26.30
Light Vehicle (Foreman	1	1.79	1.79
Total Cost Per Hour			R 103.22

B. Unit Price Efficiency: Estimated 100% efficiency = 667 M^3 per hour.

C. Efficiency of:	30 %	40 %	60 %	80 %	100 %
in M^3/hour:	200	267	400	533	667
IV. 1/ Cost in R Per M^3, No Replacement:	R 0.516	P 0.387	R 0.258	R 0.194	R 0.155

1/ Obtained by dividing total cost per hour by various efficiency rates of earth moved in M^3 per hour.

Source: Prepared by William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

(Continued on next page)

TABLE C-2d (Continued)

I. Project: Village Road-improved

II. Work Description: Earthwork-compacted

III. Cost Element: Labor

A. Description	No. Reqd	Standard 8,000 Hr Life Rate, No Replacement R/Hour	Extension
Grade Foreman	1	1.35	1.35
Equipment Operator	2	1.00	2.00
Rollerman	1	0.84	0.84
Truck Driver	2	0.67	1.34
Light Truck Driver	1	0.47	0.47
Laborers	6	0.38	2.28
Total Cost Per Hour			R 8.28

B. Unit Price Efficiency: Estimated 100% efficiency = 667 M^3 per hour.

C. Efficiency of:	30 %	40 %	60 %	80 %	100 %
in M^3/hour:	200	267	400	533	667
IV. 1/ Cost in R Per M^3, No Replacement:	R 0.041	R 0.031	R 0.021	R 0.016	R 0.012

1/ Obtained by dividing total cost per hour by various efficiency rates of earth moved in M^3 per hour.

Source: Prepared by William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

(Continued on next page)

TABLE C-2d (Continued)

I. Project: Village Road-improved

II. Work Description: Earthwork-compacted

III. Cost Element: Site Job Overhead

A. Description	No. Reqd	Standard 8,000 Hr Life Rate, No Replacement R/Hour	Extension
Superintendent	1	2.00	2.00
Timekeeper	1	0.63	0.63
Mechanic	1	1.35	1.35
Mechanic Helper	1	0.85	0.85
Surveyor	1	1.04	1.04
Rodman	4	0.46	1.84
Light Truck Driver	1	0.47	0 47
Laborers	6	0.38	2.28
Equipment:			
Mechic Truck	1	14.00	14.00
Light Truck	1	1.79	1.79
Total Cost Per Hour			R 26.25

B. Unit Price Efficiency: Estimated 100% efficiency = 667 M^3 per hour.

C. Efficiency of:	30 %	40 %	60 %	80 %	100 %
in M^3/hour:	200	267	400	533	667
IV. 1/ Cost in R Per M^3, No Replacement:	R 0.131	R 0.098	R 0.066	R 0.049	R 0.039

1/ Obtained by dividing total cost per hour by various efficiency rates of earth moved in M^3 per hour.

Source: Prepared by William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

(Continued on next page)

TABLE C-2d (Continued)

I. Project: Village Road-improved

II. Work Description: Earthwork-compacted

III. COST SUMMARY: Standard 8,000 Hr Life Rate in R per M^3

Description	at Efficiency Factors of 30 %	40 %	60 %	80 %	100 %
a. Material	0.003	0.003	0.002	0.001	0.001
b. Equipment(a)	0.516	0.387	0.258	0.194	0.155
c. POL	-	-	-	-	-
d. Labor	0.041	0.031	0.021	0.016	0.012
e. Site Job OH	0.131	0.098	0.066	0.049	0.039
f. Org OH(b)	0.138	0.104	0.069	0.052	0.041
g. SUBTOTAL	0.829	0.623	0.416	0.312	0.248
h. +10% Contngcy	0.083	0.062	0.042	0.031	0.025
i. TOTAL COST IN RAND PER M^3	0.912	0.685	0.458	0.343	0.273

(a) See Table C-1 for hourly cost data.

(b) Estimated 20% of above cost elements covering supplies, office training, transportation, personnel and other general nonallocable costs.

Source: Prepared by William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

110

TABLE C-2e

I. Project: Village Road

II. Work Description: Gravel-no compaction

III. Cost Element: Equipment

A. Description	No. Reqd	Standard 8,000 Hr Life Rate, No Replacement R/Hour	Extension
Wheeled Loader, Cat 920	1	18.52	18.52
Motorgrader, Cat 120G	1	27.78	27.78
Dump Trucks	2	13.15	26.30
Light Truck (Foreman)	1	1.79	1.79
Total Cost Per Hour			R 74.39

B. Unit Price Efficiency: Estimated 100% efficiency = 80 M^3 per hour.

C. Efficiency of:	30 %	40 %	60 %	80 %	100 %
in M^3/hour:	24	32	48	64	80
IV. 1/ Cost in R Per M^3, No Replacement:	R 3.100	R 2.325	R 1.550	R 1.162	R 0.930

1/ Obtained by dividing total cost per hour by various efficiency rates of earth moved in M^3 per hour.

Source: Prepared by William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

(Continued on next page)

TABLE C-2e (Continued)

I. Project: Village Road

II. Work Description: Gravel-no compaction

III. Cost Element: Labor

A. Description	No. Reqd	Standard 8,000 Hr Life Rate, No Replacement R/Hour	Extension
Foreman	1	1.35	1.35
Equipment Operator	2	1.00	2.00
Truck Driver	2	0.67	1.34
Light Truck Driver	1	0.47	0.47
Laborers	6	0.38	2.28
Total Cost Per Hour			R 7.44

B. Unit Price Efficiency: Estimated 100% efficiency = 80 M^3 per hour.

C. Efficiency of:	30 %	40 %	60 %	80 %	100 %
in M^3/hour:	24	32	48	64	80
IV. 1/ Cost in R Per M^3, No Replacement:	R 0.310	R 0.233	R 0.155	R 0.116	R 0.093

1/ Obtained by dividing total cost per hour by various efficiency rates of earth moved in M^3 per hour.

Source: Prepared by William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

(Continued on next page)

TABLE C-2e (Continued)

I. Project: Village Road

II. Work Description: Gravel-no compaction

III. Cost Element: Site Job Overhead

A. Description	No. Reqd	Standard 8,000 Hr Life Rate, No Replacement R/Hour	Extension
Superintendent	1	2.00	2.00
Timekeeper	1	0.63	0.63
Mechanic	1	1.35	1.35
Rodman	2	0.46	0.92
Light Truck Driver	1	0.47	0 47
Laborers	4	0.38	1.52
Equipment:			
Light Truck (Sup't)	1	1.79	1.79
Total Cost Per Hour			R 8.68

B. Unit Price Efficiency: Estimated 100% efficiency = 80 M^3 per hour.

C. Efficiency of:	30 %	40 %	60 %	80 %	100 %
in M^3/hour:	24	32	48	64	80
IV. 1/ Cost in R Per M^3, No Replacement:	R 0.362	R 0.271	R 0.181	R 0.136	R 0.109

1/ Obtained by dividing total cost per hour by various efficiency rates of earth moved in M^3 per hour.

Source: Prepared by William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

(Continued on next page)

TABLE C-2e (Continued)

I. Project: Village Road

II. Work Description: Gravel-no compaction

III. COST SUMMARY: Standard 8,000 Hr Life Rate in R per M^3

Description	at Efficiency Factors of 30 %	40 %	60 %	80 %	100 %
a. Material	0.026	0.019	0.012	0.009	0.006
b. Equipment(a)	3.100	2.325	1.550	1.162	0.930
c. POL	-	-	-	-	-
d. Labor	0.310	0.233	0.155	0.116	0.093
e. Site Job OH	0.362	0.271	0.181	0.136	0.109
f. Org OH(b)	0.362	0.271	0.181	0.136	0.109
g. SUBTOTAL	4.558	3.418	2.278	1.708	1.366
h. +10% Contngcy	0.456	0.342	0.228	0.171	0.137
i. TOTAL COST IN RAND PER M^3	5.014	3.759	2.505	1.878	1.503

(a) See Table C-1 for hourly cost data.

(b) Estimated 20% of above cost elements covering supplies, office training, transportation, personnel and other general nonallocable costs.

Source: Prepared by William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

TABLE C-2f

I. Project: Village Road-improved

II. Work Description: Gravel-compacted

III. Cost Element: Equipment

A. Description	No. Reqd	Standard 8,000 Hr Life Rate, No Replacement R/Hour	Extension
Wheeled Loader, Cat 920	1	18.52	18.52
Motorgrader, Cat 120G	1	27.78	27.78
Compactor, 8-10 Ton	1	13.15	13.15
Dump Truck ($5M^3$)	2	13.15	26.30
Water Truck (5,000 L)	2	13.15	26.30
Light Truck (Foreman	1	1.79	1.79
Total Cost Per Hour			R 113.84

B. Unit Price Efficiency: Estimated 100% efficiency = 167 M^3 per hour.

C. Efficiency of:	30 %	40 %	60 %	80 %	100 %
in M^3/hour:	50	67	100	134	167
IV. [1/] Cost in R Per M^3, No Replacement:	R 2.277	R 1.699	R 1.138	R 0.850	R 0.682

[1/] Obtained by dividing total cost per hour by various efficiency rates of earth moved in M^3 per hour.

Source: Prepared by William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

(Continued on next page)

113

TABLE C-2f (Continued)

I. Project: Village Road-improved

II. Work Description: Gravel-compacted

III. Cost Element: Labor

A. Description	No. Reqd	Standard 8,000 Hr Life Rate, No Replacement R/Hour	Extension
Foreman	1	1.35	1.35
Equipment Operator	2	1.00	2.00
Rollerman	1	0.84	0.84
Truck Drivers	4	0.67	2.68
Light Truck Driver	1	0.47	0.47
Laborers	6	0.38	2.28
Total Cost Per Hour			R 9.62

B. Unit Price Efficiency: Estimated 100% efficiency = 167 M^3 per hour.

C. Efficiency of:	30 %	40 %	60 %	80 %	100 %
in M^3/hour:	50	67	100	134	167
IV. 1/ Cost in R Per M^3, No Replacement:	R 0.192	R 0.144	R 0.096	R 0.072	R 0.058

1/ Obtained by dividing total cost per hour by various efficiency rates of earth moved in M^3 per hour.

Source: Prepared by William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

(Continued on next page)

TABLE C-2f (Continued)

I. Project: Village Road-improved

II. Work Description: Gravel-compacted

III. Cost Element: Site Job Overhead

A. Description	No. Reqd	Standard 8,000 Hr Life Rate, No Replacement R/Hour	Extension
Superintendent	1	2.00	2.00
Timekeeper	1	0.63	0.63
Mechanic	1	1.35	1.35
Mechanic Helper	1	0.85	0.85
Surveyor	1	1.04	1.04
Rodman	2	0.46	0.92
Light Truck Driver	1	0.47	0.47
Laborers	6	0.38	2.28
Equipment:			
Mechanic Truck	1	14.00	14.00
Light Truck	1	1.79	1.79
Total Cost Per Hour			R 25.33

B. Unit Price Efficiency: Estimated 100% efficiency = 167 M^3 per hour.

C. Efficiency of:	30 %	40 %	60 %	80 %	100 %
in M^3/hour:	50	67	100	134	167
IV. 1/ Cost in R Per M^3, No Replacement:	R 0.507	R 0.378	R 0.253	R 0.189	R 0.152

1/ Obtained by dividing total cost per hour by various efficiency rates of earth moved in M^3 per hour.

Source: Prepared by William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

(Continued on next page)

TABLE C-2f (Continued)

I. Project: Village Road-improved

II. Work Description: Gravel-compacted

III. COST SUMMARY: Standard 8,000 Hr Life Rate in R per M^3

Description	at Efficiency Factors of 30 %	40 %	60 %	80 %	100 %
a. Material	0.014	0.012	0.008	0.006	0.004
b. Equipment(a)	2.277	1.699	1.138	0.850	0.682
c. POL	-	-	-	-	-
d. Labor	0.192	0.144	0.096	0.072	0.058
e. Site Job OH	0.507	0.378	0.253	0.189	0.152
f. Org OH(b)	0.598	0.447	0.299	0.223	0.179
g. SUBTOTAL	3.588	2.680	1.794	1.340	1.075
h. +10% Contngcy	0.359	0.268	0.179	0.134	0.108
i. TOTAL COST IN RAND PER M^3	3.947	2.948	1.973	1.474	1.183

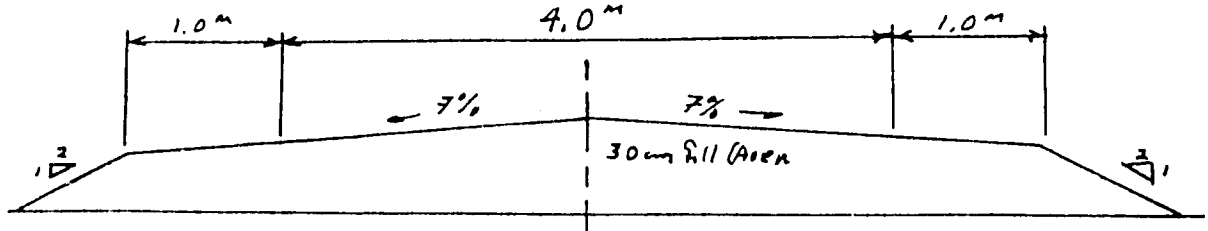
(a) See Table C-1 for hourly cost data.

(b) Estimated 20% of above cost elements covering supplies, office training, transportation, personnel and other general nonallocable costs.

Source: Prepared by William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

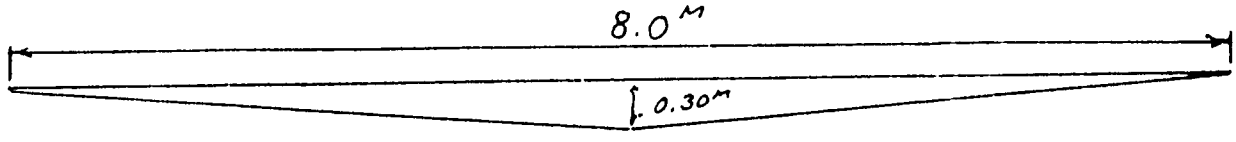
TABLE C-3

SECTIONS SHOWN ARE AVERAGE BUT VARY WITH THE TERRAIN--NO SCALE

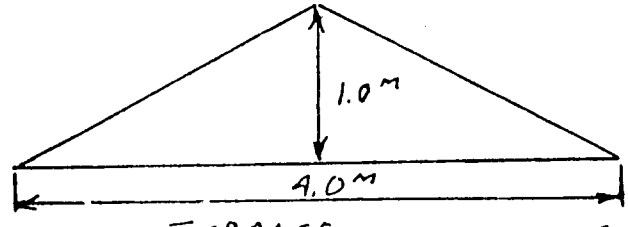


TYPICAL SECTION

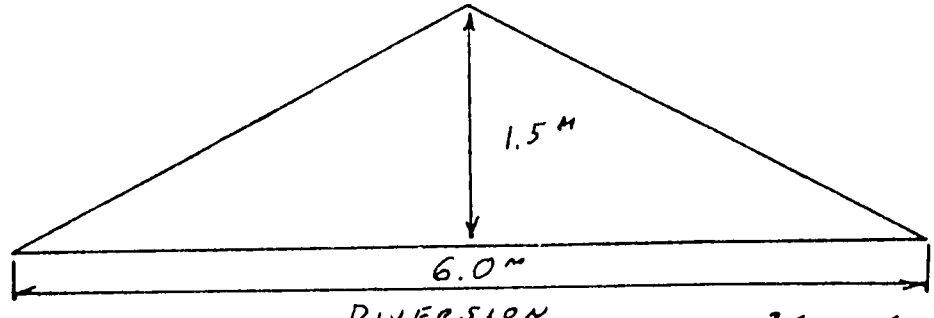
VILLAGE ROAD - IMPROVED
EARTHWORK - 1.87 m^3/m OR 1872 m^3/km
GRAVEL - 1.08 m^3/m OR 1080 m^3/km



WATERWAY (SEEDED)
EARTHWORK VOLUME = 1.2 m^3/m OR 1200 m^3/km



TERRACE
EARTHWORK VOLUME = 2.0 m^3/m OR 2000 m^3/km



DIVERSION
EARTHWORK VOLUME - 4.5 m^3/m OR 4500 m^3/km

Source: Prepared by Wm. Niese, Jr., P.E., Regional Engineer Advisor, USAID/REDSO/EA

119

TABLE C-4

UNITED STATES GOVERNMENT

Memorandum

TO : Mr. Ronald Wykstra, A.I.D. Consultant DATE: January 24, 1979

FROM : William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA

SUBJECT: Equipment Cost Vs Use Analysis

EQUIPMENT COST ANALYSIS

Standard equipment costing practices do not afford funds to replace units because they do not normally consider inflation factor. We would like to show the cost of equipment when one considers inflation factor but omits interest, insurance and taxes as governments never usually pay these directly. This analysis will point out some of the misconceptions and evil of not making maximum and early use of equipment.

The cost of a D-6 Cat - Bulldozer with ripper on 1 January 1976 was 90,600 Rand ($105,096) (Rate 1R=$1.16).

Dozer Purchase Price	Date	Rand
	79	90,600
	80	101,472
	81	113,649
	82	127,287
	83	142,561
	84	159,668 (5th Year)
	85	178,828
	86	200,288
	87	224,323 (8th Year)

Based on 12% inflation factor.

In addition to costs, spare parts obsolescence becomes a problem after 8 years. This means that at the end of 8 years many parts will have to be locally manufactured for old machines.

This presents two problems.

1. The state of the art of local parts fabrication in many LDC's is not advanced sufficiently to ensure really serviceable parts.

2. When the state of the art is advanced sufficiently to provide really serviceable parts the cost becomes prohibitive.

TABLE C-4 (Continued)

Let us look at the real cost of this dozer based on:

A. Manufacturer recommendation in developed countries - 10,000 hrs in 5 years.

B. Manufacturer recommendations in LDC's - 8,000 hrs in 5 years.

C. Use factor in LDC's of under 900 hr/yr - a reasonable life factor of 8 years.

D. 700 hr/year - 8 years.

A. 10,000 hr - 5 yr (Moneys are in Rand)

Replacement cost of Dozer (5th year) 159,668

Maintenance Cost ÷ 10,000 = $15.97/hr

1.	90,000 ÷ 5 x 90%	=	16,308.00
2.	101,472 x	=	18,264.96
3.	113,649	=	20,456.82
4.	127,287	=	22,911.66
5.	142,561	=	25,660.98
			103,602.42

÷ 10,000 = 10.36

26.33

+ 5% Cont 1.32

OWNERSHIP EXPENSE 27.65 R/Hr

B. 8,000 - 5 yr (Moneys are in Rand)

Replacement Cost = 159,668

÷ 8,000 = 19.96

Maintenance Cost 103,602.42

÷ 8,000 12.95

32.91

Cont 5% 1.65

34.55 R/Hr

A 25% increase in effective cost.

121

TABLE C-4 (Continued)

C. 900 hr/yr for 8 years (7,200 hrs - 8 years)

Replacement cost of Dozer (8th year) = 224,323

÷ 7,200 = 31.16

Maintenance Cost

1st yr	90,600	÷ 8 x 90%	= 10,192.50
2nd yr	101,472		= 11,415.60
3rd yr	113,649		= 12,785.51
4th yr	127,287		= 14,319.79
5th yr	142,561		= 16,038.11
6th yr	159,668		= 17,962.65
7th yr	178,828		= 20,118.15
8th yr	200,288		= 22,532.40
			125,364.71

÷ 7,200 = 17.41

48.57

Cont 5% 2.43

Ownership Expense 51.00 R/hr

D. 700 hr/yr - 8 hr (5,600 hr - 8 yr)

Replacement Cost = 224,323

÷ 5,600 = 40.06

Maintenance Cost 125,364.71

÷ 5,600 = 22.39

62.45

Cont 5% 3.12

Ownership Expense 65.57 R/hr

TABLE C-4 (Continued)

Maintenance

The cost of yearly maintenance is not normally reduced by lack of use since deterioration of various parts of assembly components create problems that would not be classified as "fair wear and tear" of a normally operated machine.

In addition to maintenance problem the proficiency of the operator is often less than 40% since he is not constantly working a machine to improve his skill and reach the 80% efficiency quotient that should be a standard.

This reduced production is reflected in idleness of other personnel, increased overhead and a complete loss of "esprit de corps."

LDC governmental officials should do all in their power to eliminate this waste, and foreign advisors who are not diligently trying to alleviate this problem should be immediately terminated as they are showing a lack of professional integrity and in essence are defrauding the donor that is paying for their services and the LDC recipient who is placing a trust in their guidance.

TABLE C-4 (Continued)

COMPARISON-HOURLY COST OF D-6 DOZERS
WITH VARIOUS USE FACTORS

	Replacement	Cost/Hr Maintenance	Contingency	Owner-ship Expense	% Diff
10,000 Hr-5 Year	15.97	10.36	1.32	27.67	
					25 %
8,000 Hr-5 Year	19.96	12.95	1.65	34.55	
					48 %
7,200 Hr-8 Year	31.16	17.41	2.43	51.00	
					28 %
5,600 Hr-8 Year	40.06	22.39	3.12	65.57	

TABLE C-5

HOURLY RATES FOR LABOR
(+ 0.10 for field support)

Operators	Rand/Hr
Dozer	1.00
Motorgrader	1.00
Wheeled Scraper	1.00
Wheeled Loader	1.00
Compactor	0.84
Dump Truck	0.67
Water Truck	0.67
Light Truck	0.47
Concrete Mixer	0.84
Water Pump	0.84
Generator	0.84
Foreman	1.35
Mason	0.85
Carpenters	0.85
Mechanic	1.35
Mechanic Helper	0.85
Labor	0.38
Timekeeper	0.63
Watchman	0.44
Surveyor	1.04
Rodman	0.46

Source: William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA, and Michael Nyquist, Conservation Engineer, Thaba Bosiu.

TABLE C-6

MINISTRY OF WORKS CIRCULAR NO. 10 OF 1975

W/CHY/P/POL/12. MECHANICAL BRANCH, MINISTRY OF WORKS, P.O. BOX 56, MASERU

TO: SENIOR DEPUTY SECRETARY, 27 March 1975

ALL PERMANENT SECRETARIES, DIRECTOR OF P.&T.,

COPY: PRIVATE SECRETARY TO HIS MAJESTY, CLERK TO ASSEMBLY,

OFFICER-IN-CHARGE CONRUDCV., COMMISIONER OF POLICE,

MESSRS GIANTS CUP MOTORS, OFFICER-IN-CHARGE MECHANICAL BRANCH, CACHA

GOVERNMENT PLANT POOL

REVISED ADMINISTRATIVE INSTRUCTIONS AND HIRE CHARGES.

With effect from the 21st March 1975, the Government Plant Pool became responsible for Plant Operators of steered plant and as a result it has become necessary to revise the Government Plant Pool Administrative Instructions. These are attached herewith.

2. In addition, because the Government Plant Pool is now responsible for salaries of Operators of steered plant the Plant Hire Charges promulgated under Ministry of Works Circular NO. 19 of 1974, have been increased by R1.25 per hour in respect of steered plant.

3. A revised Circular of hire charges is being prepared showing this increase and will be distributed in due course but in the interim any queries regarding hire charges can be clarified by telephone with the undersigned.

4. It is imperative that Client Departments should adhere explicitly with these Instructions especially with regard to the submission of returns and full co-operation where these are concerned is essential to the efficient operation of the Government Plant Pool. This point cannot be too strongly emphasised.

5. Should further copies be required of this Administrative Instructions they may be obtained from the offices of the Mechanical Branch, Ministry of Works.

R. T. JOY.

for PERMANENT SECRETARY MOT WORKS.

126

TABLE C-6 (Continued)

ADMINISTRATIVE INSTRUCTIONS GOVERNING THE
HIRE OF CIVIL ENGINEERING AND CONTRACTORS PLANT.

(1.0) With effect from 21st March, 1975 certain basic changes in the system of Plant Hire will occur due to the transference of Plant Operators from the Roads Branch to the Mechanical Branch. Steered plant henceforth will only be available complete with operator. Two systems of hire, Short Term Hire and Long Term Hire will continue to be observed.

(2.0)

SHORT TERM HIRE

(a) Plant requisitioned for a period of less than 3 months will only be hired out on Short Term Hire. Long Term Hire conditions will not be available to clients hiring plant for less than this minimum period.

(b) Under this form of hire charges will commence without exception the day a machine leaves the Plant Pool yard and terminate the day it returns.

(c) Charges will be raised against the client on the expiry of the hire period at the relavent hourly rate. A minimum of 9 hours per day will be charged for the number of days on hire including Saturdays, Sundays and Public Holidays, and operators provided for all steered machines on these days.

(d) A minimum hire period of 9 hours or one day will be applied reduced only by down time following reported breakdown of the machine (see Paragraph 5.0).

(e) Machines will be issued on Short Term Hire with their fuel tanks full and must be correspondingly returned with full tanks by the clients.

(3.0)

LONG TERM HIRE

(a) Plant will only be hired on a Long Term basis for periods of 3 months or longer.

(b) The hire arrangements will be based on operator hours and the minimum hire charge will be based on 8 hours of operator time daily reduced only by down-time following reported breakdown of the machine (see Paragraph 5.0) overtime hours in excess of 8 hours daily will be charged pro-rata.

(c) Plant may be hired for any period in excess of three months and will be on a "first come first served" basis with preference given in the case of Lesotho Government Ministries and Departments. A long term hire order will therefore secure the item of plant for any period in excess of 3 months and a minimum hire rate of 8 hours per day, 5 days per week, Monday to Friday will be charged for all operational machines. It is the responsibility of the client to use the machines fully during the hire period.

2/ .....

127

TABLE C-6 (Continued)

(3.1)

SATURDAYS, SUNDAYS AND PUBLIC HOLIDAYS

(a) Clients will be allowed to retain machines on site on Saturdays, Sundays and Public Holidays and providing they are not used no charge will accrue to the client.

(b) The acceptance of any hire order however implies that the client accepts responsibility for machines at all times. The client will compensate the Plant Pool fully for any loss or damage which machines may suffer due to theft, vandalism or the intervention of unauthorised personnel.

(4.0)

SPECIAL ARRANGEMENTS

Arrangements of a special nature may be made with the Plant Pool Manager for short hires of a specified period. The charges will be based on operators - hours worked and the minimum hours to be charged will be notified by the Plant Pool Manager in each case.

(5.0)

BREAKDOWNS

In the case of breakdown the Plant Pool Workshops Manager must be advised by submission of Form MB/PP/02. Hire charges continue to be raised until such time as this advice from the client department is received. The Plant Pool reserves the right to replace a machine with another of equal capacity at any time in the event of breakdown or other defect; it does not however undertake to replace any machine on demand.

(6.0)

DEFECTS.

All defects notified by the operator must similarly be reported on Form No. MB/PP/02 by deleting the word "BREAKDOWN" and substituting the word "DEFECT".

(7.0)

CHARGES AND PAYMENT FOR PLANT HIRE.

(a) Hire charges will be raised at the termination of the hire, or once a month, against Lesotho Government Ministries and Departments. This will be done by way of a Journal Entry in accordance with the rates in force.

(b) Full details of the hours worked by each Plant Pool operator on site must be recorded and returned daily on Form No.MB/PP/03 by the client's site agent; a copy of this form is attached. A separate form for each operator must be submitted to reach the Plant Pool Workshops Manager as soon as possible but in any case not later than 5 days after the day to which the form refers. This form is the basis on which charges are made and in the case of late arrival of forms a minimum hire period of 8 hours per day for Long Term Hire and 9 hours per day for Short Term Hire will be charged and the necessary adjustment will be made the following month.

3/ .....

TABLE C-6 (Continued)

- 3 -

The operator's time must be fully booked from the hour he he reports on site to the hour he leaves.

One hour however will be deducted from the time recorded on Form NO.MB/PP/03 and will not be chargeable to the account of the client; this hour is to allow time for "Starting Up" and Shutting Down" procedures (see Operators Plant Operating Permit and Rules book.)

(8.0)

REQUISITIONING OF PLANT

(a) Plant will, when available be provided on submission by the client Department to the Plant Pool Workshops Manager of a requisition at least 5 working days before the commencement of the hire period.

(b) Type of plant, location, chargeable head and hire arrangements required must be indicated on the requisition and the period of anticipated hire must be defined.

(c) Clients are specially requested to communicate any change in location immediately to the Plant Pool Workshops Manager for obvious reasons of control, the most important being the payment of wages to operators by the Plant Pool.

(d) Submission of a further requisition is required to advise when an item of plant is "off-hired" which must also be 5 working days before the expiry of the hire period.

(e) The client Department will continue to be responsible for the security of the machine until the Plant Pool is able to arrange the transportation of the machine from site (see Paragraph 3.1b) or until the machine returns to the Plant Pool yard, depending on the type of hire.

(9.0)

TRANSPORTATION TO SITE

(a) The cost of transporting a machine or item of plant to and from the Plant Pool yard, Maseru or between sites will be to the account of the client. Low-bed transporters are available in the Plant Pool. Requisitions for low-bed transporters should accompany the plant requisition.

Three days or 27 hours will be the maximum charge for a Plant Pool low-bed transporter for journeys in Lesotho.

(b) Hire charges normally commence for machines the day the item leaves the Plant Pool yard and terminate the day it is returned. Long Term Hire plant transported on a Plant Pool low-bed or on one hired commercially through the Chief Mechanical Engineer's agency will be an exception to this rule and charges for long term hire plant so transported will commence from the hour and day they are unloaded on site and terminate on the hour and day the off-hire notification comes into force.

(10.0)

FUEL

The supply of clean fuel for all machines is the responsibility of the client.

4/ .....

129

TABLE C-6 (Continued)

- 4 -

(11.0)

HIRE TO NON-GOVERNMENT ENTITIES

All non-government entities will be required to leave a deposit with the Chief Mechanical Engineer covering the specified hire period at the rate of 10 hours per day. Accounts will be adjusted when the machine is off-hired. Machines will automatically be withdrawn once the hire period has expired unless a new hire agreement is made and fresh deposit accepted. Deposits must be in cash or a bank-guaranteed cheque.

(12.0)

COMMERCIAL HIRE

When machines are not available in the Plant Pool the Chief Mechanical Engineer will, at the clients request, endeavour to hire them from the private sector; all the arrangements will be made by the Chief Mechanical Engineer and the cost passed on to the client plus a service charge of 5%. This service will only be available to Lesotho Government Ministries and Departments.

(13.0)

GENERAL

The client's site agent will be required to sign each operator's "Plant Operating Permit and Rules" book when the operator arrives on site and to acquaint himself with its contents.

APPENDIX D: LABOR INTENSIVE WORKS

Presently the Government of Lesotho is utilizing a Labor Construction unit (LCU) for various conservation work tasks on an increasing but still experimental scale. 1/ On the basis of this unit's actual historical experience, the Ministry of Works of the Government of Lesotho also has a labor absorbing contingency plan 2/ designed to create employment for 10,000 laborers.

Job reports issued by the LCU indicate that worker productivity has increased since task-work systems were introduced, and that output per direct manday employed ranges from two to three M^3 per manday, averaging no less than 2.5 M^3 per man for excavation-throw work under normal conditions. 3/

The data in Tables D-1 to D-4 of this appendix present detailed information on direct labor and equipment costs by Km of output based upon the experience of LCU activities to date as well as design layouts and a commentary on compaction. This information is summarized below

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1/ See various Labor Construction Unit "Job Reports."

2/ See Labor Construction Unit, "A Contingency Plan During a Possible Emergency Period," January 1979.

3/ World Bank studies of several developing nations indicate that these productivity rates are relatively commonly achieved under task work or incentive pay systems with proper supervision. See I.K. Sud, et.al. discussion paper in P.A. Green and P.D. Brown in Indian Roads Congress Papers of 37th Annual Session, December 1976, pp. 2-10.

in terms of direct costs (which does not include tools and site overhead expenditures). 1/

Labor Intensive Direct Costs:	Waterways*	Terraces*	Diversions*	Village Roads
I. M^3 Earthwork/Km	1,200	800	3,370	948
II. Mandays Employed/Km	860	427	2,530	507
III. No. Ha Protected per Km Constructed	50	4	150	84
IV. DIRECT LABOR & OTHER COSTS:				
R per M^3 earthwork	1.72	1.53	2.05	2.01
R per Km constructed	2,064	1,225	6,915	1,904
R per Ha/protected	41.3	306.3	46.1	22.7

* Terraces, waterways and diversions embody lower M^3 of earthworks than required under capital intensive methods.

Source: Tables D-1, D-2, D-3 and D-4.

As can be seen from data presented above and the accompanying backup Appendix table data (Tables D-1 to D-4), substantial amounts of direct employment are created in a labor intensive operation. For example, conservation works per Ha of area protected would require an estimated 147 mandays of direct employment under labor intensive methods based upon those productivities shown in Tables D-1 to D-4. 2/

The Labor Construction Unit has completed road construction and realized the productivity-cost relationships shown in the Appendix, and is now engaged

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1/ See the discussion which follows.

2/ That is, roads 6.0 = 507/84.2; terraces 107.0 = 427/4; waterways 17.2 = 860/50; diversions 16.9 = 2,530/150.

in other conservation works. [1] The 31.5 Km Mazenod Road now completed involved some 47,500 mandays of employment and was constructed at a direct cost of some R 6,300 per Km. Site and camp overhead costs averaged R 700 per Km). [2] The Mazenod Road was heavily graveled and is not a village road as is cost analyzed in Table D-4, however. Construction of village roads and other conservation works likely will have higher site overhead costs --as shown in Table D-7 of this Appendix.

Estimated site overhead costs approximate R 119,000 yearly for a 600 man labor gang working full time or 150,000 mandays annually. This represents some R 0.80 per manday of employment, or an average of 33 percent of direct wage payments, including depreciation of hand tools. These latter costs are estimated, for purposes of our cost analysis of labor intensive methods, as some R 20 per manyear of employment. In total, then, site overhead costs based upon a work gang of 600 laborers approximate R 0.80 per manday or some one-third of direct labor costs. These costs are summarized below by type of Conservation Division output:

Site Overhead Costs:	Waterways	Terraces	Diversions	Village Roads
No. of Mandays/Km	860	427	2,530	507
Site OH Costs in R/Km	R 688	R 342	R 2,024	R 406
Site OH Costs in Ha/Protected	R 13.8	R 85.5	R 13.5	R 4.8

Source: Table D-7 of this Appendix.

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[1] See Tables D-5 and D-6 of this Appendix.

[2] That is, R 240 and R 460 respectively. Direct employment approximated R 3,000 per Km or about 1,500 mandays per Km.

No attempt is made here to assess headquarters overhead costs which, in the case of labor intensive versus capital intensive methods for the Conservation Division, likely would remain unchanged. 1/ Most frequently we shall use direct costs for comparisons between labor intensive and capital intensive methods, primarily because of greater confidence in these data. However, inclusion of site overheads also is important because these costs tend to be greater for labor intensive construction methods. 2/

A great deal of additional cost and related information on labor intensive operations can be found in the World Bank's recent "Re-Employment Mission" study 3/ and also in the very extensive study on "Labor Intensive Works" published by the International Labor Organization. 4/ The site overhead costs noted above appear to be realistic and further conform generally to similar estimates made elsewhere by the World Bank. 5/

1/ Overhead charges typically would approximate 30% of direct labor and site overhead costs.

2/ Scott, Wilson, Kirkpatrick & Partners estimated capital intensive methods with site overhead costs at approximately two-thirds the level associated with labor intensive methods. These estimates were some R 125,000 yearly for a work-program capable of treating some 1,330 ha yearly for a total fleet of six dozers and seven graders (R 94 per ha protected and treated). Actual equipment hours operated were estimated at 17,500 annually, or site overhead charges approximated R 7 per operating hour. This is about 23% of direct machine costs in contrast to their use of 30% for labor intensive methods.

3/ International Bank for Reconstruction and Development, Lesotho, Report of the Migrant Workers Re-Employment Mission, April 1975.

4/ E. Costa, et.al., Guidelines for the Organisation of Special Labour Intensive Works Programs, Geneva, International Labor Organization, March 1977.

5/ IBRD, op. cit., pp. 1-4 of Annex VI. Adjusting these data for inflation from 1975 to 1979) yields a comparable total OH rate (excluding expatriate staff) of some R 0.80 per manday for the 360,000 mandays in a "typical" labor intensive construction unit.

Civil works was identified by the World Bank as a primary target in its 1975 study of migrant worker reemployment. 1/ In their analysis the World Bank Mission expressed the opinion that "there is a strong likelihood that certain types of work (in Lesotho) can be done at about the same cost with labor intensive as with equipment intensive techniques." 2/ One of the bases for this conclusion was the assumption of normal but conservative labor productivity rates described as follows:

	M^3 per Manday 3/
Excavation (hardrock)	0.25
Excavation (soft rock)	1.00
Excavation (normal)	2.00
Loading in trailers	4.00
Spreading	8.00

These productivity rates have been generally exceeded in the Labor Construction Unit works to date by about 25 percent, and it is expected that additional labor productivity gains of 25 to 35 percent are realizable. 4/ Consequently, estimated labor costs of the Conservation Division outputs may well decline to 75 to 80 percent of the amounts shown in this Appendix.

Unfortunately, much of the Conservation Division's experience with labor has been with food-aid labor, noted here and elsewhere for its

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1/ Ibid., p. 9. The following discussion draws heavily on the conclusion of this study.

2/ Ibid., p. 21.

3/ Ibid., p. 27.

4/ Scott, Wilson, Kirkpatrick & Partners; and J.R. Dawson, Labor Construction Unit, Government of Lesotho.

"extremely low productivity" because of poor supervision and motivation and a daily wage payment basis. This is a situation which led the Re-employment Mission office of the World Bank to recommend five years ago that "much of its work could be better done in other ways." 1/

In evaluating labor intensive versus capital intensive techniques in numerous road construction projects, the Re-employment Mission noted costs increased for labor intensive techniques on the order of 15 to 20 percent as compared to capital intensive methods. 2/ The International Labor Organization also has identified financial cost differentials for various construction works. 3/ While financial costs comparisons reveal capital intensive methods to be least costly, economic costs differentials are lower for labor intensive methods (see commentary below).

Nonetheless, "...the social benefits of creating more employment within Lesotho may well outweigh the somewhat higher financial costs involved." 4/ However, as the Re-employment Mission has noted, it is important to take into account "...the effects of seasonal demand for labor for agricultural purposes...," an impact that the Labor Construction Unit has not dealt with to date. 5/ Further, taskwork must be

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1/ IBRD, op. cit., p. 26.

2/ IBRD, op. cit., pp. 29-31.

3/ IBRD, op. cit. See International Labor Organization, pp. 60-67 of Section IV. These data, for select construction functions only, are also adjusted for a shadow price to reflect factor price distortion.

4/ IBRD, op. cit., p. 32.

5/ Ibid., p. 4 of Annex II.

related to wages as the Labor Construction Unit is now doing, and the mining-ingrained work attitudes and disciplines of Basotho workers already is apparent from the Labor Construction Unit's productivity achievements.

The true social costs of labor typically are lower than the going wage rate which is taken here as R 2.40 daily for labor. Thus, in evaluating projects from a national point of view, one can justify using a "shadow" wage rate to price labor. [1/] If the shadow wage is approximated as the opportunity cost of common labor in the private sector, labor intensive costs likely would approximate 20 to 40 percent of those shown in this Appendix. [2/] The marginal product of crop farming as an alternative activity for labor might be used to determine economic (as contrasted to financial) cost, and the economic rate of return to a specific project. Analyses so conducted will lead to "...an increase in the proportion of labor to be used..." but at higher financial costs. [3/]

Higher financial costs also may result from the longer time period of construction with labor intensive methods that results in delayed benefits. An offset to these benefits foregone is the longer project gestation period and the equipment shipment delays accompanying capital intensive methods. Labor intensive methods also may be relatively more economical if local labor is used and camp costs are not needed particularly since

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[1/] See, for example, ibid., p. 1 ff of Annex II; and C. Harral, et.al, Study of the Substitution of Labor and Equipment in Civil Construction: Phase II, Final Report, IBRD Staff Paper No. 172, January 1975.

[2/] See ibid., p. 12 and pp. 1-2 of Annex II. At R 0.60 to R 1.00 daily as compared to R 2.40.

[3/] Ibid., p. 1 of Annex II.

equipment parts and mobilization costs tend to be significant in capital intensive projects. Finally, lower standards of durability or quality may reduce relative labor intensive method benefits (or increase maintenance cost frequency), if they do in fact exist. The frank truth is that engineers are not agreed about the differential quality factor.

These are all important considerations which may have to be accepted in the interest of employing labor and using capital as a productivity aid instead of a way of replacing or "disemploying" labor.

TABLE D-1

Project: Waterways [1/]

Work Description: Earthwork

SUMMARY	Earthwork Base No M^3	Mandays Employed	Cost in R Per M^3	Cost in R Per Km	Cost in R per Ha Protected
LABOR	1,200	860	R 1.72	R 2,064	R 41.28

I. Productivity:

A. Excavate and haul = 1.25 M^3 per manday

B. Excavate and throw = 2.5 M^3 per manday

C. Spread and shape = 5.0 M^3 per manday

II. Each 1m = 1.2 M^3. So 1 Km = 1,200 M^3 and mandays are:

A. 800 ÷ 1.25 = 640 mandays

B. 400 ÷ 2.50 = 160 mandays

C. 1,200 ÷ 5.0 = 60 mandays

860 mandays

III. At wages of R 2.40 x 860 = R 2,064 per Km.

IV. An estimated 20 1m is needed per ha protected. The cost is then R 41.28 per ha.

[1/] Sketch layout is as shown in Appendix Table B-1.

Source: J.R. Dawson, Labor Construction Unit, Government of Lesotho.

Amendment

TABLE D-1

SUMMARY	Earthwork Base No M^3	Mandays Employed	Cost in R Per M^3	Cost in R Per Km	Cost in R per Ha Protected
LABOR	1,200	429	R 0.858	R 1,029.6	R 20.59

I. Productivity:

All earthworks operation = 2.8 M^3 per manday

II. Each 1m = 1.2 M^3. So 1 Km = 1,200 M^3 and mandays are:

1,200 ÷ 2.8 = 429 mandays

III. At wages of R 2.40 x 429 = R 1,029.6 per Km.

IV. An estimated 20 1m is needed per ha protected. The cost is then R 20.59 per ha.

Source: J.R. Dawson, Labor Construction Unit, Government of Lesotho.

TABLE D-2

Project: Terraces [1/]

Work Description: Earthwork

SUMMARY	Earthwork Base No M^3	Mandays of Employment	Costs in R per M^3	Costs in R per Km	Costs in R per Ha Protected
LABOR	800	427	R 1.03	R 1,025	R 256
COMPACTION IN RD (roller days)	(800)	-	0.25	200	50
TOTAL			= R 1.53	R 1,225	R 306

I. Productivity :

A. Excavation = 2.5 M^3 per manday

B. Spread-Shape = 7.5 M^3 per manday

II. Each 1m = 0.8 M^3. So 1 Km = 800 M and mandays are:

A. Excavation = 800 M^3 ÷ 2.5 = 320 mandays

B. Spread-Shape = 800 M^3 ÷ 7.5 = 107 mandays

427

III. At wages of R 2.40 per m.d. x 427 m.d. = R 1,025 per Km.

IV. An estimated 250 1m is needed per ha of acre protected. The cost of labor is thus = R 256 per ha.

V. Compaction [2/] by roller is 100 M^3 per roller day at R 25 daily, or R 0.25 per M^3 (R 0.2 per 1m). Therefore compaction = R 200 per Km of terrace or R 50 per ha acre protected.

[1/] See page D-11 following Table D-2 for sketch layout. Labor intensive methods require less earth moved and accommodate more tailored design than do equipment produced terraces. Thus, M^3 per Km of terraces is less for labor intensive methods.

[2/] See page D-12 for comments on compaction.

Source: J.R. Dawson, Labor Construction Unit, Government of Lesotho.

Amendment

TABLE D-2

SUMMARY	Earthwork Base No M^3	Mandays of Employment	Costs in R per M^3	Costs in R per Km	Costs in R per Ha Protected
LABOR	800	307	R 0.96	R 764	R 184.2
COMPACTION IN RD (roller days)	(800)	-	0.25	200	50.0
TOTAL		307	= R 1.21	R 964	R 234.2

I. Productivity :

A. Excavation = 4.0 M^3 per manday

B. Spread-Shape = 7.5 M^3 per manday

II. Each 1m = 0.8 M^3. So 1 Km = 800 M and mandays are:

A. Excavation = 800 M^3 ÷ 4.0 = 200 mandays

B. Spread-Shape = 800 M^3 ÷ 7.5 = 107 mandays

307

III. At wages of R 2.40 per m.d. x 307 m.d. = R 763.8 per Km.

IV. An estimated 250 1m is needed per ha of acre protected. The cost of labor is thus = R 184.2 per ha.

V. Compaction by roller is 100 M^3 per roller day at R 25 daily, or R 0.25 per M^3 (R 0.2 per 1m). Therefore compaction = R 200 per Km of terrace or R 50 per ha acre protected.

Source: J.R. Dawson, Labor Construction Unit, Government of Lesotho.

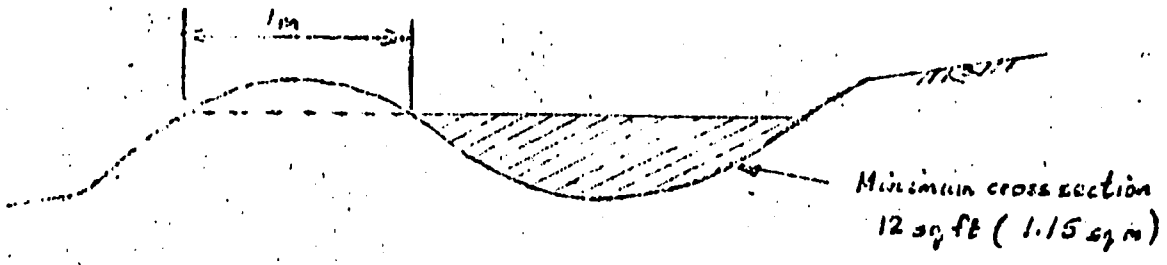
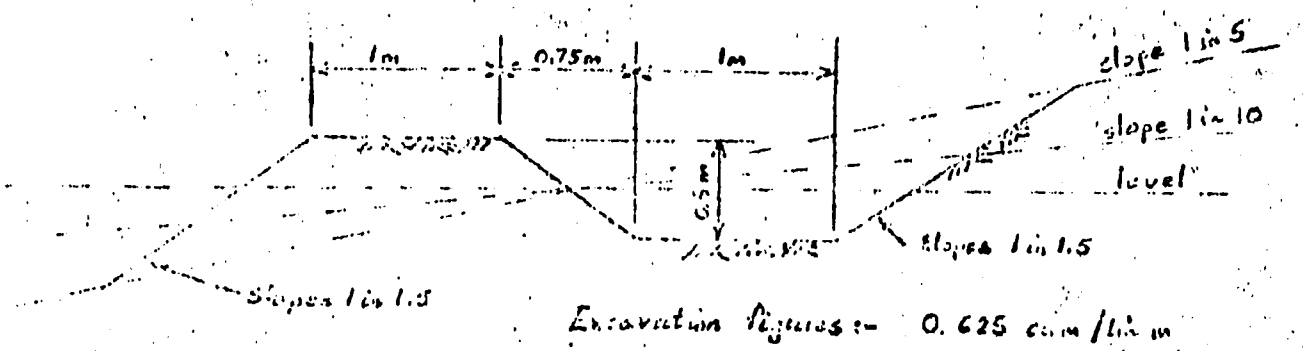


Fig 2 Design criteria for terrace bank and ditch



Excavation figures:- 0.625 cu m / lin m level
0.805 cu m / lin m 1 in 10
1.062 cu m / lin m 1 in 5

Fig 3 Hand built terrace bank and ditch

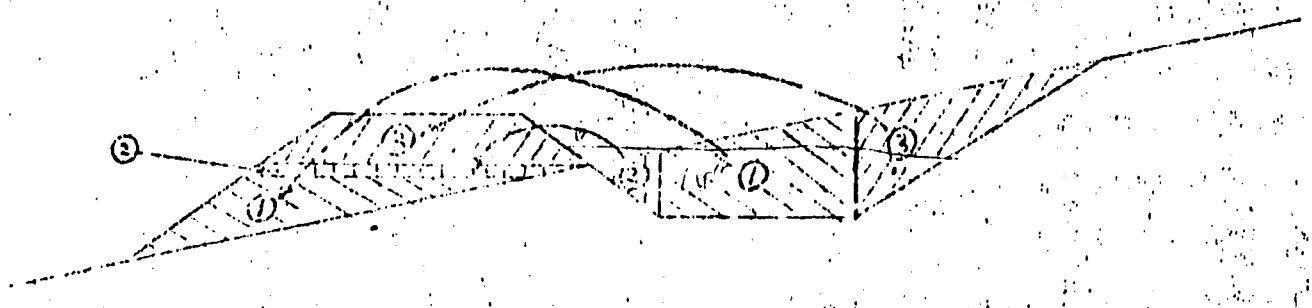


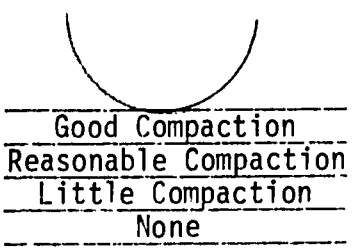
Fig 4 Hand built bank and ditch showing method of marking

Source: J.R. Dawson, Labor Construction Unit, Government of Lesotho.

TABLE D-2 (Continued)

Note on Compaction

To get good compaction it is necessary to apply the compactive effort to thin layers of fill. For example, British Transport and Road Research Laboratory recommends maximum layer thickness at 300 mm for a 12 ton vibrating roller and 150 mm for a 1,000 Kg tandem vibrating roller. The reason for this is that the effect of the roller varies with depth:



Clearly if a grader wheel is run over the terrace bank the compaction will work like this (if a dozer track is used the compactive effect is much less):

It might be argued that from the point of view of both the function of the bank as a water retaining structure and as a structure that will need to be vegetated this is an erroneous method; i.e., what is needed is a compacted core and an uncompacted surface so grass will grow.

In any case the whole argument is a bit academic. Lesotho is covered by either aged water retaining structures or those built by

TABLE D-2 (Continued)

food-aid labor (many under the auspices of Ministry of Agriculture) that have had little or no compaction at all except from whatever arose from labor constructing them. These structures appear to give a satisfactory level of service (most failures come from inadequate spillway design); thus, it may be questionable whether or not terrace banks should be constructed with compacting.

However, if it is insisted that a machine should be used for compacting terrace banks, then a pedestrian operated vibrating roller could be used at the cost of R 0.25/cu. m. and it could cover the output of 35-50 men (100 cu. m./day).

Some 35-50 men would be working on something like 100-150 m. of terrace. Thus a machine could make a number of passes over the terrace in the course of its construction and compaction would be thus: 1/

1/ Supplied by J.R. Dawson, Labor Construction Unit, Government of Lesotho.

TABLE D-3

Project: Diversions [1/]

Work Description: Earthwork

SUMMARY	Earthwork Base No M^3	Mandays Employed	Costs in R per M^3	Costs in R per Km	Costs in R per Ha Protected
LABOR	3,370	2,530	R 1.80	R 6,072.00	R 40.48
COMPACTION	(3,370)	-	0.25	842.50	5.65
TOTAL		2,530	R 2.05	R 6,914.50	R 46.13

I. Productivity:

A. Excavate and haul = 1.25 M^3 per manday.

B. Excavate and throw = 2.5 M^3 per manday.

C. Shape and compact = 5.0 M^3 per manday.

II. Each 1m = 3.37 M^3. So 1 Km = 3,370 M^3 and mandays are:

A. Excavate-Haul 1,270 M^3 ÷ 1.25 m.d. = 1,016 mandays

B. Excavate-Throw 2,100 M^3 ÷ 2.5 m.d. = 840 mandays

C. Shape-Compact 3,370 M^3 ÷ 5.0 m.d. = 674 mandays

2,530 mandays

III. At wages of R 2.40 per m.d. x 2,530 m.d. = R 6,072 per Km of labor.

IV. An estimated 1 Km = 150 ha area protected or 6.7 1m needed per ha of area protected at a labor cost of R 40.48 per ha.

V. Compaction by roller is 100 M^3 per roller day at R 25 daily or cost is R 0.25 per M^3 (i.e., R 0.8425 per 1m). Therefore, compaction cost is R 842.50 per Km of diversion or R 5.65 per ha protected.

[1/] See page D-15 following Table D-3 for sketch layout. Somewhat less M^3 per Km of excavation is required with labor intensive methods for reasons noted in terrace construction.

Source: J.R. Dawson, Labor Construction Unit, Government of Lesotho.

Amendment

TABLE D-3

SUMMARY	Earthwork Base No M^3	Mandays Employed	Costs in R per M^3	Costs in R per Km	Costs in R per Ha Protected
LABOR	3,370	1,517	R 1.08	R 3,640.00	R 24.38
COMPACTION	(3,370)	-	0.25	842.50	5.65
TOTAL		1,517	R 1.33	R 4,482.50	R 30.03

I. Productivity:

A. Excavate and throw = 4.0 M^3 per manday.

B. Shape and compact = 5.0 M^3 per manday.

II. Each 1m = 3.37 M^3. So 1 Km = 3,370 M^3 and mandays are:

A. Excavate-Throw 3,370 M^3 ÷ 4.0 m.d. = 842.5 mandays

B. Shape-Compact 3,370 M^3 ÷ 5.0 m.d. = 674.0 mandays

1,516.5 mandays

III. At wages of R 2.40 per m.d. x 1,516.5 m.d. = R 3,639.60 per Km of labor.

IV. An estimated 1 Km = 150 ha area protected or 6.7 1m needed per ha of area protected at a labor cost of R 24.38 per ha.

Source: J.R. Dawson, Labor Construction Unit, Government of Lesotho.

147

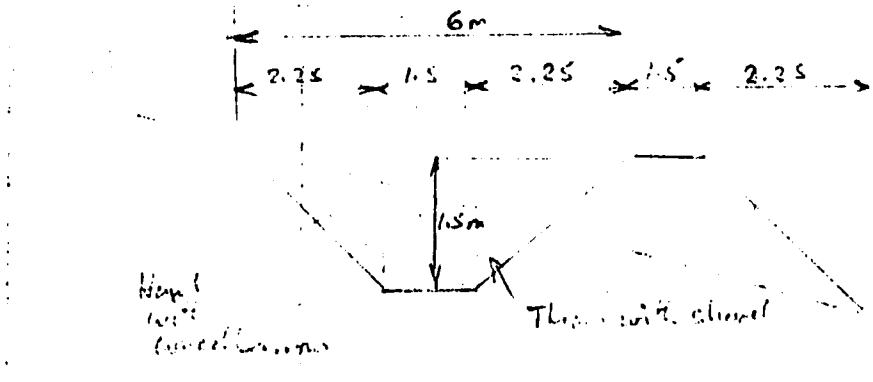
TABLE D-3 (Continued)

Volume of excavation:

$= \frac{1}{2} \times 1.125 \times 0.75 + 1.5 \times 0.75 + \frac{1}{2} \times 1.125 \times 0.75 + 0.75 \times \frac{1}{2} \times$

$4.875 - \frac{1}{2} \times 1.125 \times 0.75$

$= 0.42 + 1.125 + 0.42 + 1.828 - 0.42 = 3.37\ M^3$ per lineal meter



<u>For balanced cut & fill</u>

Volume to be thrown with shovel = 2.1 M^3 per lineal meter

Volume to be hauled with wheelbarrow = 1.27 M^3 per lineal meter

TABLE D-4

Project: Village Roads [1/]

Work Description: Earthwork

SUMMARY	Earthwork Base No M^3	Mandays of Employment	Costs in R per M^3	Costs in R per Km	Costs in R per Ha Protected
LABOR	948	507	1,127	R 1,217	R 14.48
COMPACT & EQUIP	-	-	-	687	8.18
				R 1,904	R 22.66

I. Productivity:

A. Excavate-Ditch = 2 M^3 per manday.

B. Gravel load-unload = 1.5 M^3 per manday.

II. Each 1m = .75 M^3. So 1 Km = 750 M^3 and mandays are:

A. Excavation = 750 M^3 ÷ 2 M^3 = 375 mandays.

B. Gravel (33% x 6 at 0.1 thick) = 198 M^3/Km ÷ 1.5 M^3 = 132 mandays.
507 mandays.

C. [2/] 6.7 days tipper truck (R 81 day) = R 535)
6.7 days compaction roller (R 23 day) = R 152) = R 687

III. At wages = R 2.40 per day x 507 m.d. = R 1,217 per Km.

IV. An estimated 11.9 1m is needed per ha of area protected. The labor cost is thus R 14.48 per ha.

V. Compaction and tipper truck required is R 0.687 per 1m or R 8.18 per Ha area protected.

[1/] Design layout is 6 M width at 0.5 M^3 per 1m formation clearance with 0.25 M^3 per 1m ditch excavation; partial gravel-compaction as noted.

[2/] Includes operator and fuel at private hire rates of R9/hr for 9 hour day, and roller cost is based on Lesotho plant pool charge rate. When hiring pedestrian operated vibrating rollers it is not necessary to pay the R 2.50/hr operator charge as one of the Labor Construction Unit's own labor operate it at R 0.35/hr.

Source: J.R. Dawson, Labor Construction Unit, Government of Lesotho.

TABLE D-5

COST SUMMARY FOR THE MAZENOD ROAD
(As built by labor)

Resource Category	Actual Cost	Cost Per Kilometer
Wages(a)	R 92,660	R 2,993(a)
Equipment(a)	85,100	2,749
Materials	10,880	351
Tools	7,270	235
Total Direct Costs	195,910	6,328
Camp	7,460	241
Site Overheads	14,240	460
Aggregate Costs	217,610	7,028
Estimated 30% addtion for HQ overheads & expatriates	65,280	2,108
Estimated Total Cost	R 282,890	R 9,136

(a) Earthworks R 2,129 per Km and graveling R 3,577 per Km.

Source: Scott, Wilson, Kirkpatrick & Partners.

TABLE D-6

ACTUAL PRODUCTIVITIES ON THE MAZENOD ROAD

TASK	UNIT	MONTH										
		Oct 1977	Nov 1977	Dec 1977	Jan 1978	Feb 1978	March 1978	April 1978	May 1978	June 1978	July 1978	Aug 1978
Excavate ditch in ord. ground	m^3/md	2.7	2.5	-	2.8	2.2	2.1	2.4	2.4	2.4	2.8	3.4
Excavate ditch in rocky ground	m^3/md	1.0	0.7	-	-	-	1.1	1.0	1.0	0.8	0.6	-
Excavate to formation	m^3/md	-	-	-	2.9	-	3.3	2.0	2.3	2.8	2.9	-
Excavate and load gravel	m^3/md	1.4	1.5	1.4	1.6	2.3	1.4	1.7	1.8	2.2	2.3	2.4
Excavate and load sand	m^3/md	-	-	-	-	-	-	-	-	1.8	1.7	1.4
Haul gravel by tipper	m^3/tpd	44.0	40.9	39.5	19.5[1]	46.2[1]	31.2	38.7	42.3	51.2	53.2	41.4
Haul gravel by wheelbarrow	m^3/wbd	-	-	-	-	-	3.7	2.2	-	-	-	-
Haul stone by tipper	m^3/tpd	-	-	-	-	-	21.7	43.1	27.0	-	22.2	20.0
Haul stone by wheelbarrow	m^3/wbd	-	-	-	-	-	-		1.9	2.5	-	-
Haul sand by tipper	m^3/tpd	-	-	-	-	-	-	-	-	21.7	12.5	10.0
Spread gravel	m^3/md	5.2	4.5	4.5	3.4	6.4	4.8	7.8	7.5	7.5	4.8	6.1
Spread and trim for formation	m^3/md	2.0	4.1	4.5	3.9	-	2.7	2.2	-	-	-	-
Compact gravel by roller	m^3/rd	42.0	72.0	72.9	34.4[2]	65.1[2]	32.5	54.4	75.0	106.0	101.3	52.9
Mix and place concrete	m^3/md	-	-	-	-	-	-	-	-	-	0.2	0.3
Erection of retaining walls	m^3/md	-	-	-	-	-	0.9	1.1	2.6	3.8	-	0.9
Lay culverts	Pipes/md	-	0.2	-	0.2	-	0.4	0.1	0.2	0.2	0.2	0.2
Clean ditches	m^3/md	-	-	-	-	-	-	-	-	-	-	1.5
Build check walls	m^3/md	-	1.5	-	-	-	-	-	-	-	-	-

Notes:

1. Here, double-shift work figures have been adjusted to give 1 tipper-day
2. Here, double-shift work figures have been adjusted to give 1 roller-day

Source: Scott, Wilson, Kirkpatrick & Partners.

TABLE D-7

YEARLY SITE OVERHEAD ESTIMATES FOR TWO 300 MAN WORK GANGS

A. No laborers employed: 600; 150,000 mandays; R 360.000/year.

B. Site Staff

No Mandays	No Persons	Work Grade	Pay Rate/Yr	Total R
500	2	PTO	R 4,000	8,000
1,000	4	TO	2,140	8,560
3,000	12	TA1	1,440	17,280
6,000	24	TA2	840	20,000
1,000	4	Timekeepers	1,000	4,000
500	2	Storekeepers	1,000	2,000
1,500	6	Drivers	800	4,800
SUBTOTAL 13,500	54			64,640

C. Camp and Site Costs

48 huts (10 x 10 at R 80/yr over 5 years)	=	R 3,840
Set up costs huts (1,120 mandays)	=	5,376
Set up costs huts (34 tipper days)	=	5,508
Camp running costs (estimated yearly)	=	2,000
6 vehicles	=	18,000
6 caravans (PTD & TO, R 7,000 each write off 5 years)	=	8,000
Hand tools	=	12,000
SUBTOTAL		R 54,724

Summary of Total Costs

A. Direct Labor (150,000 mandays)	R 360,000
B. Site Staff Labor Overhead (13,500 mandays)	64,640
C. Other Site Overhead (camp., equip., etc.)	54,724
GRAND TOTAL	R 479,364

* Site OH as % of total costs	27 %
* Site OH as % of direct labor	36 %
* Site OH per manday of direct labor	R 0.80

Source: J.R. Dawson, Labor Construction Unit, Government of Lesotho.