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Development of Lahore at west bank of Ravi

By

DR. JAVED YUNAS UPPAL
Engineering Project Development Consultants

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SUMMARY

Lahore, second largest city of Pakistan and 30th in the World, situated on the eastern bank of the river Ravi, is in compelling need of expansion across on to the West Bank, due to the pressures of urban growth, national communications grid and proximity to the international borders. The West Bank of the river, however, being a vast low lying flood plain of mud and silt is an unhabitable wasteland. The river Ravi, deprived of its waters most of the year, carries abrupt flood discharges up to 5700m³/sec in monsoons. The river therefore has to be trained and the land has to be reclaimed. There are numerous examples in the World, where flood affected low plains have successfully been turned into benefitial urban areas. Method has been suggested in this paper to provide a flood protection dike at the West Bank with remodelling of the bed of the channel, providing of reclamation fill behind the dike and construction of associated drainage works. Alignment of the West Bank dike is a dominant cost/benefit effective parameter. An optimisation exercise has been conducted through dynamic programing to arrive at the best alignment of the dike. A positive feasibility has emerged on account of the benefits by the enhancement of the value of land in relation to the costs.

WEST BANK OF RAVI

Beyond the Western bank of the river Ravi, and around the present Sharakpur Road, are lying promising areas of land. In the North, the land is already connected to Lahore through the existing bridge over Ravi. In the South, it is proposed that a second bridge may here be constructed over Ravi near Niaz Beg Thokar at Multan Road. This second bridge will provide a bypass for the South-north inter-city traffic and a relief for the existing road network. The new area will be located at a strategically safer position in wartimes. Since the land is almost completely barren, there will be a plenty of room to plan beautiful environments and skylines on modern levels. The vast area however has to be properly reclaimed and the problem of flooding has to be resolved. The costs of flood protection, reclamation and the new river bridge are off set by the increase in selling price of the developed land. This makes this preposition economically feasible.

THE RIVER RAVI

Today, the waters of the Ravi are mostly used by India for theirown irrigation purposes. However, the floods are released. Most of the year, the Ravi remains more or less dry and any time between June to September the influx of high flood is received. The flood discharges through the Ravi at Lahore are of the order of 5700 m³/ sec 50 years return.

The Ravi has its first head works at Madhopur about 32 km up in India. From the borders, down to the confluence with the Chenab, the Ravi has a stretch of about 680 km with a fall of about 100m spread almost uniformly. There are two major head works namely Balloki taking off 230 m³/sec and Sidhani 150 m³/sec.

Flood is the most important aspect not only with respect to direct losses but also with respect the restrictions provided for general development. Floods are normally generated in the upstream mountaineous areas where snowmelt, intense rainfall and flashy stream build up high river dis-

Managing Director Engineering Project Development Consultants Lahore Ltd.

charges. The flood control measures have largly been through dike construction.

EXAMPLES

Methods can be studied, where solutions to similar problems have been successfully sorted out elsewhere in the World. Some typical examples are:

Macan China

Macan, a coastline in China was once a low lying reed marsh on soft and massive mud. The sandy soil available in the adjacent sea bed was dredged, stock piled on the sea coast and then pumped and spread on the mud. Water from mud was drained through a network of horizontal and vertical drains. Filling over the entire area was thus provided in layers ranging 1 to 1.5m in depth. Each layer required 4 to 6 weeks time for consolidation. The land was ultimately developed for a high rise housing and commercial development.

Lagos

In Nigeria, the commercial housing development in the South of Lagos is an interesting example. Hundreds of thousands of acres were reclaimed which had once been low lying sea shores. Sand filling of entire area was done by dredging and pumping. The sandfill varies in thickness, and at places was as much as 4m. Compaction was carried out by watering. At places, settlements by more than 1m in a period of one year or so occured before the area was finally ready for development.

Netherlands

Netherlands consisted of low lying waste lands, mud dumps, swamps and uncultivable marine salt sands. As early as in the 17th century, large areas were reclaimed by constructing dikes and water fronts between Amsterdam and Alkammar in the North. In 1918 and afterwards, over half a million acres of cultivable land was developed by drying the sea of Zuyderzee.

At present under the Delta Plan, colossal stretches of delta are being turned into rich useful agricultural and urban areas.

LAND PROTECTION AND RECLAMATION FOR LAHORE

The West Bank Dike

A dike along the Eastern bank is already existing between the present bridge down to Dholanwal which effectively protects the Western parts of the city of Lahore from floods. A similar dike can be constructed along the Western bank of the river so that the land between this dike and the Sharakpur Road now lying almost waste can be developed. The length of such a dike as shown on the plan is of the order of about 14.5 kilometers. The section between the dikes can be effectively trained through the dredging and revetment so that it can pass the the floods safely.

The Filling

The land beyond this dike can be dried through a network of drainage and a system of pumping. Once the land is dry, the filling can be done in layers using the dredged materials mixing adequate proportion of sand. As the filling proceeds, small waterways and ditches will be necessary in order to facilitate natural drainage. Drainage of the surrounding area, also, has to be remodelled.

ANALYSIS

Description

The problem so identified is (i) to provide a flood protection dike (5) at the West Bank, (ii) remodelling bed of the channel, (iii) reclamation fill behind and (iv) associated drainage works. A dike at the East Bank already exists, so its alignment is fixed. Although the number of inter-dependent of parameters is so large that it is extremely difficult to isolate the influence of any single one of them, the alignment of the dike at the West Bank is a dominant variable. In the present exercise, the 'alignment' of the West Bank dike is the single parameter studied. In making of the analytical system, references 1,2,3 and 4 have been followed. The depth and width of the regulated channel is so adjusted that the sediment transport capacity is not largely affected. The longitudinal slope is also adjusted to match with the adjacent reaches. The possibility of coincidence of flood waves as well as the possibility of creation of upstream backwater have also been studied.

Behind the dike, the fill material is foreseen. Part of it will be supplied from the dreding of the channel and a part of it will be imported. Drainage of this area at various stages as well as the drainage of the surrounding area has also been included in the system.

The nonlinear programing formulation for optimisation (6) can be conceptually stated as

minimise C (A,L,Q,H,h,p)
maximise P (A)
subject to G (A,L,Q,H,h,p)
where C = Cd + Cc + Cf + Cr = Sum Cost
Cd = Cost of dike
Cc = Cost of regulating channel
Cf = Cost of fill
Cr = Cost of drainage
P = Sum price of developed area
G = Set of constraint functions
A = Resulted developed area = f (Q)
L = Level of fill = f (Q,h)
Q = Vector of dike alignment cordinates
B = Distance between dikes
H = Array of topographical levels
h = Array of Hydraulic parameters
p = Array of unit prices.

Parameters

Parameters used in the study are listed out in Table-1. They have been taken from the available data of last 30 years and from the type of development forseen. Whereas the natural channel has been catered for floods of 5 years return period, the regulated channel between the dikes has been foreseen to cater for floods of 50 years return period. Top levels of the dike have been taken to cater for floods of 200 years return period.

The soil type found in the bed and in the surrounding area is mainly silt. Topographic characteristics of the flood plain were noted. The contours are generally equi-distant and are parallel to the natural stream.

The unit costs of the material were obtained from local sources and the available cost indices.

TABLE-1: FLOW PARAMETERS

Stream	Ephemereal
Data	30 years
Natural channel, Q5	500 m^3/s 5 years return
Max flood, Q50	5700 m^3/s 50 years return
Dike levels for Q200	7400 m3/s 200 years return
Regulated reach	14.75 km
Free board	1.00 m
Bed soil	Silt
Side slopes	1:3
Mannings 'n'	0:030
Longitudinal slpoe, I_o	1:7500

ALDR Computer Program

A computer program 'ALDR' has been developed on the flow chart described in Figure-1. The program takes as input, the flow parameters such as (i) longitudinal slope (ii) flood discharges, (iii) sediment mass and (iv) an array of topographical levels. A trial alignment of the West Bank dike is then fed. The program performs hydraulic calculations and calculates cost involved in regulating the channel. The program works out earthwork quantities both for the dredged material and also for the fill material behind the dike. The program then performs drainage calculation and works out the costs of works provided to cater for seepage of the development area and drainage of the surrounding area. The computer then works out the total developed area so evolved and estimates its selling prices. The program performs dynamic optimisation and works out the costs and benefits by successively choosing different alignments of the West Bank dike.

Results

Different alignments of the West Bank dike, expressed as 'distance between two dikes', are given in Figure-2 and 3. When it is varied, its effect on the system cost is shown by curve-1 in Figure-4. The relationship with the system benefits is shown by curve-2. A third curve-3 gives the ratio of benefits/cost. It can be observed that the optimum alignment (at maximum ratio) of the dike is the one where the distance is 5km. This enables development of an urban area of about 10000 acres. An economic feasibilty based on the resulted optimum alignment is can now be evaluated.

ECONOMIC FEASIBILITY

Although an accurate feasibility analysis can only be performed after a detailed study, a rough picture can be made to assess the oder of the parameters. The project of this magnitude will naturally be phased out such that the capital expenditures and the returns will be spread to a number of years in an admissible cash flow arrangement.

Expenditures

Capital Expenditures can be assessed as below:

Land: 10000 acres	$ 14.00 m
Bridge:	$ 4.50 m
Bund:	$ 4.70 m
Reclamation:	$ 10.30 m
Services:	$ 2.00 m
Establishment:	$ 2.00 m
Total capital expenditures:	$ 37.50 m

Recurring expenditures can be listed as:

Interest on Loans:	$ 1.00 m/yr
Taxes:	$ 1.50 m/yr
Repair & Maintenance:	$ 1.50 m/yr
Establishment:	$ 1.00 m/yr
Total recurring expenditure	$ 5.00 m/yr
At 15% rate of interest, the discounted value of 15 years recurring expenditures at zero year is:	$ 30.00 m
Total expenditures therefore are:	$ 67.50 m

Returns

As far as returns are concerned, out of a total of say 10,000 acres, 2/3rd might be saleable, 80% land may be residental and 10% may be commercial/industrial. 30% fund may be spent on infrastructure development. On this basis, the returns can be estimated to be of the order of $ 100 m.

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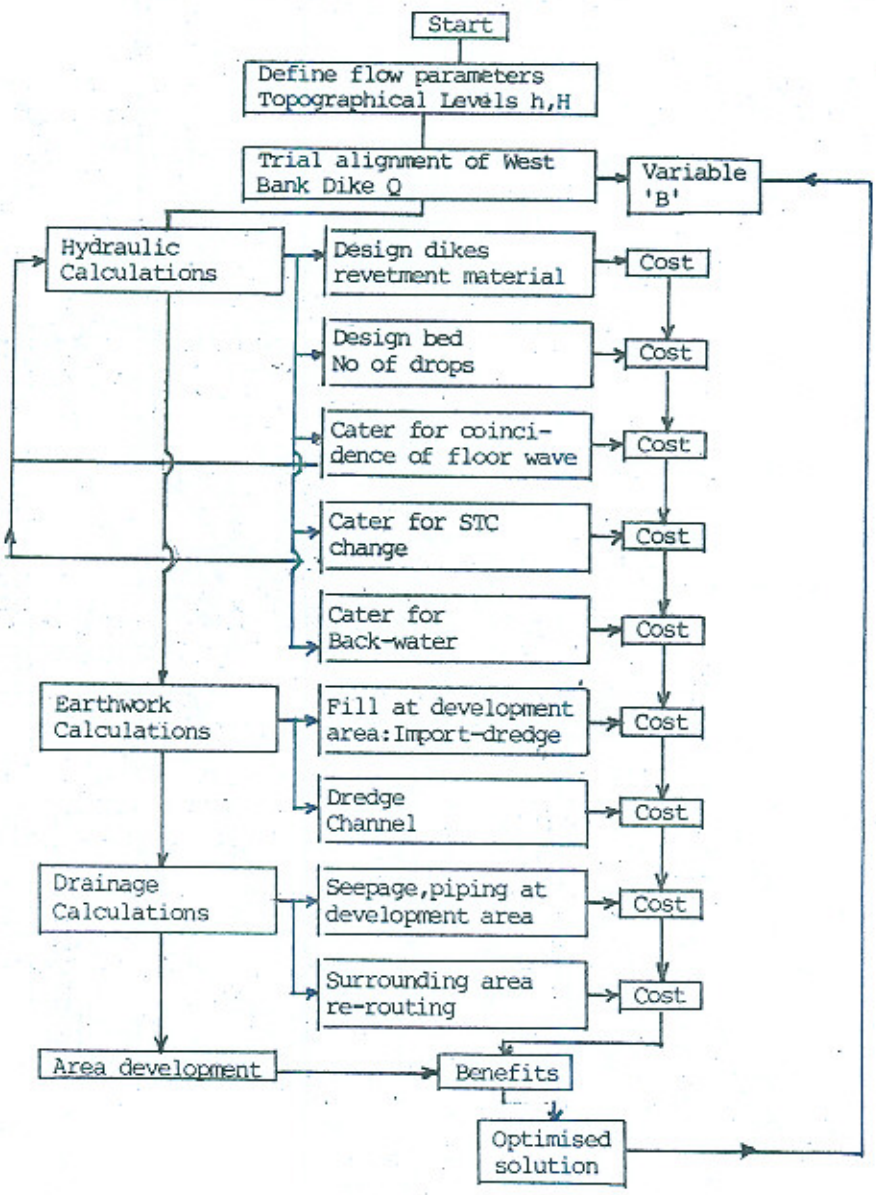


FIGURE - 1: FLOW CHART FOR ALDR

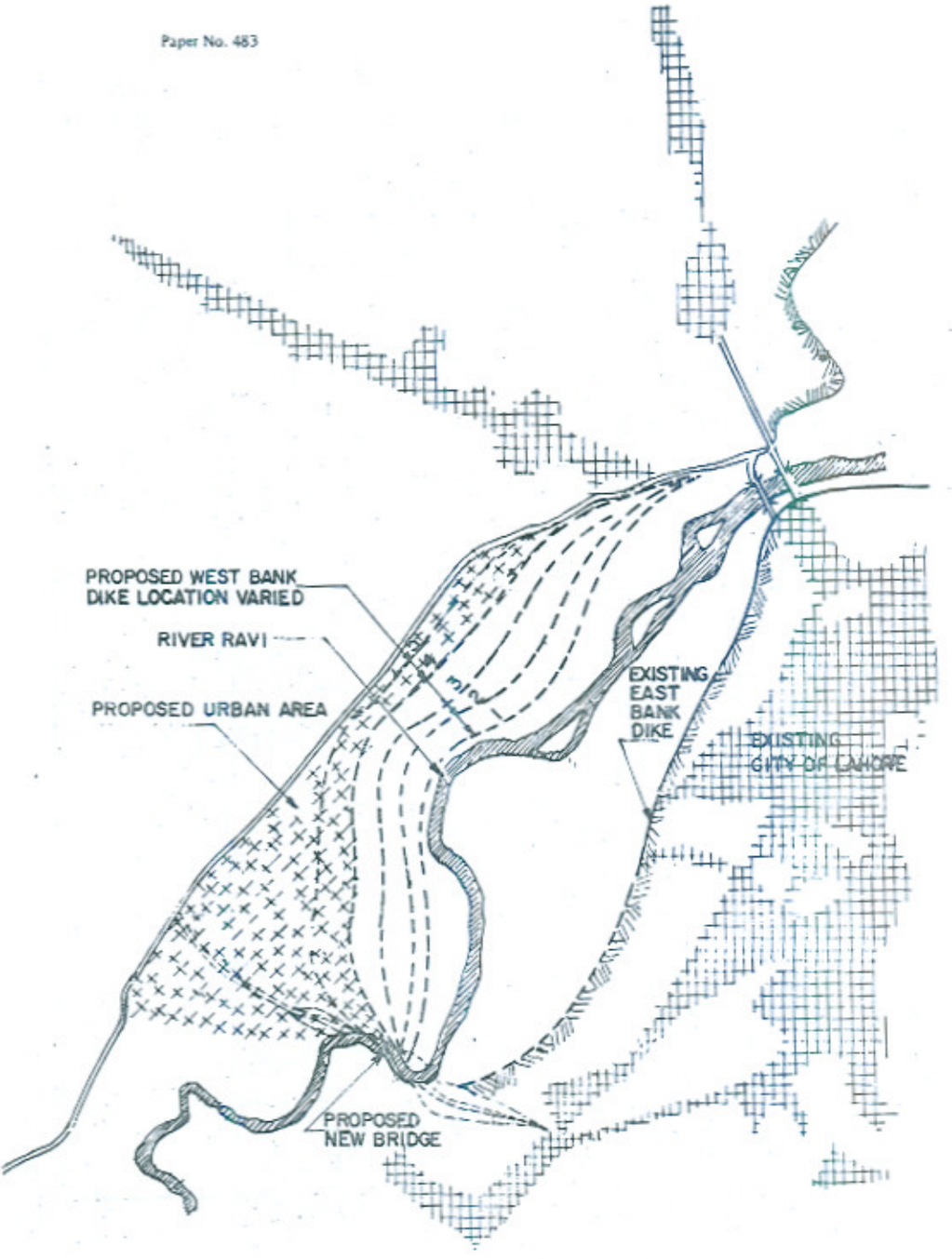


FIGURE-2 PLAN OF RIVER RAVI

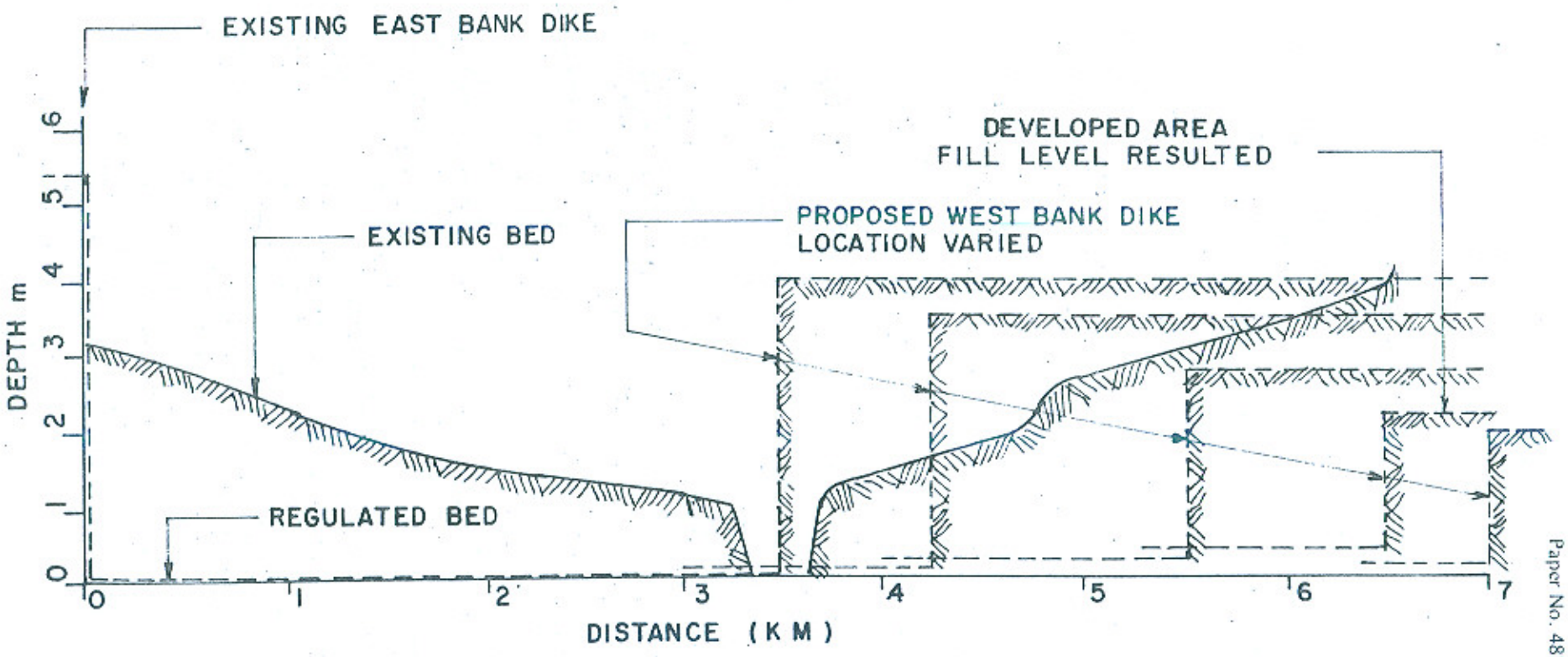


FIGURE-3 CROSS SECTION

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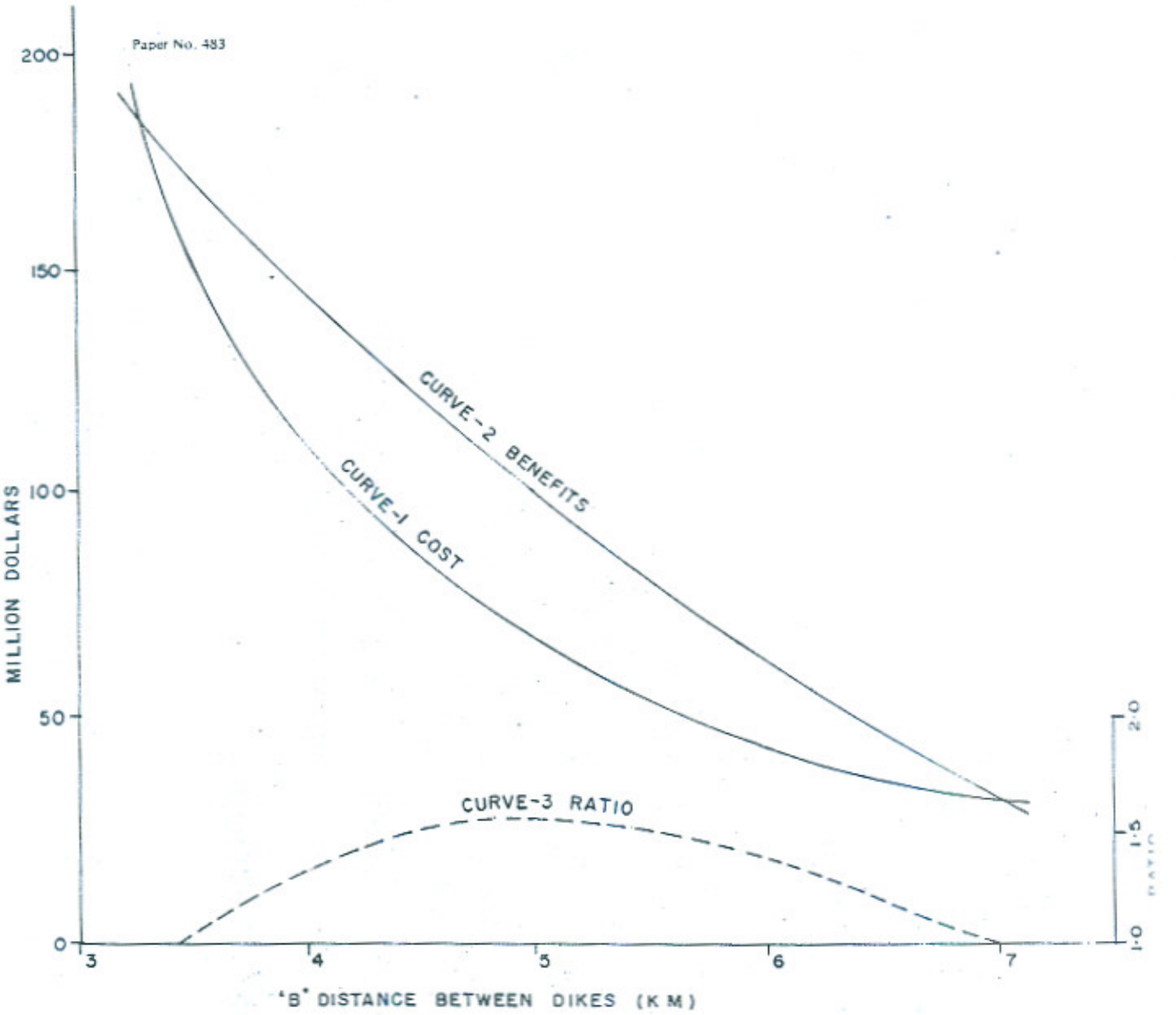


FIGURE-4 RESULTS OF ALDR