TARBELA DAM

KEY FACTS

Dam Type:	Earth and Rockfill
Height:	485 ft. (above riverbed)
Reservoir Area:	95 sq. miles
Gross Storage Capacity:	11.62 MAF
Live Storage Capacity:	9.7 MAF
Main Spillway Capacity:	6.5 million cusecs
Year of Completion:	1977
Geology & Bedrock:	Alluvium under Main Dam and Limestone, Phyllite and Schist under the Abutment
Power Generation:	3,478 MW

Please Insert Sketch in the file called "Location Map" sent separately in MS Word format. It is a scanned figure.

1.0 HISTORIC DEVELOPMENT

In April 1948, India diverted the flow of the Ravi, Sutlej and Beas rivers, an act, which threatened irrigated cultivation in Pakistan. That same year, in an effort to mitigate the consequences of possible interference by India with the supplies of the canals feeding from those rivers, Pakistan embarked on a program of link canal construction to enable the transfer of water between rivers.

Until 1967, the entire irrigation system of Pakistan was fully dependent on unregulated flows of the Indus and its major tributaries. The agricultural yield was very low for a number of reasons, the most important being a lack of water during critical growing periods. This problem stemmed from the seasonal variations in the river flow and the absence of storage reservoirs to conserve the vast amounts of surplus water during periods of high river discharge.

Tarbela Dam was the second such development, which was constructed to reduce the shortcomings and strengthen the irrigation system. Approved by the World Bank in 1965, its construction started in 1968. The expected time of completion of the dam was April 1975, but it was built ahead of schedule and the test filling of the reservoir stated in July 1974. A serious problem occurred in all four tunnels at water levels of 1462 and the reservoir had to be depleted. After rectification, the dam was completed in 1977 but normal operation of the reservoir could not start before the *kharif* of 1978.

2.0 THE TARBELA DAM PROJECT

The Tarbela Dam is the largest earth and rockfill dam of the world. It was constructed as part of the Indus Basin Settlement Plan. The primary function of the Tarbela project was to regulate the Indus River flows for the benefit of irrigation. A secondary function is the generation of electric power. Incidental benefits include limited flood control of the Indus River, a substantial contribution to tourism, commercial fishing possibilities and added employment opportunities during and after construction.

The reservoir was completed in 1977 with units 1 - 4 providing 700 MW of power. Units 5 - 8 of 700 MW were added in 1982. Units 9-10 of 350 MW were completed in 1985 and finally units 11 - 14 of 1,728 MW were completed in 1992-93, making the total power generation capacity of Tarbela Dam 3,478 MW.

3.0 MAIN ELEMENTS OF TARBELA DAM

The principal elements include:

- An earth and rockfill embankment across the entire width of the main Indus river valley and the attributed reservoir. The main embankment dam is 9,000 feet long. It involved 138 million yards^3 of fill, which makes it the largest dam in the world.

On Left Bank:

- Two auxiliary earth and rockfill embankments to close saddles at the upstream end of a side valley.
- Two spillways discharging into the side valley.
- A tunnel through the left abutment to provide controlled releases for irrigation downstream.

On the Right Bank:

- A group for tunnels through the right abutment to provide for river diversion (during last phase of construction), regulated power and irrigation releases.
- A small diameter tunnel for irrigation to the Gandaf plateau.
- A powerhouse and a switchyard.

4.0 THE BASIN

The Indus basin above Tarbela consists of two areas quite dissimilar in their characteristics. The larger part of approximately 158,000 km^2 is about 960 km long and 160 km wide. It lies between the great Karakoram and Himalayan ranges and its axis is oriented generally southeast-northwest. Perpetual snowfields and glaciers occupy about one quarter of the area.

The smaller and lower drainage area of approximately 10,360 km^2 lying immediately upstream of the dam site and extending northward to the southern slope of Himalayas is open to monsoon storms coming from the south. Runoff from this area is derived from rainfall chiefly during the monsoon period.

5.0 FINANCIAL BENEFITS

The total project cost including power units 1-14 was US$ 2.63 billion with local and foreign currency components in almost equal proportions.

The rupee cost was met entirely by the Government of Pakistan while the Tarbela Development Fund was established in 1968 to take care of the foreign currency requirements. The balance amount of the Indus Basin Development Fund was diverted and bilateral loan agreements were signed with several European countries, Canada and USA. In 1980, an agreement with Saudi Arabia, Kuwait and Abu Dhabi had to be entered to augment the fund.

The benefits of the project can directly calculated by the availability of water and generation of power. The calculations in the table have disregarded the other benefits of Tarbela such as national security against upstream riparian, flood mitigation, recreation, etc

Year	Water		Power		Total Benefit
	Storage Releases	Rs. 900 per Ac-F	Generation	Rs. 0.3 per Ac-Ft	
July to June	MAF	Benefit, Rs. Milli	MKWH	Benefit, Rs. Milli	Rs. Million
1996-97	9.15	8,235	14,230.17	4,269.05	12,504.05
1997-98	8.66	7,794	15,084.90	4,525.47	12,319.47
1998-99	9.04	8,136	16,377.84	4,913.35	13,049.35
1999-00	8.71	7,837	14,747.64	4,424.29	12,261.49

6.0 SILTING OF TARBELA DAM

The River Indus carries a large volume of suspended sediments. It was analyzed on the basis of measurements carried out by the Irrigation Research Institute and WAPDA through a rating curve on discharge that the annual suspended sediment load at Darband was 430 million ton per year or 0.26 MAF per year.

It was assumed that the trap efficiency will be 100% until the gross capacity reduces to 4.5 MAF, thereafter, the trap efficiency will reduce to a uniform rate of 60%. The useful efficiency of Tarbela based on these assumptions was expected to be 50 years.

7.0 THE TARBELA WATERSHED MANAGEMENT PROJECT

The primary objective of this project was to prolong the life of Tarbela reservoir through improved methods of land-use and implementation of watershed management practices in the catchment area above Tarbela dam. The project, besides reducing silt entry into Tarbela reservoir, has also improved the following:

- socio-economic condition of the people living in the area by improvement of land with consequent increase in agriculture,
- forest and range-land produce,
- increase in sub-soil water resources and perennial stream flows,
- minimizing runoff with consequent reduction in flood hazards and
- environmental protection of the area

The Tarbela Watershed Management Project started in 1971 with the inception of the Tarbela Dam Project. It has been financed throughout by the World Food

Program and also later by KfW. The project is said to have increased the life of Tarbela reservoir by 27 years.

The watershed management practices include reforestation of bare and denuded lands, development of range-lands, improvement of cultivated fields by land leveling/ improvement of terraces and structural works such as silt trap storages, spillways, check dams, retaining diversion walls and gully control structures.

8.0 THE RESSETLEMENT ISSUE

The Tarbela Dam Project initially estimated that 100 villages would be submerged and the inhabitants will have to be displaced, but in fact 120 villages were submerged, affecting 96,000 people.

Depending on the size of land holding and type of irrigation practiced, two-thirds of the affectees were provided replacement land and the rest were given cash compensation. However, according to a survey conducted in 1996, there were 1953 families still waiting for possession of allotted land.

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