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AE SERVICES FOR THE TRANSPORTATION FEASIBILITY FOR LINKING THE WEST BANK AND GAZA STRIP (294-C-00-05-00233-00) PROGRESS REPORT

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CHAPTER 1- INTRODUCTION

The Progress Report summarizes the work accomplished on AE Services for the Transportation Feasibility Study for Linking the West Bank to Gaza Strip (Contract 294-C-00-05-00233-00) from October to the end of December 2005. It also presents the initial findings of the study and describes the tasks remaining to be completed during the final phase of the study.

1.0 The Progress Report

The Progress Report encompasses two volumes: Volume 1, the Main Report, and Volume 2, Drawings. The Main Report consists of five chapters and covers the work activities defined in the Scope of Work (See Annex 1-1). Volume 2 includes detailed drawings of each of the alignments studied, location maps and typical cross sections. The following subsections summarize the contents of each of the Main Report's chapters.

1.1 Forecasts (Chapter 2)

This Chapter presents the population and economic forecasts for the West Bank and Gaza Strip (Gaza) covering the feasibility study period (2005 to 2030). These projections are largely refinements and modifications of work done by others, including the World Bank, IMF, and FAFO. Additional analyses will be conducted to improve the population projections to account for the potential of significant in-migration of Palestinians from abroad. Traffic forecasts for the proposed link are also presented. Because the transportation link would be without precedent and historical traffic data between the two territories are of limited value, it was necessary to develop a new traffic model that could provide results that were independent on having survey or other primary data. This model has been developed and is now being refined and internally reviewed by Berger Team to improve upon the assumptions utilized. Initial results are given for Medium, High and Low growth scenarios. USAID, the World Bank and the Palestinian Authority have been briefed on the methodology used and the preliminary results of the forecasts. The comments received have or will be considered in the further refinements of the forecasts.

1.2 Route Selection – Initial Results (Chapter 3)

Chapter 3 reviews six alternative alignments (18 combinations of road only, rail only, and road/rail options). Four technical annexes explain the proposed design standards used by the study, a hydrological assessment of the alternative alignments and geological considerations in selecting the alternative alignments. A screening analysis of the six alternative alignments was conducted based on a desk study and a field trip to the proposed corridors, which was used to eliminate several candidate alignments. Key factors that will be used to select the preferred alignment are the location of the terminus of the link in the West Bank and in Gaza, and connectivity to road networks within each area and to regional connectors. The corridor between northern western corner of Gaza at Beit Hanum and the West Bank at Tarkumiya appears to represent the best location for the proposed transport infrastructure. This finding is similar to the conclusions of earlier assessments. There are two alternative alignments with two variations (for a total of 4 alignments) that satisfy the project's criteria, which will be further assessed in the next phase of the project. Within these four alignments are nine modal combinations that will be studied. Those alignments connecting to the south near Meitar were found to be economically less attractive. On several occasions, USAID, the World Bank and the Palestinian Authority have been briefed on the process being made by the consultant in the assessment of the alternative routes being evaluated. Comments received helped in making the final selection.

1.3 Utilities (Chapter 4)

A transportation link connecting the West Bank to Gaza Strip would provide the opportunity to incorporate within its right-of-way the utility transmission lines for water, power (electricity), natural gas and telecommunications. Chapter 4 presents the feasibility study's initials findings on economic viability of using the transportation corridor for utilities transmissions. Utility cost estimates are undergoing further development and are subject to further modifications as additional data are collected and analyzed.

Our technical findings indicate that the proposed transportation link should be sized to accommodate the transmission of all four utilities. However, the economic data do not support the construction of any of the transmission lines in the near future. For example, in the absence of a major discovery of additional natural gas reserves off Gaza, there is no economic rationale for installing a gas transmission line connecting the two areas. Similarly, the large and rapid changes in the telecommunications industry would render a current decision based on present technology for transmission of electronic data in, say, the 2015 period as highly risky. Similar high levels of risk would also be associated with any decision to build electricity and water transmission lines within the corridor. Uncertainty about the timing of a future desalinization plant, for example, and the potential for large changes to demographic patterns once the transportation link is built would greatly influence the economic viability of these projects. Nonetheless, one or more of these transmission lines might become important to the long-term economic development in a future Palestinian State, and therefore it would be prudent not to foreclose the opportunity to construct utility transmission lines within the proposed transportation corridor as needed. The chapter describes current supply and demand issues associated with water, electricity, natural gas in the West Bank and Gaza Strip and their ramifications for building utility links between the two regions. USAID, and the World Bank have been briefed on the utility assessment. The comments received have or will be considered in the further refinements of the forecasts.

1.4 Environmental Considerations (Chapter 5)

This Chapter describes the existing environmental, cultural resources, and socio-economic conditions and data collected during the first months of this project; it provides an analysis of the preliminary conceptual alignments and the environmental factors that played a central role in the adjustment of the proposed routes as they were being developed by the transport engineers in conjunction with environmental experts; and describes the potential environmental issues to be considered during the subsequent impact analysis of alternatives to be presented in the Draft Final Report. It is important to emphasize the difference between analysis of proposed alignments and of proposed alternatives. The comparative impact analysis of the possible alternatives cannot be conducted at this stage of the project. It will be conducted once the alignments and engineering options are developed in more detail. The reason behind this resides on the fact that an alignment can have diverse environmental effects depending on the design and construction types selected (e.g. cut- and-cover, at-grade road, sunken road, segmented tunnels, railroad vs. road).

2.0 Further Analysis of the Alternative Routes

As noted above, during the initial assessment of the alternative alignments, a total of eighteen options based on a selection of at-grade, sunken, or partial tunnel configurations, and selection of road only, rail only, or combined road and rail options were evaluated. The description of these alternative alignments is given in Table 1-1 below. Their relationship to each other is shown in Figure 1-1.

Table 1-1: Alternative Alignments, with Rail/Road Possibilities, Lengths, and Comments - Preliminary Evaluations

Alternative Alignments	Railroad	Road	Combined	Approx. Length in Israel (km)	Project Length (km)	Length in GZ to Seaport	Length in WB to near Tarkuiya or Meitar	Length in WB to N. Hebron Jct.	Total Length: Seaport to N. Hebron	Est. # of overpass/ underpasses for major routes	Comments
Al 1	√	√	√	41	45	19	2	14	76	7	Follows existing road and rail corridors to Tarkumiya
Al 2		√		39	43	19	2	14	74	7	Sunken Alignment to Tarkumiya, new corridor
Al 2a	√	√	√	39	43	19	2	14	74	7	At grade, New Corridor
Al 2b	√	√		39*	43	19	1	14	73	1	Tunnel sections from Gaza to Tarkumiya
Al 3	√	√	√	51	55	14	2	14	81	7	From Gaza SE & NE to Tarkumiya
Al 4	√	√	√	40	50	14	8	31	93/89**	8	South of Sderot to Meitar: requires 800m tunnel
Al 4a		√		40	50	14	8	31	93/89**	8	Sunken alignment south of Sderot to Meitar: requires 800m tunnel
Al 5		√		40	49	14	7	31	92/88**	9	South of Sderot to Meitar along existing routes
Al 6		√		50	59	8	7	31	96/92**	9	Seaport to Meitar

*. Al 2b includes approx. 6 kms of tunnel

** First value is for rail and second value is for shorter road solution

A more detailed assessment of the alignments eliminated the number of alternatives to a more workable set of options. All options, which terminated in the West Bank at the southern terminus located north of Meitar were removed from further evaluation based on several factors, including:

- Discussions with Palestinian officials, they did not view these options favorably, questioned whether any continuation of a rail route from its southern terminus to points north would ever prove viable, and noted the possibility albeit difficulty of a rail continuation from Tarkumiya;
- Only one of the four southern options allowed for a combined road/rail possibility. The remaining road only alternative required a 20 km increase in length between Gaza and Hebron, with no tangible benefits;
- All origin/destinations using the southern alignments would require substantially long trip lengths and consequently increased travel costs and travel time in a new corridor. These added costs and would confer no tangible benefits to the Palestinians.

Alternative Alignment 3 was also eliminated, for several reasons, including:

- It could not follow the Route 334 corridor as originally envisaged, due to conflicts near Sederot, and with park lands east of Dorot
- It added 12 kms length across Israeli territory, or an increase in distance of 31%, over all other options terminating at Tarkumiya
- It added approx. 8 kms, or an additional length of 11 percent over other options for total distance between Gaza City and the junction north of Hebron
- The additional length occurs primarily at a location in the foothills, creating a more expensive and problematic alignment in this geographic area

The elimination of these road/railway alignments reduced the number of alternatives to 9, including four distinct alignments. These alignments will undergo for further review in the next phase of the project during which costs estimates will also be developed. The 9 options are shown in Table 1-2.

Table 1-2: Alternative Alignments, with Rail/Road Possibilities for Further Study

Alignment	Railroad	Road	Combined	Type	West Bank Destinaton
Al 1	√	√	√	At Grade	Tarkumiya
Al 2		√		Sunken	Tarkumiya
Al 2a	√	√	√	At Grade	Tarkumiya
Al 2b	√	√		Tunnel/Partial Tunnel	Tarkumiya

It should be noted that the option involving a continuous road tunnel of 40 km is not considered practical and greatly exceeds the length of the longest existing road tunnel in the world (24.5 km in Norway). A partial tunnel solution, however, is a viable alternative and will be assessed in the next phase of the project. One issue that will need to be addressed is the provision of outlets because of the potential for accidents, which would increase as the length of tunnel increases due to driver fatigue. The tunnel sections would occur at critical areas where settlement, infrastructure and environmental avoidance issues lead to its consideration. It is also important to note that large diameter water pipelines and power transmission lines would not be located within the tunnels since they could be located in buried trenches above the tunnel at considerably less cost. The

transport of highly flammable materials (gas) should not use the tunnel and hence would need to be transported through a different corridor.

Finally, additional revisions to the selected alignments are possible later in the study as more information becomes available. For instance, for all Alignment 1 alternatives, there are potential conflicts to the north of Sederot, in the corridor between Kiryat Gat and Lahish, and environmental concerns near Nehusha, all of which could alter the alignment to a certain degree and have an impact on costs Nevertheless, the corridors selected are indicative of the possibilities and are of sufficient accuracy at this stage to continue to a further investigation of their feasibility.

3.0 Additional Issues

A major issue in executing the project during the first 3 months has been the lack of input from the Government of Israel (GOI). Through the end of December, the Consultant was unable to meet formally with officials of the GOI to brief them on progress made and take into account their comments on the work performed to date. Informal meetings have been held with various government organizations and agencies and although the discussions have been cordial, relatively little information has been provided. Certain officials noted that because they have not received approval to discuss official policies with the Consultant's staff, they are hesitant to provide information that could be helpful to the study. There is considerable concern that the inability to obtain critical environmental data could adversely impact the study's schedule or even prevent the study from being complete in terms of assessing potential environmental and social impacts. Finally, while data on West Bank has been relatively easy to obtain, information on Gaza has been much more difficult to access.

4.0 Remaining Tasks for the Final Phase of the Feasibility Study

Table 1-3 summarizes the status of the work that has been completed to date and the work yet to be done.

Table 1-3: Status of Work

Activity	Subactivity	Present Status	Work to Be Done	Comments
Forecasts				
	Population			
	Base	Done	IC	IC = Incorporate comments
	Immigration	Reassessed	To complete	
	Employment	Not done	To be done	
	Traffic Forecasts			Internal review of methodology
	Passenger			
	Coefficients	Review and update	IC + Complete	Internal review underway
	Modal Analysis	Refine	IC + Complete	Internal review underway
	Freight	Refine base data	IC + Complete	Internal review underway
Route Selection				
	Alignments			Initial Selection Completed
	Plan	Further refinement	Refine work done	
	Profile	Further refinement	Refine work done	

Cross sections	Further refinement	Refine work done	
Tunnel Alternatives	Underway	To Complete	Geological analysis of well data
	Overview	To Complete	Underway
	Select tunneling methods	To be done	
	Road	To be done	Partial
	Rail	To be done	Partial and Full
Capital Costing	In progress	To complete	Using Israel unit prices
Construction Method	In progress	To complete	Accelerated methods
Operation of the route	Rail	To be done	Operational plan for rail and cost
	Road	To be done	Operational plan for road and cost
Maintenance	Rail	To be done	
	Road	To be done	
Utilities			
Water	Almost complete	To complete	Internal review underway
Power	Refine costs	To complete	Internal review underway
Natural Gas	Done	IC + Complete	Internal review underway
Telecommunications	Done	IC + Complete	Internal review underway
Environment			
Preliminary Screening of Alignments	Done	Refine work done	
Gathering of additional Data and official link to Government agencies		In Progress	
Tunnel Alternatives	In Progress	To be done	
Social			
Preliminary Screening of Alignments	Done	Refine work done	
Gathering of additional Data and official link to Government agencies		In Progress	
Tunnel Alternatives		To be done	
Economic Evaluation of Alternatives			
Methodology	Not begun	To be done	
Analysis	Not begun	To be done	

CHAPTER 2- DEMOGRAPHIC, ECONOMIC, AND TRAFFIC FORECASTS

2.1 Population and the Economy

The population and economic forecasts used in the feasibility study and presented in this chapter are primarily derived using previous projections (e.g., World Bank) and represent more of a consensus of opinion rather than a purely original effort.

The Palestinian Territory is encompasses two separate areas, the larger land locked West Bank located in the east and the Gaza Strip on the Mediterranean Sea.. The West Bank comprises eleven (11) Governorates covering 5,740 sq km. West Bank Governorates north of Jerusalem are: Jenin, Jerico, Nablus, Qalqiliya, Ramallah, Salfit, Tubas and Tulkarm and West Bank Governorates south of and including Jerusalem are: Bethlehem, Hebron and Jerusalem. The Gaza Strip consists of five (5) Governorates covering an area of 360 sq km. Gaza Governorates are North Gaza, Deir El-Balah, Gaza, Khan Yunis and Rafah

2.1.1 Population Projections for West Bank and Gaza Strip

2.1.1.1 Overview

Discussions regarding the current and future demography of the West Bank and Gaza Strip invariably elicit strong responses from the spectrum of stakeholders involved in Palestinian/Israeli planning issues. The continuing conflict, inadequate institutional capacity, and other socio-political and cultural factors have prevented the conduct of regular and definitive census counts over the last five decades. Because there are no reliable historical series of demographic data for any of the administrative or geographical regions comprising the Palestinian territories, efforts to establish a baseline population and develop even short-term demographic forecasts are inherently fraught with a high level of uncertainty and subject to wide interpretation. For example, recent estimates of the 2005 Arab population in the West Bank and Gaza Strip range from a high of 3.82 million (PCBS 2005)[1] to a low of 2.4 million (AEI, 2005)[2], a discrepancy exceeding 1.4 million persons. Using these figures, as alternative baseline years for a 25-year population projection would lead to a highly divergent set of end- year estimates. Such a large discrepancy would have a major impact on how planners could address the potential long-term availability of scarce resources or estimate the demand for infrastructure. The political ramifications of demographic projections cannot be overstated in a region with such a large and conflicted population residing in a small area.

Because of the contentious issues associated with population estimates and the limited scope of this study, no new baseline projections have been developed. Instead, a review was conducted of existing studies, including those conducted by the Palestinian Authority, Israeli Demographers, and independent organizations. Based on this review, it was determined that the population projections developed by Norwegian researchers associated with the Fafo, Institute for Advanced

[1] Palestinian Central Bureau of Statistics. *Palestine in Figures 2004*, 2005,Ramallah, Palestine.
[2] American Enterprise Institute, *Arab Population in the West Bank and Gaza*, January, 2005

International Studies (2004) would be suitable for this study[3]. The study builds upon earlier demographic research efforts conducted by Fafo in the 1990s and employs well established and widely accepted methodologies. Furthermore, since it was published in December 2004, it is the most recently publicly available demographic study on the Palestinian Territories. The only significant modification of the Fafo projections for use in this feasibility study is an extrapolation from 2015 (the last year of that study's forecast) to 2030, the end-year for the current study.

The Fafo Study (Dalen and Pedersen, 2004), "The Future Size of the Palestinian Population of the West Bank and Gaza Strip" characterizes the size and composition of the Palestinian population based on the December 1997 Census. Using these data and trends in fertility rates, the Fafo Study developed high and low growth rate scenarios for estimating the Palestinian population through the year 2015, at five-year intervals.

The Fafo Study uses the Palestinian 1997 as a baseline for its projections, albeit with one modification; the Norwegians assumed an undercount of approximately 2.4 percent. It should also be noted that the Fafo population baseline also included the Arab population of East Jerusalem, which totaled about 210,000 at the time.

The population projections generated by the Fafo study were developed using the cohort-component method, which essentially uses the age and gender structure of the current population to simulate changes to each cohort with regard to births, deaths, and migration, based on age-specific fertility, death, and migration rates. It is important to note that this study only took into account natural changes to the population and assumed a net zero migration rate. Although there are no definitive statistics on migration flows into and out of the Palestinian Territories, there is a general consensus that there has been a net positive out-migration during the past decade. This outflow of migrants has posed problems for the projections developed by the Palestinian Central Bureau of Statistics, which in 1999, assumed a net positive migration of 45,000 per year from 2001 to 2010.

Because of the significant uncertainties associated with projecting migration rates, especially with the ongoing political conflict and a poorly performing Palestinian economy, the study author's assumed a zero net migration for the forecast period 2005 to 2015. Although the current feasibility study, includes an "optimistic scenario" that implies a degree of political stability and an improvement of economic conditions in the Palestinian Territories, the assumption of zero net migration is retained, because of the high uncertainty associated with projecting the timing and the size of the potential in-coming population. In short, both the Fafo projections and the modified projections used in this feasibility study are completely decoupled from economic and political conditions. As such, the total population projections for the optimistic scenario could be overly conservative.

2.1.1.2 Population Estimates and Projections 1997 to 2030 – Based on FAFO

As described above, the Fafo study developed projections to 2015, using data from the 1997 Palestinian Census along with other sources on West Bank and Gaza (WB/G) demographics. As seen in the Table below, the total WB/G population in 1997 was estimated at 2.83 million, with 64 percent of the inhabitants residing in the West Bank.

[3] Dalen and Pedersen**,** *The Future Size of the Palestinian Population of the West Bank and Gaza Strip*, 2004, FAFO, Oslo Norway

Using high and low growth rate scenarios, the Fafo study projected the total 2005 population to range from approximately 3.51 million to 3.61 million. For purposes of the feasibility study, a medium forecast was also generated, using the midpoint of the Fafo low and high growth rate scenarios.

Table 2-1 Projected Populations for the West Bank and Gaza Strip 1997 to 2030

	1997	2002	2005	2010	2015	2020	2025	2030
West Bank (High)	1,822	2,094	2,265	2,558	2,854	3,184	3,553	3,964
Gaza Strip (High)	1,010	1,219	1,350	1,579	1,815	2,087	2,399	2,758
Total (High)	2,832	3,313	3,615	4,137	4,669	5,271	5,952	6,722
West Bank (Medium)	1,822	2,078	2,228	2,472	2,703	2,956	3,233	3,535
Gaza Strip (Medium)	1,010	1,212	1,332	1,525	1,709	1,915	2,147	2,406
Total (Medium)	2,832	3,290	3,560	3,997	4,412	4,871	5,380	5,941
West Bank (Low)	1,822	2,062	2,193	2,389	2,562	2,746	2,944	3,156
Gaza Strip (Low)	1,010	1,206	1,314	1,473	1,609	1,758	1,921	2,098
Total (Low)	2,832	3,268	3,507	3,862	4,171	4,504	4,865	5,254

Adapted from Dalen and Pedersen, 2004

Central to the Fafo forecast is the assumption that fertility rates in the Palestinian Territories have decreased since 1997 and will continue to do so until birth rates become more in line with other Arab countries in the region. Nonetheless, growth rates are projected to be sufficiently high to cause a doubling of the 1997 population before 2025 under the high growth rate scenario and before 2035 under the low growth scenario.

For the WB/G as a whole, under the high growth scenario, estimated average annual growth of 3.14 percent for the period 1997-2002 is projected to decrease to 2.41 percent annually by 2015. Under the low growth scenario, annual percentage increases are projected to drop from 2.86 percent to 1.54 percent over the same period.

Within the Palestinian Territories there are large differences in population growth rates. For example, the Gaza has a much higher growth rate than does the West Bank Region and within the West Bank, the urban populations around Jerusalem have lower fertility rates than in the rural areas of the southern West Bank. The Gaza Region was estimated to have an average annual growth rate of 3.76 percent during the period 1997 to 2002 compared to a 2.78 percent growth rate for the West Bank (under the high-growth scenario). These growth rates are projected to decrease to 2.79 and 2.19 percent, respectively, by the year 2015.

To project population levels outward from 2015 to 2030, the feasibility study assumes a stabilizing of the projected fertility rates. Specifically, it is assumed that the lower growth rates achieved by the year 2015 continue for the remainder of the forecast period.
Accordingly, in the year 2030, the total WB/G population is estimated to range from a low of 5.25 million under the low growth scenario to more than 6.72 million under the high growth scenario. The proportion of the West Bank population under all of the scenarios decrease from 64 percent of the total Palestinian population in 1997 to about 58 and 60 percent by 2030, under the high and low growth scenarios, respectively.

2.1.1.2 Population Estimates and Projections 1997 to 2030 – Modified for In Migration (TBD)

2.1.1.3 Employment Estimates and Projections 1997 to 2030 (TBD)

2.1.1 The Palestinian Economy

The following sections present an overview of the Palestinian economy, including a discussion of current conditions, distribution of output by major sector, sector employment external trade, and projections of future economic performance. Each of these factors, together with future demographic changes will strongly influence transportation demand for the proposed linkage between West Bank and Gaza Strip. The primary source of data for these discussions is the Palestinian Central Bureau of Statistics, although many of the estimates of changes in socioeconomic indicators during the last five years have been estimated by the World Bank. It should be noted that economic data collection efforts were severely impeded during the worst violence of the second *Infitada*, leaving significant gaps in the availability of information on national accounts.

2.1.2.1 Overview of Current Conditions

The current status of the Palestinian economy can at best be characterized as fragile, despite some modest improvement from the precipitous decline in almost all socioeconomic indicators during 2001 and 2002. During the two-year period following the inception of the second *Intifada*, Palestinian real gross domestic product (GDP) per capita decreased by almost 40 percent (World Bank, 2004). This decline, however, does not begin to capture the magnitude of losses felt by Palestinian inhabitants of the West Bank and Gaza Strip. For example, at peak levels, Israel and Israeli settlements generated about 128,000 jobs and employed 25 percent of the Palestinian labor force. Following the outbreak of the second *Intifada* in September 2000, this figure dropped substantially, and by the end of 2002 Israeli employment of Palestinians decreased to 16,000 (Rand, 2005). Unemployment increased from 14 percent to above 30 percent. By 2004, approximately half the Palestinian population (and nearly two-thirds in Gaza) was living below the official poverty line of US$2.20 a day. Those living in severe poverty (below US$1.50 per day) were estimated at 16 percent.

By 2003, the Palestinian economy had somewhat stabilized and the steep declines of the previous two-years turned modestly positive for several key economic indicators.. According to the World Bank, real GDP per capita increased by one percent, but real Gross Disposable Income (GDI) – which includes remittances from abroad and foreign assistance – increased by over 11 percent per capita. Contributing factors to these economic gains were an overall reduction in violence, and fewer restrictions of movement on Palestinian workers, as well as a resumption of transfers by the Government of Israel (along with the return of US$178 million in withheld revenues). The World Bank also estimates that approximately 100,000 jobs were created.

Although the tenuous recovery of 2003 continued through 2004 in the West Bank, the Gaza economy regressed, with the imposition of stiff restrictions on movements of goods and people across the borders with Israel and Egypt. The volume of Gaza's exports was further reduced and humanitarian assistance temporarily curtailed. For example, worker access to the Erez Industrial Estate and to Israel from Gaza declined to a daily average of less than 1,000 in the second and third quarters (compared with 6,000 the previous year); at the same time, an additional 8,900 jobs have been lost within Gaza – resulting in a 6 percent increase in the unemployment rate in Gaza to 35 percent. In the West Bank, employment increased slightly, with unemployment averaging 23 percent in 2004, an improvement of 5 percentage points from 2002.

Recent data from the Palestinian Central Bureau of Statistics (PCBS, 2005) indicate some improvement to the overall Palestinian economy compared to 2004. For example, the third quarter, 2005 labor survey conducted by the PCBS, estimated that West Bank unemployment at 19.9 percent, while the Gaza unemployment rate dropped to 29 percent[4]. Nonetheless, the economy remains extremely fragile and most of the indicators are well below levels attained in the period preceding the second *Intifada*. For example, the quality of the jobs recently generated is well below that prior to the year 2000. For example, the percentage of employees whose monthly wages are below the poverty line reached 57 percent in the 3rd Quarter of 2005, compared to 43 percent in 2000. Similarly the economic dependency ratio[5] continues to rise, reaching 5.1 and 7.5 in the West Bank and Gaza Strip, respectively (PCBS, 2005). The comparable ratios for the year 2000 were 4.3 and 5.9, respectively. Almost all other socioeconomic indicators remain significantly below 2000 levels. In short, the Palestinian economy has made modest gains in the past 3 years, but has yet to regain the huge losses of economic output and quality of life experienced in the two-year period following the second *Intifada.* The economy remains extremely weak and highly vulnerable to exogenous political and economic events. In the absence of institutional reforms together with further abatement of restrictions to the movement of goods, services, and people, and improvements in infrastructure, the Palestinian economy will be hard pressed to attain significant economic development in the future.

2.1.2.1 Composition of Palestinian Economy

The PCBS has published data on economic activity by sector only through the year 2000. To some extent, these data might not accurately reflect the current distribution of economic output because the ongoing conflict has not affected all sectors equally. For example, prior to the second *Infitada*, almost a quarter of the labor force was employed by establishments in Israel or by Israeli settlements. Currently, the figure is greatly reduced, with more laborers working in establishments in their village, including agriculture. Hence, employment and output in this sector has increased relative to other sectors, despite a downward trend over the last decade.

In terms of value of gross output, in the year 2000, according to PCBS figures, manufacturing accounted for 17 percent of the total output of the Palestinian economy. The service sector generated 16.5 percent of the output, followed by public administration (13.3 percent), construction (11 percent), and agriculture (9.6 percent). Wholesale trade, transport, financial institutions, and other services accounted for the remainder of the output. As noted above the Infitada has in some ways restructured the economy. UNCTAD estimated that by the end of 2002, the manufacturing sectors contribution to the economy decreased to 16 percent and construction lost half its share of GDP (UNCTAD). Agriculture increased to about 15 percent of the GDP in 2002.

The PCBS has been able to conduct regular labor force surveys, with the most recent data collected for the third quarter of 2005 and these surveys provide a snapshot view of Palestinian employment distribution by sector. The service sector, which includes a large public sector component generates the largest proportion of jobs in both the West Bank and Gaza. Historically, the public sector has played a disproportionately large role in the economy. As recent as 1999, public administration and services accounted for approximately 23 percent of the domestic employment (Rand, 2005). Commerce, restaurants, and hotels still account for almost a fifth of

[4] Includes those persons in the labor force who are unemployed and are seeking a job.
[5] Number of population divided by the number of persons employed.

the jobs in both regions, whereas agriculture generates about 18 percent of the employment in the West Bank but only 10 percent in Gaza. The largest proportion of Palestinian workers associated with Israeli employment is in the construction industry, although the number of employed Palestinians working in Israel or on the Settlements has been drastically reduced. This has also had a disproportionate effect on the economy because Israeli employment on average paid almost double the amount earned by Palestinian employees working in either the West Bank or Gaza. Finally, it should be noted that the Palestinian economy is driven almost totally by small business enterprises. According to UNCTAD, 90 percent of the establishments employed fewer than five workers (UNCTAD, 2005).

Table 2-3: Economic Activity and Place of Work (percentage)
3rd Quarter 2005

Economic Activity	West Bank	Gaza	Israel and Settlements	Total
Agriculture, fishing, forestry	18.4	10.4	5.6	14.9
Mining, quarrying Manufacturing	13.9	7.9	22	13
Construction	10.1	8.5	43.6	13.0
Commerce, restaurants, and hotels	21.4	17.5	19.3	20.1
Transportation, storage, communication	5.7	5.6	2.2	5.3
Services	30.5	50.1	7.3	33.7
Total	100	100	100	100

Source: PCBS 2005

2.1.2.3 External Trade

Despite severe constraints, trade has filled an important role in sustaining the Palestinian economy. Imports of final goods, services, equipment and intermediate inputs have historically accounted for approximately 70 percent of GDP, while exports of goods and services represented less than 20 percent of GDP (World Bank, 2004). However, external trade like all other components of the Palestinian economy had decreased dramatically since the year 2000. Disruptions in production, restrictions on movement, and the large increases in transaction costs have rendered the Palestinian exports less competitive

As seen in the table below, total exports decreased from almost $395 million in 1998 to about $241 million in 2002. Exports to regions in the world, except for Arab Countries and the Americas declined. These two regions together, however still accounted for only about 6.4 percent of the total value of exports. Israel share of the exports decreased from almost 97 percent to 84 percent. Jordan is the primary destination of exports to the Arab region, accounting for more than 82 percent of the total exports to Arab Countries.

Table 2-4: Palestinian Exports to the Rest of World 1998-2002 (million US$)					
Country	1998	1999	2000	2001	2002
American Countries	$82	$365	$71	$128	$203
Arab Countries	$11,498	$9,631	$29,122	$14,576	$15,093
EUCC Countries	$1,636	$1,506	$1,675	$2,453	$8,921
Eastern European Countries	$45	$7	$0	$29	$1
Israel	$381,517	$360,469	$369,988	$273,164	$216,409
Other Countries	$68	$170	$0	0	0
Total	$394,846	$372,148	$400,856	$290,350	$240,627

Source: PCBS 2005

Table 2-5 presents export data by sector and show similar reductions for all export factors. Manufacture goods and articles, and food and live animals were the three largest exporting sectors and accounted for about 74 percent of the export value in 1998 and about 71 percent of the export value in 2002.

Table 2-5: Palestinian Exports by Sector – 1998 to 2002 (million US$)					
Sector	1998	1999	2000	2001	2002
Food and live animals	$61,793	$60,878	$84,552	$34,073	$27,036
Beverages and Tobacco	$25,432	$14,567	$13,573	$13,478	$13,657
Crude materials Inedible except fuels	$17,566	$13,406	$15,670	$12,887	$14,375
Mineral fuels Lubricants and related materials	$7,006	$4,952	$3,671	$2,161	$2,481
Animal and Vegetable oils Fats and waxes	$5,343	$4,133	$5,713	$5,755	$5,720
Chemicals and related products n.e.s (not elsewhere specified)	$24,631	$30,250	$29,687	$27,594	$20,263
Manufactured goods classified chiefly by material	$165,862	$151,240	$153,239	$120,473	$94,954
Machinery and transport equipment	$21,736	$20,758	$23,958	$16,920	$12,042
Miscellaneous manufactured articles	$64,397	$71,545	$70,596	$56,496	$49,834
Commodities and transactions n.e.s in the SITC-3	$1,080	$419	$198	$512	$505
Total	$394,846	$372,148	$400,857	$290,349	$240,867

Source: PCBS 2005

The World Bank estimates that exports continued to decline in 2003 (-4 percent in nominal and real terms) and remained some 30 percent below their *pre-intifada* level by the second quarter of 2004. A significant consequence of the *Intifada* is that producers have been targeting production to meet internal demand rather than world markets.

The economic crisis, which has greatly reduced the purchasing power of Palestinian households, has also dampened their demand for imports. Reduced output of the manufacturing industry also decreased demand for production inputs including equipment. As seen in Table 2-6, imports have also contracted by roughly one-third compared to year 2000 levels

Table 2-6: Palestinian Imports from the Rest of World 1998-2002

	1998	1999	2000	2001	2002
American Countries	$40,385	$99,868	$66,966	$52,242	$8,186
Arab Countries	$85,339	$81,085	$39,668	$36,781	$31,074
EUCC Countries	$226,028	$484,644	$263,605	$358,829	$16,116
Eastern European Countries	$12,089	$29,541	$26,802	$26,976	$23,089
Israel	$1,983,253	$2,285,629	$1,958,322	$1,534,842	$1,274,234
Other Countries	$28,008	$26,460	$27,444	$23,978	$162,909
Total	$2,375,102	$3,007,227	$2,382,807	$2,033,648	$1,515,608

Source: PCBS 2005

Imports from other Arab countries have dropped by more than 60 percent and imports from the EU have decreased by more than 93 percent. As seen in Table 2-7 , machinery and transport equipment imports decreased by more than 50 percent and manufactured good by 48 percent. Food and live animal importation dropped by about a third.

Table 2-7: Palestinian Imports by Sector – 1998 to 2002 (million US$)

Sector	1998	1999	2000	2001	2002
Food and live animals	$447,195	$524,314	$431,837	$408,615	$324,628
Beverages and Tobacco	$97,494	$104,929	$101,711	$97,172	$75,811
Crude materials Inedible except fuels	$67,185	$73,321	$62,136	$42,094	$35,502
Mineral fuels Lubricants and related materials	$409,881	$391,547	$455,507	$377,478	$361,339
Animal and Vegetable oils Fats and waxes	$19,558	$23,528	$17,942	$15,930	$15,468
Chemicals and related products n.e.s (not elsewhere specified)	$189,737	$225,559	$230,765	$163,519	$139,632
Manufactured goods classified chiefly by material	$567,422	$715,674	$522,204	$498,404	$291,502
Machinery and transport equipment	$386,625	$616,903	$352,360	$248,323	$180,835
Miscellaneous manufactured articles	$175,642	$321,232	$199,200	$180,962	$90,882
Commodities and transactions n.e.s in the SITC-3	$14,363	$10,221	$9,145	$1,150	$9
Total	$2,375,102	$3,007,228	$2,382,807	$2,033,647	$1,515,608

Source: PCBS 2005

2.1.2.4 Economic Outlook for Palestinian Economy Based on Previous Studies

Given the continuing political volatility affecting the region and poor quality of historical data, economic forecasts, especially one covering 25-years will be inherently speculative. The Palestinian economy is vulnerable to a myriad of internal and exogenous political, social and economic forces any of which could significantly affect short-term and long-term performance. As described above, it took only two-years of the *Intifada* to reduce the Palestinian economy by 40 percent. The relative clam during the past two-years has allowed to economy to recover only a portion of these losses. Continued volatility in the future is likely to render any single-point forecat obsolete before it is published. Accordingly, most attempts to forecast the future performance of the Palestinian economy have developed alternative growth scenarios in order to capture a broad range of outcomes. Proposed policy or project impacts can then be evaluated to determine their relative efficacy under conditions ranging from pessimistic to optimistic. The approach used for this feasibility study is to present three alternative economic scenarios (low, medium, and high) based on previous forecasts developed by the World Bank and the Rand Corporation. The following provides an overview of the two forecasts; much more detail is provided in the actual reports.

World Bank Economic Forecasts: As part of its 2004 study on the potential effects of the Israeli disengagement the World Bank(the "Bank") developed a medium-term economic forecast (2004-2008) for the Palestinian economy under three different scenarios; (1) *Status quo*; (2) *Disengagement Plus*; and (3) *Economic Recovery (World Bank, 2004a).* The Bank also simulated impacts under a disengagement alone scenario and found that the differences between that scenario and Status Quo Scenario were so negligible that the Status Quo Scenario was used as a baseline and the Disengagement alone scenario was dropped from the forecast. Under the Status Quo scenario the Bank assumed that the closure regime that existed at the time would remain essentially unchanged, with no appreciable revival in private investment would be expected. Under the Disengagement Plus Scenario the Bank assumed the removal of internal closures in Gaza and the Northern West Bank, and the completion of the Separation Barrier in 2005. Closures were assumed to remain in place in other parts of the West Bank. *Relevant to the current study, the Bank assumed that access between Gaza and the West Bank would though the inauguration of a Gaza/Tulkarm rail link by end-2007.* The Bank's high growth scenario or the Economic Recovery Scenario encompasses the Disengagement Plus scenario, but assumes a much improved trade regime. Specifically, under this scenario it is assumed border cargo facilitation measures would be implemented, including the abolishment of the back-to-back system; all internal closures are dismantled, the flow of goods and people between Gaza and the West Bank is significantly improved, a Gaza Roll-on Roll-off port comes into operation at the end of 2007, and Israelis are permitted to enter border-industrial estates (triggering appreciable job creation in the Erez, Karni and Jenin industrial estates by 2008). It should be noted that the Bank assumes annual Donor assistance of approximately $3.6 billion for the period 2005 through 2008 under the Disengagement Plus and Economic Recovery Scenarios. Donor assistance under the Status Quo was assumed to be $3.4 billion annually for the same period. Table X.x presents the outputs of the Bank's forecast of Gross Domestic Product (GDP) and Gross Disposable Income (GDI) per capita under the 3 scenarios.

As seen in Table 2-8, the Bank's prognosis for the next four years is quite pessimistic, except even under the high growth scenario. Under the high growth scenario, nominal GDP would grow by 40 percent and real GDP would increase by 30 percent. However, due to a high relative population growth rate, nominal GDI per capita would increase by only 6.5 percent and real GDI per capita by only 1 percent. Under the other scenarios, economic indicators in real terms would actually decrease. For example, under the Disengagement Plus Scenario real GDI per capita

would fall 14 per cent from 2004 levels. Decreases would be more steep and rapid under the Status Quo Scenario.

Table 2-8: World Bank Projections of GDP and GDI Per Capita under Three Scenarios (US$)				
	2004	2008	2004	2008
Scenario	GDP		GDI per capita	
Economic Recovery	$ 3,336	$ 4,687	$1,393	1,484
Disengagement Plus	$ 3,366	$ 3,778	$1,393	1,227
Status Quo	$ 3,336	$ 3,472	$1,393	1,156

Source: World Bank, 2004

In sum, the medium term Bank forecasts presume limited opportunity for rapid economic growth. A scenario involving a rail linkage with other trade reforms leads to a modest growth pattern over the period 2005 to 2008. The scenarios without trade reforms and greater connectivity between the West Bank and Gaza project continued stagnation and growing poverty throughout the Palestinian Territories.

The RAND Economic Forecasts: In support of its study "Building a Successful Palestinian State" (RAND, 2004), the RAND Corporation, developed a series of forecasts for the Palestinian economy for the period 2004-2019. The RAND forecasts encompassed four scenarios: (1) high geographical contiguity/high economic integration (*Scenario HH*); (2) high geographical contiguity/low economic integration (*Scenario HL*); (3) low geographical contiguity/high economic integration (*Scenario LH*); and (4) low geographical contiguity/low economic integration (*Scenario LL*).

Although there are common elements to the RAND and World Bank analytical approaches, they employ different assumptions on the evolution of the political process and consequently differ in how quickly the Palestinian economy revitalizes. Of course the RAND forecasts are for a much longer time-frame, but its short-term assumptions are much more optimistic than the Bank's assumptions. For example, the RAND HH study assumes a much higher degree of autonomy than does the World Bank study, in the short-term. The major assumptions for each RAND Scenario are as follows:

> Scenario HH: Provides a high degree of geographical contiguity under which Palestinians would have control over more land (e.g., Jordan valley, Dead Seas Coast) and rights to water resources; movement of people would be unimpeded, Road and Rail Link between Gaza and West Bank. Economic integration is also implemented through free trade agreement, reopening of Israeli labor market to Palestinian workers, transit and travel procedures would be simplified.
>
> Scenario HL: Assumptions regarding Palestinian control of land and water resources are the same as for the HH Scenario. The primary difference is that economic links with Israel remain undeveloped and Palestinian workers have little or no access to the Israeli labor market.

Scenario LH: Under low geographical contiguity assumptions, Israel would retain over land and water resources, external borders, and existing settlements. It does assume less Israeli control over internal movement, although closures could be imposed if the government chose to do so. A level of economic integration approaching that of Scenario HH is attained.

Scenario LL: Assumes limited connectivity across Palestinian Territory and low economic integration with Israel.

The Rand Study divides the forecast time-frame into 3 phases;

- 2005-2009 Economic Recovery
- 2010-2014 Economic modernization
- 2014-2019 Consolidation of gains and sustainable growth

Table 2-9 present RAND's projections for GDP and per capita Gross National Income (GNI) for the years 2014-2019.

Table 2-9: RAND Projections of GDP and GDI Per Capita under Four Scenarios (US$)

GDP					GNI per capita			
Scenario	2004	2009	2014	2019	2004	2009	2014	2019
HH	3,420	7,480	11,710	17,810	1,110	2,160	2,860	3,740
HL	3.420	7,610	11,680	17,040	1,110	2,000	2,640	3,370
LH	3,420	7,260	10,960	15,910	1,110	2,100	2,690	3,370
LL	3,420	7.020	10.180	14,180	1,110	1,185	2,310	2,810

Adapted from RAND 2004

The RAND projections are certainly more optimistic in the early years than are the World Bank forecasts for which there is an overlap in the timeframe. The HH Scenario, for example projects a 23.7 percent average annual growth rate for the years 2005 to 2009, with GDP reaching $ 7.5 billion at the end of 2009. The HL Scenario also projects high growth rates for the first 5-year period, in fact reaching a 2009 GDP of $7.6 billion. Both the LH and LL Scenarios are less robust than the HH and HL Scenarios. The RAND model also indicates that high geographical contiguity is a greater stimulant to economic growth than economic integration. As shown in the Table, the HL Scenario always performs better than the LH Scenario.

2.1.2.5 Feasibility Study Economic Forecast

Using either the World Bank or the RAND economic forecasts for purposes of the transportation feasibility study poses numerous challenges. Neither forecast covers the full time-frame used in the current study (2005 to 2030); the World Bank forecast covers the time-frame of (2004 to 2008 and the RAND forecast covers the longer period 2005 to 2019. Both forecasts also encompass

scenarios that would not be applicable to the current study. For example, the World Bank's Status Quo Scenario and the RAND's low contiguity scenarios (LH and LL) assume no connectivity between the West Bank and Gaza. The more optimistic of the World Bank scenarios include a rail link in 2007, but no road. The RAND's high contiguity scenarios do include rail and road links, but also assume the implementation of political changes that do not appear to be realistic in the short-term, such as significant land and resource rights concessions to the Palestinian Authority. Consequently, the RAND study assumes a rapidly developing economic recovery period beginning in 2005, such that average annual GDP growth for the period 2005-2009 exceeds 20 percent for all scenarios. Although no GDP figures are yet available for 2005, PCBS surveys on labor force as well as other economic data, indicate that the Palestinian economy, while stabilizing from its recent crisis, is not yet poised to accelerate to growth levels assumed in RAND study. Other recent developments, including the call for new Israeli elections in 2006 are likely to delay the implementation of agreements that would increase the geographical contiguity and economic integration of Palestinian Economy that are the primary drivers of economic recovery and growth in the RAND forecast model. The RAND assumptions are not necessarily incorrect; however, it appears that the timing of critical assumption used in their forecasting model may be premature.

The methodological differences between RAND and World Bank studies preclude the assimilation of the two forecasts into a single coherent detailed model. Nonetheless, for purposes of generating three generic growth scenarios (high, medium, and low) it is reasonable to use the more conservative World Bank forecast as a basis for the period 2005 to 2010 and then use the RAND more robust scenarios for beginning in the out-years, albeit modified to account for differences between the assumptions used by RAND and those used this feasibility study. In particular, the current study does not make assumptions regarding territorial changes, removal of settlements, or transfer of land and water resource rights. Therefore, economic growth rates estimated in the RAND forecast for the period 2010 to 2020 are reduced to more modest levels to take into account the removal of these positive growth factors.

As noted above, the operation of a permanent road and/or rail link is not likely to begin until after 2010. Political, environmental, economic, and other legal compliance issues would prevent construction start-up for at least 2 to 3 years. A basic premise of this study is that the transportation link could provide a powerful economic stimulus to the Palestinian economy by reducing its fragmentation and by the synergy that it could create with other infrastructure projects. For example, the full economic benefits from development of a Gaza Seaport[6] and the reopening of the Gaza Airport would only be achieved if goods produced from the West Bank could be cheaply transported to these facilities and goods imported through Gaza could be efficiently transferred to the West Bank and even on to Jordan. The importance of connectivity between the two regions as a economic stimulus, is supported by the RAND forecast model. The HL Scenario, for example, performed better than the LH Scenario over the full forecast period. Hence, geographical connectivity influences Palestinian economic performance more than improved economic integration with Israel.

An overall characterization of the three scenarios used for this study is as follows:

High Growth Scenario: The economic and political relationships with Israel will remain cordial and good allowing trade and commerce to develop between the two. Initially, internal growth will depend to a large extent on the remittances and investments received from Palestinians living

[6] The feasibility study assumed that the Gaza Airport were to reopen, it would primarily provide passenger service and would not provide transshipment of commercial goods.

abroad. However, with greater openness of the economy, Palestinian entrepreneurs as well as other investors will make good use of the comparative advantage that it will have relative to the Israeli economy. With greater demand for labor in Palestine, growth will depend on less on remittances from labor and from funds provided by overseas investors. Emphasis will on developing increased value added domestic opportunities in services and high tech light industry.

Initially, linkages between Israel and Palestinian economies will occur in the area of tourism, agriculture services, and light industries and then in higher tech industries. They will help to develop synergies with other sectors of their economies. Due to continued reforms to the Palestinian economy it will become more competitive and streamlined resulting in large improvements in productivity. The dependence on the public sector will be greatly reduced, and the private sector will be the primary "engine" of growth for the economy. External trade and economic relations with its other immediate neighbors, Egypt and Jordan, will also grow but not to the extent that they do with Israel.

Medium Growth Scenario: The economic and political relationships with Israel will remain correct but will not be strong. Over the period to 2030, internal growth will depend to a large extent on the remittances, funds and investments received from the Palestinian in the region. However, the openness of the Palestinian economy will be constrained from achieving its full potential due to only undertaking a limited number of political and economic reforms. Because of these constraints, Palestinian entrepreneurs will have only limited access to the Israeli economy. Its comparative advantage with its neighbor will not be fully realized. For these reasons, opportunities to absorb investments will be limited.

Cooperation between both economies will occur mainly in the areas of tourism, agriculture and low-tech light industries such as textiles and building materials, and some types of services. Due to partial and incomplete reforms to the economy, long-term improvements in productivity will be modest. The dependence on the public sector is reduced, but will remain an important component of the economy. Although the private sector will take on greater economic importance it will not be seen as an "engine" of growth. It will be constrained by regulation, control and the lack of transparency. External trade and economic relations with its immediate neighbors, Egypt and Jordan, will grow but will not achieve their potential because of internal restrictions.

Low Growth Scenario: The economic and political relationships with Israel will remain highly variable from good to poor, but they will create an economic environment of uncertainty. Over the period to 2030, internal growth will overly depend on: (1) the remittances and investments received from Palestinians working abroad; (2) the donor community; and (3) limited foreign direct investment. The lack of openness of the Palestinian economy will limit internal growth due not only to a lack of political reforms but to economic reforms as well.

Palestinian entrepreneurs will have very limited access to the Israeli economy due to limited cooperation between the two countries in economic matters. Cooperation, which will occur, will be mainly in the areas of tourism, agriculture and light industry in low tech sectors.

Due to partial and incomplete reforms to the economy improvements in productivity will be small. This will be reflected in an overdependence on the public sector.. Private sector will continue to be constrained by over regulation and control and by corruption and lack of transparency in the Government. External trade and economic relations with its other immediate neighbors, Egypt and Jordan, will grow and be seen as the main bright spots. Even so, this growth will not achieve its full potential because of internal restrictions.

The actual forecast for this study derives from the World Bank and RAND forecast with several modifications;

- For the Period 2005 to 2010, the forecast employs the Bank's growth rates for the three Scenarios (high, medium, low). The Bank's projected growth rates are extended until 2010. Although the short-term low growth scenario is based on the Bank's Status Quo Scenario, which assumes no linkages, that assumption is consistent with the feasibility study, which assumes that the link will not be operational until 2010.

- For the period 2011-2030, the forecast uses the growth rates developed by RAND, but reduced by 25 percent to account for the fact that the feasibility study does not assume implementation of agreements (e.g., land and water concessions) that account for a portion of RAND's projected growth estimates. The final final years of the forecast assumes a further 25 percent reduction in growth rates. It is assumed that by 2025, the economy will have assimilated most of the benefits of economic reform and geographical connectivity. Under ever the most auspicious conditions the economy would not likely sustain double digit growth throughout the final 20 years of the forecast period.

Table 2-9 presents the projected GDP for 5-year intervals from 2005 to 2030, with the World Bank's 2004GDP estimate of $3.3 billion serving as the baseline year. Consistent the RAND projections the difference between the high and medium growth scenarios is rather modest; average annual growth rates for the 25 year period are 7.6 and 6.6 percent, respectively. Nonetheless, the result is that the high growth rate leads to a 30 percent larger GDP by 2030 than the medium growth scenario.. The low growth scenario is significantly lower with an average growth rate of 4.7 percent leading to a GDP almost half of the other tow scenarios in the year 2030. By reducing the RAND growth rates by 15 percent rather than 25 percent yields 2030 GDP levels of $28.7, $ 21.7 and $12.5 billion, respectively.

Table 2-9: Projected GDP for the Palestinian Economy
2004 to 2030 in million of US$

	2004	2005	2010	2015	2020	2025	2030
High	$ 3,336	$ 3,620	$ 5,556	$ 9,992	$ 13,984	$ 19,152	$ 24,247
Medium	$ 3,336	$ 3,440	$ 4,020	$ 7,324	$ 10,099	$ 14,734	$ 18,721
Low	$ 3,336	$ 3,369	$ 3,542	$ 5,554	$ 7,067	$ 9,382	$ 11,002

Source: Consultant's Estimate

Projected per capita will depend on which of the demographic scenarios materialized over the 25-year study period. Under the medium economic growth and moderate population growth scenario, per capita GDP reaches $3,067 in year 2030. That figure reaches $4,615 under a high economic growth, low population growth scenario. The worst case scenario would be a low economic growth high population growth scenario, which would lead to a GDP per capita of only 1,637 in the year 2030.

Table 2-10: Projected GDP per Capita through 2030 in US $						
	2005	2010	2015	2020	2025	2030
MM	966	1006	1,660	2,073	2,739	3,067
MH	952	972	1,569	1,916	2,476	2,711
ML	981	1,041	1,756	2,242	3,029	3,468
HL	1,032	1,439	2,369	3,105	3,937	4,615
LH	932	856	1190	1,341	1,576	1,637

Source: Consultant's Estimate

It must be emphasized that this analysis does not take into account how changing demographics would affect output. The RAND economic forecast uses a set of assumptions regarding demographic changes for each scenario. Hence, using the high economic growth scenario with a low population growth scenario developed independent of the RAND study is not methodologically appropriate. However, for the purposes of generating order of magnitude estimates for the feasibility study, this approach is reasonable.

Finally, it is noted that the feasibility forecast addresses only GDP and GDP per capita. It does not forecast gross national income (GNI) or gross national income per capita. The RAND study assumes for each scenario a level of Palestinian remittances from work in Israel. In fact, it assumed 130,000 Palestinians working in Israel during 2005, a figure far above the 39,000 workers estimated to be working in Israel or on Israeli settlements during the 3rd Quarter of 2005 (PCBS, 2005). It should also be noted that the Israeli government has indicated that all work permits would expire after 2008. Given the uncertainty of remittances and other external aid this study opted not estimate these potential contributions to future income levels. Consequently, GDP per capita is used as a surrogate for estimating elasticity for transport demand.

2.2 Traffic Forecasts

The purpose for traffic analysis is to determine the demand for and characteristics of the passenger and freight traveling between the West Bank and Gaza Strip given the proposed transport link. The proposed WBG link passes through Israel connecting the north end of the Gaza with the West Bank in the area of Hebron Governorate either as an all road link, all rail or a combination of rail and road.

2.2.1 Traffic Scenarios

The traffic forecasts take into consideration the population and economic forecasts described in the preceding sections and modal or infrastructure alternatives.

Economic Development Scenarios: Travel demand is forecasted for each of the three (3) alternative economic development Scenarios, which are defined as: (A) the Medium Growth Scenario; (B) the High Growth Scenario and (C) the Low Growth Scenario.

Transport Infrastructure Scenarios: Modal choice (road or rail) for the forecasted passenger and freight travel demand will be affected by the alternative transport infrastructure. There are three Transport Infrastructure Scenarios, which are the road only solution, rail only solution or a combination of both road and rail.

2.2.2 Methodology for Forecasting Travel Demand

There is presently very little traffic going between Gaza and the West Bank due to restrictions placed on vehicles crossing Israel. They act to increase costs and make travel uncertain to impossible resulting in very low volumes of passenger traffic traversing the approximately 40 to 50 kilometers of Israeli territory. Likewise, freight traffic is also greatly reduced because the delays are long, and the costs are high. The present traffic cannot provide a basis for analyzing travel demand in terms of population, land use and economic activities. Even if security considerations permitted the conduct of traffic counts, origin and destination and other types of traffic surveys, the information obtained would account for very little of the current unfulfilled travel demand in the WBG corridor. The relationships that would result from these surveys cannot be used to predict future travel demand. Simply stated, the forecasts of passenger and freight demand cannot be based on projections of present traffic or of present travel patterns. The potential demand for travel between the West Bank and the Gaza will be considerably higher than what is presently observed and will involve applying international experience to the forecasts of population, economic and trade characteristics of the West Bank and the Gaza.

The flow chart given in Figure 2-1 is a schematic outline of the methodology utilized in forecasting passenger and freight travel demand in the WBG link. Passenger forecasts are prepared separate from the freight forecasts. Some important elements of the forecast methodology include the following:

Passenger Demand in 2005: Passenger demand was estimated using trip generation based on trip purpose using international coefficients developed for the study. These results are compared an estimate made with a gravity model utilizing international coefficients. A number of the coefficients used in the traffic forecasts will be reviewed, crosschecked, and updated.

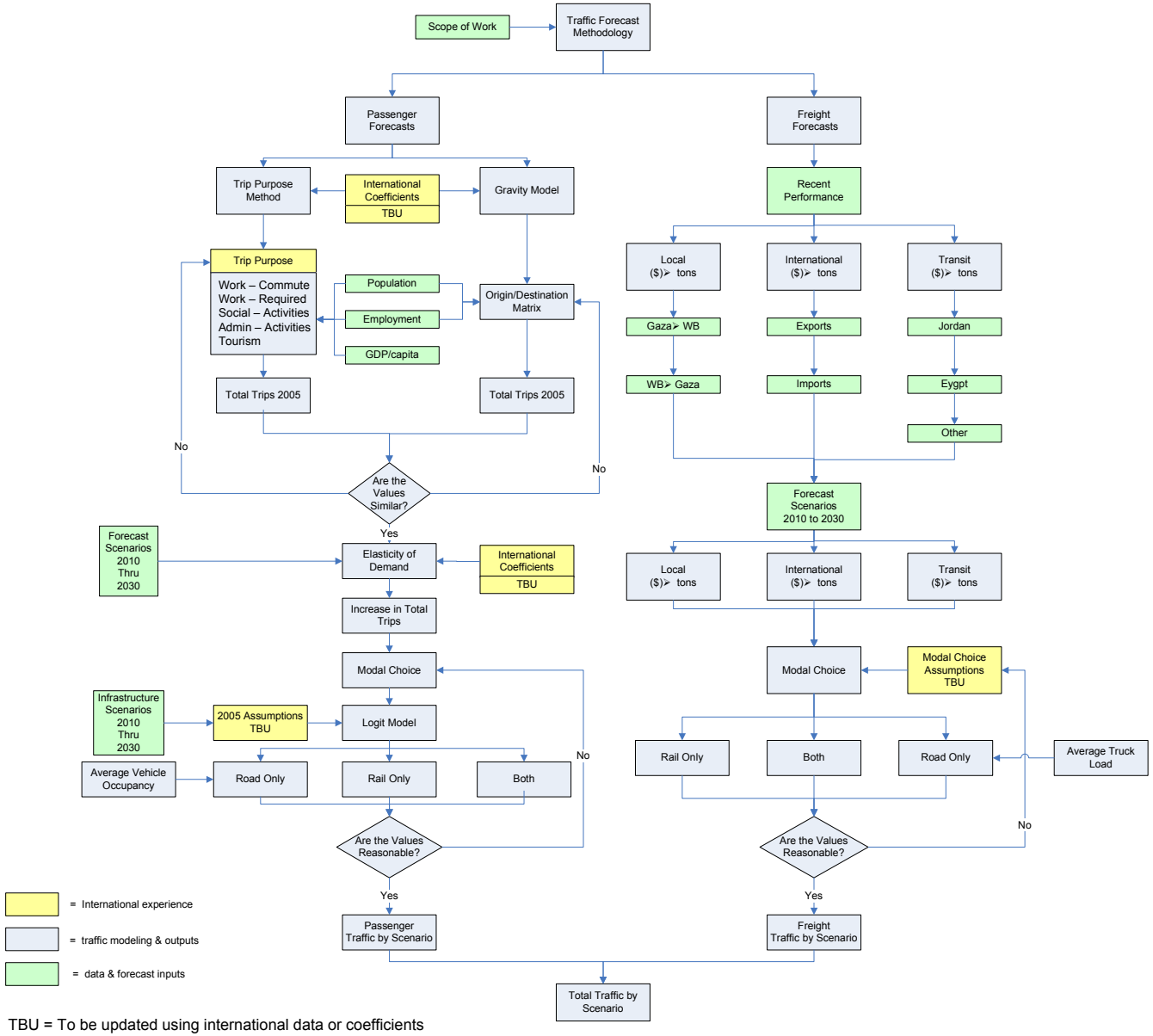
Trip generation is the number of person-trips generated by the population and economic activities in the West Bank and the Gaza.

Passenger Forecasts: Use the forecasts of population and GDP for each of the forecast scenarios between 2010 and 2030. The increase in transport demand are base on income elasticity of demand; again reliance is place on the use of international values for this variable.

Freight Forecasts: These forecasts are based on estimates of flows of goods and commodities: 1) Locally transported goods between the West Bank and Gaza, 2) Imports and exports and 3) Transit goods with neighboring countries.

Modal Choice: Modal choice is the allocation of traffic between road and rail and between vehicle types (for example, cars and buses) in the case of the road scenarios. The distribution is estimated for passenger demand between travel by light passenger vehicle (e.g. car) and public transport (bus). In the case of the combined road and rail scenario, the distribution is among light passenger vehicle, bus and passenger rail usage. For the combined road and rail scenario, the distribution of freight traffic between road truck and rail freight is also considered. The distribution of traffic is done using a Logit Model that estimates the probability of the generated West Bank and Gaza passenger and freight travel demand being destined from origins in the West Bank or Gaza to destinations at the opposite end of the WBG Corridor.

Figure 2-1: Traffic Forecast Methodology – WBG Link



TBU = To be updated using international data or coefficients

Checks: Outputs were check to determine how reasonable the results are for the 2005 estimate of passenger flows and for the general level of traffic.

Employment Forecasts: Population and GDP forecasts are described in section 2.1 of this chapter. In addition, employment forecasts were prepared. Employment is currently estimated to be 20%[7] of total population and by year 2030 is forecasted to be: 23% with Scenario "A", 38% with Scenario "B", and 14% with Scenario "C".

2.2.2 Passenger Travel.

2.2.2.1 Trip Generations

Components of future motorized (by light passenger vehicles or public transport) passenger travel in the West Bank - Gaza Corridor are expected to include the following trip purposes. In developing passenger demand, indications of travel preferences of Palestinians are reviewed. Reference is made to pre-2000 traffic studies. For instance, a month-long traffic survey conducted in the West Bank by ARIJ during 1997 determined that about 60% of intra-district (Governorate) trips were work trips and trips for such purposes as shopping, family visits and recreational excursions accounted for most of the remainder of the trips[8]. Other more recent studies were reviewed for the West Bank[9]. But, this data is probably not as applicable to the present forecasts as the earlier studies because of the deteriorating security situation, the large number of checkpoints and trips that often require taking circuitous routes.

Commuter Related Travel: Commuter travel in which some residents of the Gaza will commute to their work sites in the West Bank and some residents of the West Bank will commute to their work sites in the Gaza. It is estimated that 1% of the employed workers living in the three southern Governorates of the WB will commute to their work sites in the Gaza and 4% of the workers living in the Gaza will commute to their work sites in the WB. Half of the workers will make five (5) daily round-trips every week and the other half will make the trip one time per week, staying near the work site during the days of the work week. In 2005, this is equivalent to 10,750 one-way person-trips per day, or 35% of total person-trips.

Work Related Travel: Some jobs located in the West Bank and the Gaza will require occasional trips between the West Bank and the Gaza. It is estimated that 2.5% of the employed workers in the three (3) southern Governorates of the WB and in the Gaza will make one (1) round trip in the WBG Corridor every two (2) weeks.

In 2005, this is equivalent to 1,663 one-way person-trips per day or 4% of total person-trips.

Social and Other Related Activities: The category of trips includes travel for social, shopping, educational, religious or recreational activities for which some residents of the West Bank will travel to the Gaza and residents of the Gaza will travel to the West Bank. It is estimated that 10% of the residents of the West Bank and 15% of the residents of the Gaza will make ten (10) round trips per year in the WBG Corridor. In 2005, this is equivalent to 22,816 one-way person-trips per day or 56% of total person-trips.

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[7] This estimate is based on a consensus of several sources: (a) *Review of the Humanitarian Situation in the Occupied Palestinian Territory for 2004*, United Nations Office for the Coordination of Humanitarian Affairs (OCHA) occupied Palestinian territory (oPt). (b): PCBS Second Quarter 2004 Report on Palestinian Socio-Economic Conditions, December 2004. "In 2004, every working individual supported 6.4 non-employed persons." (c): PCBS Second Quarter 2004 Report on Palestinian Socio-Economic Conditions, December 2004. Thus, workers accounted for 15.6% of the total persons.

[8] Hanna Maoh and Jad Isaac, *The Status of Transportation in the West Bank*, 1997, Applied Research Institute – Jerusalem (ARIJ), pg 21

[9] Khaled A. Al-Sahili and Abdelmajid H. Sadeq, *Ridership Demand Analysis for Palestinian Intercity Public Transport*, 2003, An-Najah National University. The paper gives percentage distribution of person-trips by trip purpose for intercity public transport (bus) travel between six (6) Governorates in the northern and central districts of the West Bank.

Administrative Travel: Administrative travel by Palestinian Authority and other governmental officials who will need to travel between the West Bank and the Gaza to fulfill their administrative responsibilities. It is estimated that 2% of the employed workers in the WB or in the Gaza will make two (2) roundtrips every month in the WBG Corridor. In 2005, this is equivalent to 1,845 one-way person-trips per day or 5% of total person-trips.

Tourism: Tourism travel between the West Bank and the Gaza. It is estimated that the number of round trips per year in the WBG Corridor for tourism will be equal to one (1) percent of the population residing in the WB and the Gaza making two (2) roundtrips per year. In 2005, this is equivalent to 384 one-way person-trips per day, 1.0% of total person-trips.

Total 2005: The above five (5) trip purposes for personal travel in the WBG Corridor would account for a total of 40.970 one-way person-trips per day .

2.2.2.2 Gravity Model.

A gravity-type model provides an alternative method for predicting one-way person-trips in 2005 within the WBG corridor.

The general form of a gravity-type model can be:

$$T_{ij} = A * \frac{SQRT\,(P_i^{B} * P_j^{C})}{d_{ij}^{D}}$$

where:

P_i and P_j are population of Governorates I and J

d_{ij} is travel distance, time or cost for travel from Governorate I to J

A, B, C and D are calibration coefficients with A = 1.0, B =1.0, C = 1.0 and D = 1.35

The 2005 population for the Governorates in the West Bank and the Gaza for the values of P_i, and P_j are used, and the road network travel distance separation between centers of the Governorates for the values d_{ij}, were estimated. The total passenger-trips by motorized vehicles are estimated to be 700,000 total trips in the West Bank and Gaza with average trip length of 15 km; 380,232 of the trips were intra-Governorate and 319,768 were inter-Governorate; and with 21,444 of the trips along the WBG Corridor between the West Bank and the Gaza.

This value is relatively close to the one determining using the trip generating methodology based on trip purpose.

2.2.3 Passenger Traffic Forecasts

Forecast of Total Demand: Estimates of total demand for each forecast scenario were based on income elasticity of demand. With increasing GDP per capita, it is expected that trip rates per person for commuter travel and for social, shopping, educational, religious or recreational purposes will increase; a one (1) percent increase in GDP per capita will result in a 0.1% increase in commuter trips per employed person and a 1.0% increase in the trips per person for social, shopping, educational, religious or recreational activities.

Modal Choice: Travel demand, both passenger travel and freight transport, can be affected by the transport services to be provided in the WBG Corridor. With the road only solution, some of the passenger travel demand will use light passenger vehicles (e.g. private cars) and the remainder will travel by public transport vehicles (buses). With the combined road and rail solution, passenger travel will have the choice of traveling by light passenger vehicle, by bus or by rail passenger service; freight can be shipped by either highway truck or by rail.

Passenger motor vehicles using the West Bank – Gaza Corridor will include both light passenger vehicles and buses. It is estimated that initially the mode choice of passengers travelling in the Corridor will be 20% in light passenger vehicles for (a) the commuters to work sites, (b) the person-trips made for social,

shopping, educational, religious or recreational purposes, and (c) the tourist travel; and all (100%) of the work-required and administrative travel will be made by light passenger vehicles. With the increased GDP per capita forecasted for Scenarios "A" and "B", there will be an increase in the percentage of trips made by light passenger vehicles for commuter, social, shopping, educational, religious, recreational and tourist trip purposes.

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The logit model provides a method for predicting the probability of person-trips using the available alternative modes of travel (light passenger vehicle, bus and a potential future rail alternative) for travel between each combination of Governorate origins and destinations and also the probability of freight shipments using road truck or rail.

Logit models, either multinomial logit (MNL) or nested logit (NL) are the most common model type for discrete choice models. Under the theory of utility maximization, a decision-maker will generally choose the alternative that maximizes his utility. However, one cannot simply calculate the utilities for each alternative and for each decision-maker, and then determine which one is the maximum. One must transform the utility values into probability values. Each utility function is assumed to have a random error term and the distribution of this random error term determines the functional form of the logit equation. In this case, the logit equation is derived from the fact that the error term is logistically distributed. The logit equation gives the probability P that a decision-maker i will choose alternative j, given a utility U for each alternative (where n is the set of available alternatives). It is basically a way to transform utility values into probabilities. The utility is generally expressed as a linear function.

The general form of a logit model is:

$$P_{ijm} = \frac{e^{U_{ijm}}}{\text{Sum } e^{U_{ijm}}}$$

where:

P_{ijm} is the probability of trips from I to J using mode M

U_{ijm} is is the utility of mode M for travel from I to J

U_{ijm} is A + B * travel time + C * travel cost

where

A is a dummy variable

B and C are coefficients

Vehicle Occupancy: For the light passenger vehicles, the average vehicle occupancy is estimated to be 2.6 passengers per vehicle and for buses 20 passengers per bus.

2.2.3 Freight Transport.

2.2.3.1 2005 Estimates

The components of future freight transport through the WBG Corridor include the following: 1) Local traffic, 2) Foreign trade traffic and 3) Transit traffic.

Local Traffic: Local traffic consists of: 1) commodities produced and goods with origins on the West Bank and transported to and consumed in the Gaza Strip and 2) commodities produced and goods with origins in the Gaza Strip and transported to and consumed on the West Bank. For a base year of 2005, this is estimated to generate about 300,000 tons of freight per year in each direction.

Foreign Trade: Foreign trade shipments consist of: 1) exports and 2) imports.

Exports from the southern portion of the West Bank and exported by way of the proposed new international seaport at Gaza or exported through Egypt are estimated as follows:

- Bethlehem Governorate exports (year 2003) excluding exports to Israel, Jordan, Lebanon, Syria and Iraq had a total value of U$S 2,206,000. With an average value of U$S 1.20 per kg, this would be about 1,800 tons per year.
- Hebron Governorate exports (year 2003) excluding exports to Israel, Jordan, Lebanon, Syria and Iraq had a total value of U$S 762,000. With an average value of U$S 1.20 per kg, this would be 635 tons per year.
- Jerusalem Governorate exports (year 2003) excluding exports to Israel, Jordan, Lebanon, Syria and Iraq had a total value of U$S 204,000. With an average value of U$S 1.20 per kg, this would be 170 tons per year.

Exports from the remaining central and northern Governorates of the West Bank and exported by way of the proposed new international seaport at Gaza or exported through Egypt are estimated as follows:

- These exports (year 2003) from the central and northern Governorates and excluding exports to Israel, Jordan, Lebanon, Syria and Iraq had a total value of U$S 4,649. With an average value of U$S 1.20 per kg, this would be about 3,900 tons per year. It is estimated that 2,700 (about 70%) of this total tons per year would be exported by way of the proposed new international seaport at Gaza or through Egypt.

During year 2003, the total value of exports from the Gaza to Jordan was valued at U$S 1,343,979; at an average value of U$S 1.20 per kg, this would have been about 1,120 tons per year.

Imports to the southern portion of the West Bank and imported by way of the proposed new international seaport at Gaza are estimated as follows:

- Bethlehem Governorate imports (year 2003) excluding imports from Israel, Jordan, Lebanon, Syria and Iraq had a total value of U$S 12,318,000. However, the value of imports to Bethlehem has varied greatly during the years from 1996 to 2003, averaging a value of U$S 53 million per year. With an average value of U$S 1.20 per kg, U$S 53,000 per year would account for about 45,000 tons per year.
- Hebron Governorate imports (year 2003) excluding imports from Israel, Jordan, Lebanon, Syria and Iraq had a total value of U$S 72,186,000 and averaging about U$S 85 million per year during the years from 1996 to 2003. With an average value of U$S 1.20 per kg, U$S 85 million per year would account for about 71,000 tons per year.
- Jerusalem Governorate imports (year 2003) excluding imports from Israel, Jordan, Lebanon, Syria and Iraq had a total value of U$S 3,933,000 and averaging about U$S 6.5 million per year during the years from 1996 to 2003. With an average value of U$S 1.20 per kg, U$S 6.5 million per year would account for about 5,500 tons per year.

Imports to the remaining central and northern Governorates of the West Bank and imported by way of the proposed new international seaport at Gaza or through Egypt are estimated as follows:

- These imports (year 2003) to the central and northern Governorates and excluding imports from Israel, Jordan, Lebanon, Syria and Iraq had a total value of U$S 277 million. With an average value of U$S 1.20 per kg, this would be about 273,000 tons per year. It is estimated that about 200,000 (about 75%) of this total tons per year would be imported by way of the proposed new international seaport at Gaza or through Egypt.

Imports from Jordan to the Gaza for 2003 had the total value of U$S 5,978,430. At an average value of U$S 1.20 per kg, this would have been about 5,000 tons per year.

Transit Trade: Transit goods transported from Egypt to Jordan or visa versa via the West Bank and Gaza are estimated for the base year, 2005, at 300,000 tons per year from Egypt to Jordan and 30,000 tons per year from Jordan to Egypt.

Truck Characteristics. It is expected that the trucks transporting commodities in the West Bank – Gaza Corridor will have average loads of eight (8) tons per truck with 60% of the trucks having loads and the other 40% of the truck traffic not having back-hauls[10].

Present Traffic Levels: Before the Israeli withdrawal from Gaza Strip, the number and amount of freight movement was limited (40-50 trucks/day). According to the agreement with the Israelis, the daily number of vehicles will reach 150 trucks/day. This number will reach up to 400 trucks/day by the end of 2006[11]. These values compare with the estimated year 2005 truck traffic demand of 350 trucks per day in each direction of travel along the West Bank – Gaza Corridor based on the values of imports and exports and other freight transport mentioned above.

2.2.3.2 Forecast of Freight Traffic

For each of the alternative Economic Development Scenarios, the forecasted future freight traffic demand in the West Bank – Gaza Corridor is related to the forecasted annual rate of future increases in the Gross Domestic Product (GDP) for the West Bank and the Gaza: with a one (1) percent increase in GDP producing a one (1) percent increase in tons of freight transported in the Corridor.

2.2.4 Variation of Traffic by Infrastructure Scenario

The estimated traffic for each of the three scenarios is summarized on the following page in Table 2-11.

[10] Based on UN shipments, the average truckload is 12 tons and that of container is 12.8 tons. Transit Trade and Maritime Transport Facilitation for the Rehabilitation and Development of the Palestinian Economy, United Nations Conference on Trade and Development (UNCTAD), 2004

[11] Palestinian Ministry of National Economy; November 30, 2005)

Scenario "A" - Medium Growth					Scenario "B" - High Growth					Scenario "C" - Low Growth				
WBG Corridor - Road Only Solution (Road Traffic, AADT, vehicles per day)					**WBG Corridor - Road Only Solution** (Road Traffic, AADT, vehicles per day)					**WBG Corridor - Road Only Solution** (Road Traffic, AADT, vehicles per day)				
year	light pass veh	bus	truck	Total Vehicles	year	light pass veh	bus	truck	Total Vehicles	year	light pass veh	bus	truck	Total Vehicles
2015	7,706	2,796	762	11,263	2015	12,107	3,544	989	16,640	2015	4,914	2,180	589	7,683
2020	11,629	3,656	1,047	16,331	2020	19,767	4,912	1,381	26,059	2020	6,141	2,541	746	9,429
2025	18,497	5,007	1,522	25,025	2025	31,662	6,614	1,885	40,162	2025	7,941	3,060	986	11,987
2030	25,708	5,946	1,875	33,529	2030	47,225	8,190	2,380	57,795	2030	9,350	3,353	1,152	13,855

WBG Corridor - Rail Only Solution (Rail Passengers and Tons per day)			**WBG Corridor - Rail Only Solution** (Rail Passengers and Tons per day)			**WBG Corridor - Rail Only Solution** (Rail Passengers and Tons per day)		
year	passengers	freight, tons	year	passengers	freight, tons	year	passengers	freight, tons
2015	34,178	1,949	2015	46,059	2,537	2015	25,371	1,505
2020	46,508	2,662	2020	67,333	3,524	2020	30,054	1,892
2025	66,703	3,847	2025	96,570	4,790	2025	36,834	2,482
2030	83,592	4,710	2030	128,966	6,019	2030	41,113	2,875

WBG Corridor - (Road + Rail) Solution (Road Traffic, AADT, vehicles per day)					**WBG Corridor - (Road + Rail) Solution** (Road Traffic, AADT, vehicles per day)					**WBG Corridor - (Road + Rail) Solution** (Road Traffic, AADT, vehicles per day)				
year	light pass veh	bus	truck	Total Vehicles	year	light pass veh	bus	truck	Total Vehicles	year	light pass veh	bus	truck	Total Vehicles
2015	6,742	839	419	8,000	2015	10,594	1,063	544	12,201	2015	4,300	654	324	5,278
2020	10,175	1,097	576	11,848	2020	17,296	1,474	759	19,529	2020	5,374	762	411	6,546
2025	16,185	1,502	837	18,524	2025	27,705	1,984	1,037	30,726	2025	6,948	918	543	8,409
2030	22,494	1,784	1,031	25,309	2030	41,322	2,457	1,309	45,088	2030	8,182	1,006	633	9,821

WBG Corridor - (Road + Rail) Solution (Rail Passengers and Tons per day)			**WBG Corridor - (Road + Rail) Solution** (Rail Passengers and Tons per day)			**WBG Corridor - (Road + Rail) Solution** (Rail Passengers and Tons per day)		
year	passengers	freight, tons	year	passengers	freight, tons	year	passengers	freight, tons
2015	30,380	1,657	2015	40,941	2,156	2015	22,552	1,279
2020	41,341	2,263	2020	59,851	2,995	2020	26,714	1,608
2025	59,291	3,270	2025	85,840	4,072	2025	32,741	2,109
2030	74,304	4,004	2030	114,636	5,116	2030	36,545	2,444

References Chapter 2

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CHAPTER 3- PRELIMINARY SELECTION OF ALTERNATIVE ROUTE ALIGNMENTS

This chapter presents the technical findings of Berger's initial screening analysis of alternative route alignments for the proposed West Bank-Gaza Transportation link. The screening analysis was conducted based primarily on desk study reviews of existing information, including topographic, geologic, land use, and environmental data as well as previous alignment studies. Field visits were also made to the area to verify selected data and clarify various technical issues. The screening analysis results will be used to focus the final phase of feasibility analysis on those alignments that would likely be the most cost effective in serving the objectives of the proposed project. The following subsections describe the methodology used for conducting the screening analysis and present the results of that analysis.

3.1 General Considerations

Route selection is influenced by a multitude of factors, including, but not limited to terrain, hydrologic considerations, land use, and population concentrations and distributions. The shortest road alignment does not necessarily yield the most economical alternative. Often, topography, flood hazard, erosion potential, and slope stability can be significant factors in identifying the most cost effective alignment and design of cross-section. Variations in geology and slope, for example, greatly influence road design and cost of construction, and these changes can occur over very short lengths of alignment. Other factors are also important in constructing roads or railways in an environmentally sound way. Alignment geometry, earthworks, retaining structures and drainage measures must be designed to minimize the impact on the surrounding lands, land use and natural drainage systems. Although many adverse effects are often unavoidable, the design and the construction methods adopted should aim to minimize them.

The overview of the method utilized to select and evaluate the alternative alignments based on technical engineering factors is shown in Figure 3-1.

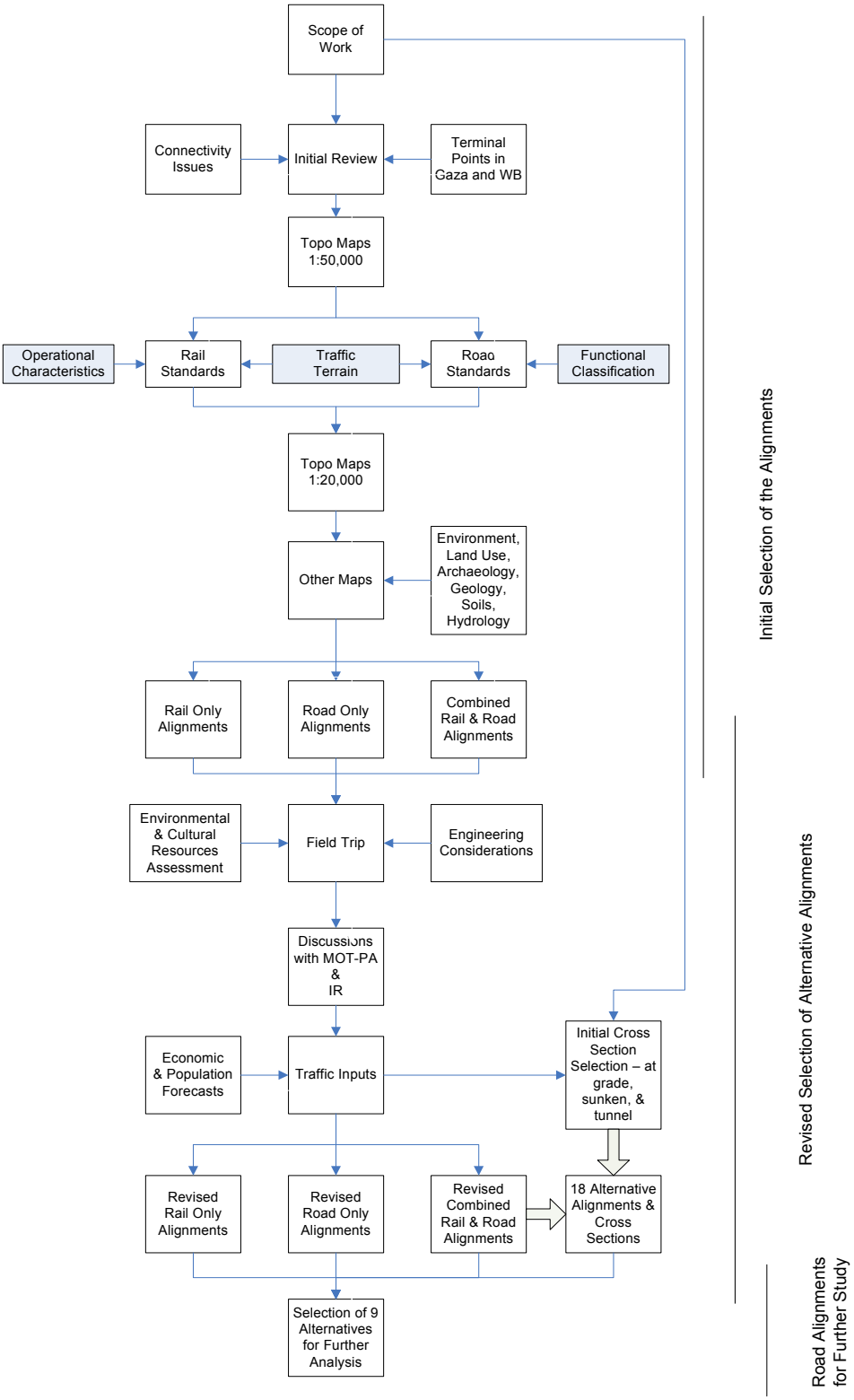
Selection of the route corridors must be preceded by first defining the controlling requirements of each alignment. Specifically, for each route or alignment, the following issues must be addressed:

1) What are the constraints in regard to the beginning and ending points of each alignment?

The scope of work for this project identifies the terminals as being the two geographic areas of the West Bank and Gaza Strip (Gaza), and the scope further emphases the examination of alignments which minimize the distance between the crossings. Hence this would limit the study to some terminal points within a few kilometers of the boundary of both the West Bank and Gaza. The terminal points therefore do not necessarily tie to existing junctions in a Palestinian village or town: in fact, there is a desire, given the anticipated traffic volumes, to avoid villages and towns en route to the larger, ultimate destinations, for instance, the proposed Seaport in Gaza, and a West Bank city such as Hebron. The railway only or a combined rail/road route would suggest a termination at a location where a trans-shipment area is a possibility, or the identification of a further corridor deeper into Palestinian territory. Avoiding built-up areas in Gaza, and the urban area of Sderot, limits the possibilities to two Gaza entry points; one along an alignment north of Sderot and one south of this town.

Terrain considerations at the approach and in the West Bank, the need to connect to an existing transportation network, the need to provide access to major Palestinian production and population centers, and the need to avoid opening an entirely new corridor in the border vicinity,

Figure 3-1: Flow Chart of the Work Accomplished through the End of December 2005



limit the road and rail possibilities here to two locations. Regional connectivity is also a consideration in the location of the terminus of the transport link.

2) What types of facilities must the route include or avoid?

In Israeli territory, the route must avoid crossing urban and heavily trafficked areas, so as to minimize delays and security concerns. It should avoid productive agricultural areas, forested areas, national parks, streams and gullies. Security concerns are paramount. Even so, to the extent possible, Israeli policy requires that the alignment of new transport projects follow existing transport corridors in preference to opening new corridors. To the extent possible, the alignments should follow existing transport corridors and comprise a parallel facility to these corridors. Within these constraints, the route should limit the length of the interconnection within Israel.

3) If major wadis (rivers) are to be crossed, what are the possible crossing locations, given constraints of topography and geology? What are the economics of the alternative bridge sites with the corresponding road and/or rail geometrics?

While wadi bridges are few, there are underpass/overpass requirements for major routes, rail routes, water ducts, and power transmission lines. The route must cross the underground Kinneret Negev Conduit.

4) What are the desired design speed and design standards? How does this standard fit the terrain in terms of geometric parameters such as gradients, and horizontal and vertical curves?

The highest possible design speed and design standards are utilized. The road only alternative would hence involve a design speed of 120 km/hr, with a possible reduction to 100 km/hr if necessary while traversing more problematic terrain. This equates to alignments with a minimum horizontal radius of 750 meters (450m for 100 km/hr), and a maximum gradient of 3 percent.

For the rail only alternative, or for a combined road/rail facility, rail design standards will prevail. These call for a design speed of either 160 km/hr, reflective of the present maximum operating speed of Israel Railways, or more favorably 200 km/hr, with a minimum desirable horizontal radius of 2000 meters, and a maximum gradient of 1.3 percent.

The initial desk study comprised in part a review of published and unpublished information concerning the physical, economic and environmental characteristics of a study area. For studying and selecting suitable alignment corridors, a detailed analysis was based on the following references, maps, and aerial photography.

Table 3-1: Basic Mapping and Reference Material Utilized

Reference:	Formal Source	Availability
- A Carta Map Israel (and Autonomous Areas) Scale 1:270,000	Carta Jerusalem	Yes
- West Bank Closures scale 1:150,000	UN OCHA August 2005	Yes
- Gaza Closures scale 1:150,000	UN OCHA August 2005	Yes
- Topographic Maps scale 1:50,000	Geological Survey of Israel	Yes
- Topographic Maps scale 1:20,000	Geological Survey of Israel	Yes
- Aerial photographs, approximate scale 1:50,000	Geological Survey of Israel	Yes
- Outcrop and Subgroup Geological Maps of The Coastal Plain and Hashephela Regions: Map 1 Outcrops 1:100,000	Geological Survey of Israel, 1967	Yes
- Outcrop and Subgroup Geological Maps of the Coastal Plain and Hashephela Regions: Map 2 Subgroups of the Base of "Kurkar" Group1:100,000	Geological Survey of Israel, 1967	Yes
- Hydrological map of Israel, scale 1:2,000,000		Yes
- Land Use and Land Cover Map, scale 1:1,000,000		Yes
- Wildlife Corridor Map		No

The above data sources were determined sufficient to analyze various alternatives; consequently neither SPOT satellite imagery nor Land System Maps were deemed necessary to complete the study.

In addition, a review of several previous alignment studies provided useful background material. However, none of the previous studies were carried out to a level of detail sufficient to integrate or build upon for use in the present feasibility study.

3.2 Preliminary Identification of Potential Corridors: Common Road/Rail End Points and Connectively Issues

Using the 1:20,000 scale maps and the constraints listed in Section 3.1, several alternative alignments could be identified. With relatively flat terrain traversed along the Israeli portion of all possible routes, the initial constraints are the beginning and ending points of the route in Palestinian Territory.

3.2.1 Gaza Terminus

The alignments initially studied terminate at indistinct locations in Gaza among houses and streets. Because the old south-north coastal railway shown on the maps was dismantled in the 1950s, while sections of it have been reportedly built over, a new corridor through heavily populated areas of Gaza will be extremely difficult to establish. Accordingly, alternative approaches to Gaza and the continuation of the alignment past Gaza City to the proposed seaport region will need to be evaluated. The exact terminus of the transportation link will have to be determined to resolve these issues. The transportation link should incorporate a terminal located at a suitable site on Palestinian territory, and with consideration of future access to the planned deep-water port and the possibility of a direct connection south along the western borders with Israel to the airport-as shown in Figure 3-2.

Figure 3-3, provided by the UN, shows possible connections within Gaza to an area in the north where settlements have been evacuated, and a possible corridor south of Gaza City proceeding along the border and hence westward towards the coast at the proposed seaport. Note that each terminus studied could also readily be connected to the north to south Salah Al Deen Road in Gaza, and to the Coastal Road which has been proposed for upgrading in a recent report by IMG for the European Commission 12.

Hence, for the Gaza Strip, the terminal point logically is either a point near the north-eastern extremity of the Gaza Strip (point A on Figure 3-3), which would minimize the route length; or a point which would provide the closest congestion-free connection to the major traffic generators: i.e., Gaza City, the Gaza Airport and/or the planned Seaport (point B on Figure 3-3). These form two possible locations: other locations are possible within these two extremities.

Several alternatives also could provide for the possibility of a continuation of the corridor in Gaza to the Ezer Industrial Zone as an option.

3.2.2. West Bank Terminus

For the West Bank, the constraints are topography. Figure 3-4, based on UN data, shows possible connections to Tarkumiya and Meitar.

To provide the best vertical alignment through the shortest distance, a connection terminating near Tarkumiya is possible (point C on Figure 3-3). A relatively flat area exists west of Tarkumyia, which could be utilized for a container terminal. The alignment alternatives allowing direct access to Hebron end in the vicinity of this town. This is also a likely terminus of the rail alternative; the terrain steeply rises towards Hebron from this point and will require capital-intensive railway engineering structures to continue in the area of the Judean Mountains. For this reason, future extension of the line and its direction is closely related to future transportation demand.

[12] Situation Paper for the Development of the Coastal Road, Provisional, IMG, July 30, 2005.

In fact, due largely to terrain constraints, there are no other realistic possibilities along the entire border of the West Bank heading south from Tarkumiya until a possibility is reached much further to the south near Meitar (point D on Figure 3-3). Even if there were feasible alternatives between these points, they would represent an unsatisfactory compromise between the options at Tarkumiya and Meitar: a longer distance than point C and a connection further south of the congestion generated by Hebron, without the alternative of a road/rail combination.

Even then, there are trade-offs between these alternatives. For the first alternative, the route terminates closest to the population centers in the West Bank, and the connecting route bypasses to the north of the traffic congestion in Hebron. However, in proceeding further east from Tarkumiya towards Hebron and hence to all other population centers in the West Bank, the existing route (#35) ascends from 385 meters at a junction west of Tarkumiya to approximately 1000 meters at the junction with Route 60 north of Hebron, over a distance of approximately 13 kilometers (an average 4.7% gradient). While this ascent is acceptable for a road route through difficult terrain, it would not allow for easy rail access, and may dictate that any rail connection would terminate at Tarkumiya for transshipment by truck. It should be noted that although such a route would not preclude a rail connection from Tarkumiya to Bethlehem and further north; it would and involve major earthworks and bridge construction while traversing difficult terrain.

For the second alternative (via Meitar), the route terminates at the southern extremity of the West Bank, far from the population centers in the West Bank. However, in proceeding north from Meitar towards Hebron and to all other population centers in the West Bank, the existing route (Number 60), or a second, more western possibility ascends from approximately 400 meters at a junction near Meitar to about 1000 meters at the junction with Route 60 north of Hebron, over a distance of approx. 30 kilometers, (an average 2.0% gradient). A feasible rail route may result in a longer alignment. An advantage of this alternative is that it would allow for a future north/south West Bank rail connection, although it would increase the overall road connection length from NE Gaza to Hebron from about 53 kms to approximately 75 kms.

3.2.3 Design Standards

Design standards for road and rail modes were developed for the study. A discussion of the road and rail design standards is presented in Annex 3-1 and Annex 3-2, respectively. The road design standards used for this feasibility study are based on Israeli standards and international "best practice". Israeli standards were used instead of the AASHTO (American Association of State Highway and Transportation Officials) because they are generally more stringent but impose few additional costs. The railway design standards are similarly based on Israeli standards, but also take into account European and UIC13 standards.

3.3 Alignment Studies: Eastern Extremity Common Road/Rail Nodes

Starting from the two alternative West Bank terminal points, it is geometry that determines alignment paths for some distance. From terminal Point C, there are benefits from following the alignment of the Route 35 in a westerly descent to a location north of Lahish. This alignment, by sharing the valley with Route 35 but remaining parallel and to the south of Route 35, attains an adequate horizontal geometry and a gradient which meets the maximum requirement for a road/rail combined route (1.3 percent). This sets a further intermediate end point based on geometric constraints at approximate point E on Figure 3-5 (see also the drawings in Volume 2 for the further detail). From this point, Route 35 continues on an alignment to the northwest rather than to the west, traverses a forested area, and proceeds through the village of Kiryat Gat, all making a further common alignment here an unviable option.

For the southern West Bank terminus, considerable effort was spent to identify an alignment which would meet the rail criterion of a maximum gradient of 1.3 percent. From Meitar at point D, it is possible to select a rail route which, to avoid the Lahav Hills, would need to proceed in a southwest direction and result in a very lengthy alignment. Another possibility considered was a route parallel to

[13] Union Internationale de Chemin de fer.

proposed Route 9 northwest to Beit Kama; however, the gradient of this alignment proved to be too steep. Similarly, the alignment of Route 325 past Dvira to Beit Kama was also too steep.

The only feasible rail/combination would be to proceed from Meitar along the boundary through the Givat Lahad Hill, and through a tunnel section of approximate length of 700 meters, continuing along the boundary to a point a few kilometers north of Route 325. The route would then traverse the foothills to a Point F near the crossing of proposed Route 9, Route 40, and the Tel Aviv- Beer Sheva Railroad. This route establishes a further intermediate end point based on geometric constraints at approximate point F on Figure 3-5.

Figure 3-2: General Location Map – Showing Potential Connectors

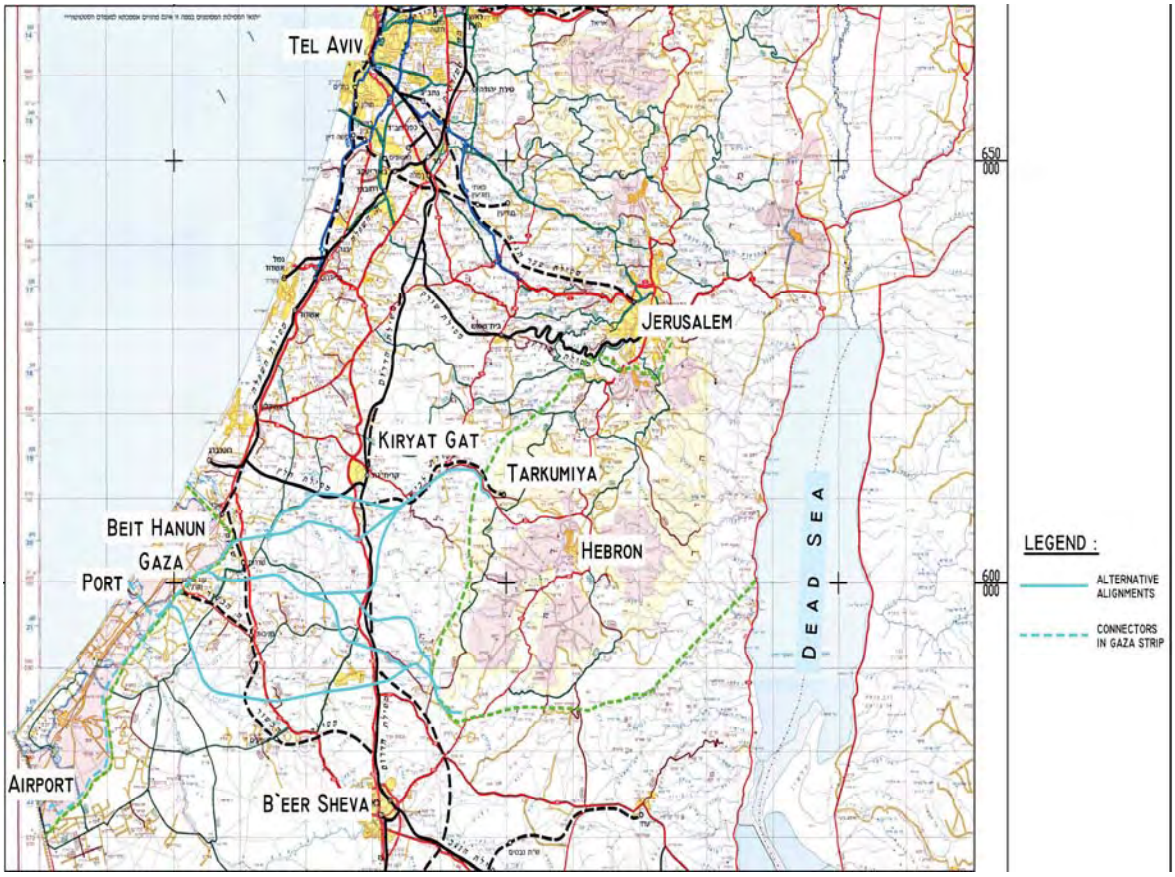
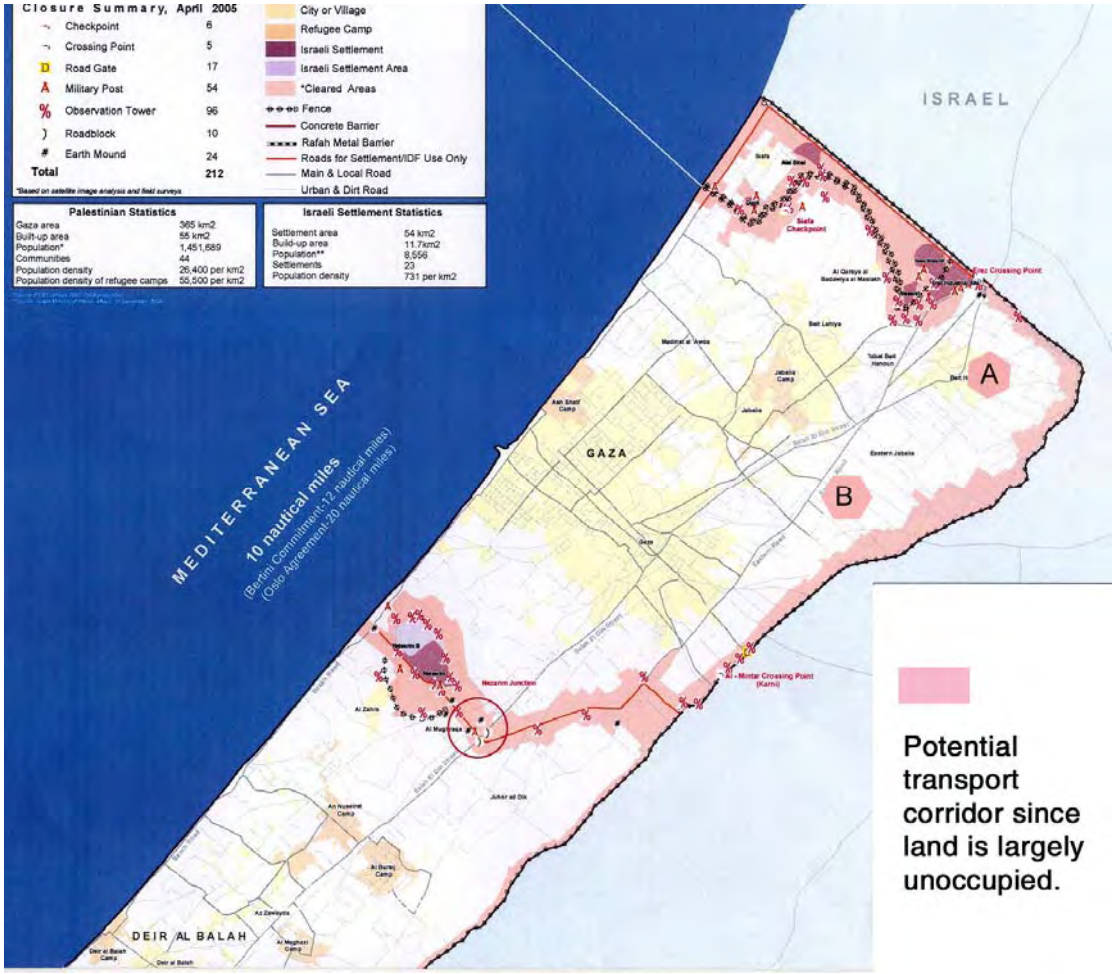
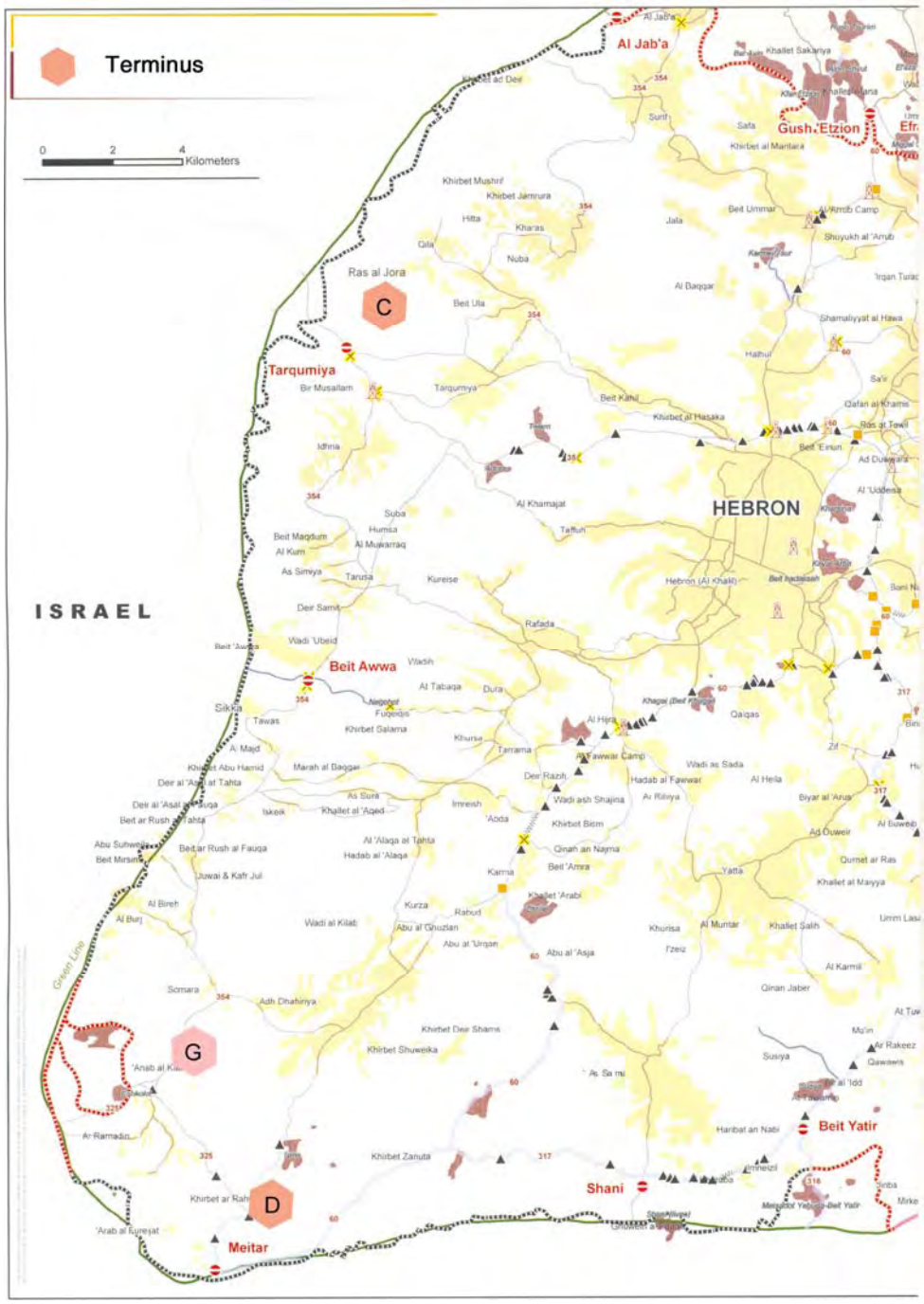


Figure 3-3: Gaza Strip Entry Points, and Potential Transport Corridor to Ezer and Seaport



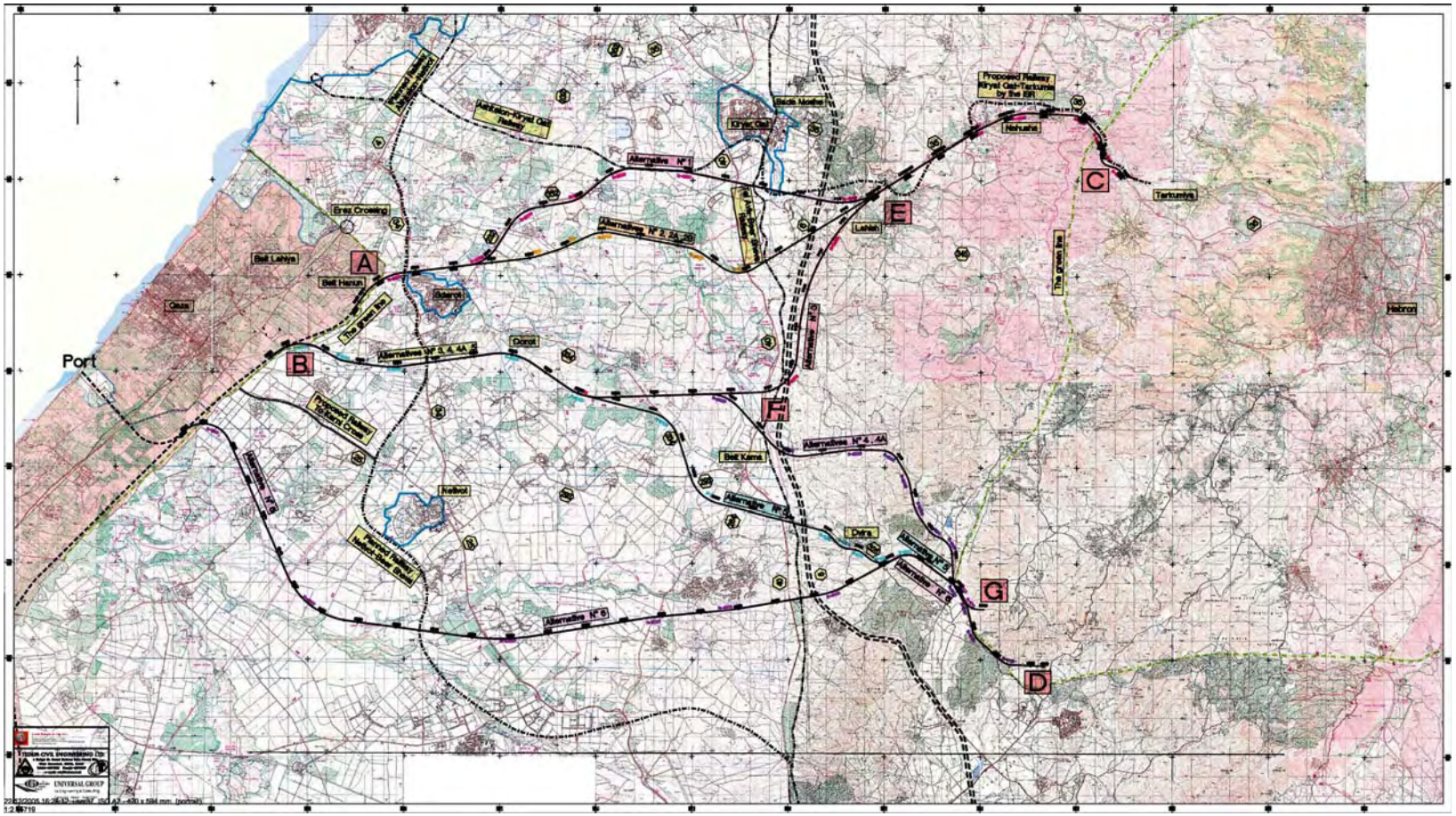
Source: Gaza Closures, April 2005, UN Office for the Coordination of Humanitarian Affairs

Figure 3-4: West Bank Entry Points



Source: Gaza Closures, August 2005, UN Office for the Coordination of Humanitarian A

Figure 3-5: Alternative Alignments



Although the C and D end points at Tarkumiya and north of the town of Meitar, respectively, are 25 kms distance from each other along a north south axis, the possible road/rail corridors at end points E and F are but 13 kms distant from each other along the same axis, effectively "squeezing" the width of the band of road/rail alternatives between A/B in Gaza and C/D in the West Bank.

3.4 Alignment Studies: Road/Rail and Road Only Point A/B to Point E/F Links

While a critical element in the selection of the route corridor A/B and E/F nodes, geometry plays at best a secondary role in the multitude of alignment possibilities connecting terminal points A or B with node points E or F. The primary constraints instead are avoidance of communities, agricultural and forest lands, and problem soils, while attempting to reduce distance and to utilize existing corridors where possible. Alternatively, for the last of these constraints, a sunken alignment would need to avoid existing established route alignments and take a route considering distance and drainage constraints.

Reviews were conducted of previously identified and newly proposed alignments that would minimize the distance traversed between Gaza and West Bank, or which would offer other advantages. The initial examination was made using the topological data and mapping. This was used to determine general alignments taking into account the limitation on grade, further assuming that the right-of-way would where possible be conducive to both road and rail traffic, and allowing for an accommodation of both freight and passenger railroad operations. The studies also considered the objectives of avoiding urban areas, intensive agricultural regions, and forest areas. This was accomplished by superimposing layers of data showing such features over base maps and selecting those routes demonstrating the least disruptions in terms of these features. The study team then conducted a visual inspection of the routes to identify any difficulties with existing land use or ground conditions.

The study team subsequently developed conceptual designs and determined the spatial requirements for the transportation and utility transmission systems to be located in the right-of-way. The locations allow for easy access for maintenance and expansion, and limit risks of disruption of services or accidents involving transport and utilities.

To ensure secure operations in the corridor for non-sunken alignments, a security barrier of sufficient height was included to separate the right-of-way from its surroundings in Israel.

The study team also determined the cost and time implications for developing an alternative alignment below grade for the entire route or alternatively for that route portion that is projected to have significant population and economic activity.

The purpose of this reconnaissance stage of the route selection process was to identify alternative routes in terms of the "corridors" within which they lie. Within these corridors, several alternative alignments were developed. Six alignments, either new alignments or refinements to alignments from earlier studies, were investigated on the basis of 1:20,000 scale mapping, and are shown on Figure 3-5 (see also the drawings in Volume 2).

Although it might first appear that a road only, or a road and passenger rail route, would allow for steeper maximum gradient and hence open up further possibilities for alignments, this in fact, turns out not to be the case. The Tarkumiya and Meitar alternatives options, at 1.3% and 1.5% gradients, respectively, yield these gradients based more on topography than geometric requirements. Options between these two extremes for end points would give higher gradients but would result in an unnecessarily longer route to West Bank destinations, would traverse and open up new corridors, and/or would involve conflict with environmentally sensitive areas.

Possible routes were examined using maps and aerial photos. Following this, visits were made to the sites to check interpretations, and findings were summarized to assist in planning and the next phase of the analysis.
Aerial photos and topographical maps were used to interpret boundaries between terrain types, and to determine where changes in topography, geology, development, drainage pattern or vegetation (land use) occur. A change in any of these gives rise to different engineering conditions, which could affect the design of the road. The following factors were considered:

- Course of rivers and wadis
- Number, type and characteristics of water courses
- Drainage areas of major catchments
- Extent of flooding of low-lying areas, if any
- Extent of erosion
- Location and extent of problem soils
- Forestation and Agriculture
- Urban areas and Human settlements affected by the road
- Assessment of land acquisition/site clearance problems
- Location of all possible bridge sites
- Possible sources of water for construction
- Possible sources of construction materials
- Topographic, geologic, and physical characteristics.
- Potential risk of slides, slope instability or floods; and
- Environmental impact of the selected route.

The initial alignments studied, generally from north to south, were as follows (refer to Figure 3-5):

Alignment 1: This rail only, road only or combined multi-modal alignment uses a corridor mostly defined by existing roads, and a short section of an existing freight railway. Exiting the Gaza Strip at its northeastern extremity, it avoids the community of Sderot by swinging in a large radius arc from an initial northeastern heading, to an easterly heading to intersect with Highway 232 near its junction with Highway 352. It parallels Highway 352 to the south of the above-mentioned railway, paralleling this also to the south for approx. 3.5 kms. From here, to avoid the built-up area of Kiryat Gat, an agricultural region to the east of Kiryat Gat, and an unnecessarily curvilinear alignment, the route heads easterly to connect north of Lahish with Highway 35. It parallels this route to the south all the way to Tarkumiya. The mountain pass used by Highway 35 appears to offers also a suitable railway approach to Tarkumyia near Hebron without a tunnel, and under 1.3 per cent gradient.

Alignment 2: This alignment roughly follows a previously studied alignment chosen as a sunken road only alternative. It proceeds on the same course as Alignment 1 to the curve to the east, crossing Highway 232 and hence continuing easterly just to the north of the riverbed of Hashikma that carries water in winter time. This alignment avoids the separation of nearby communities from their fields, and could allow for gravity drainage of the sunken configuration into the Shikma Stream. Heading further east, it crosses over and parallels the Shikma Stream to the south, with similar advantages. It crosses Highway 40 and the Tel Aviv-Beer Sheva Railway Line, avoiding several smaller communities south of Kiryat Gat to join the Alignment 1 alignment at Highway 35 north of Lahish, and hence to Tarkumiya. In contrast with Alignment 1, this alignment avoids any existing road or rail alignments.

Alignment 2a: While initially conceived as a sunken alignment, it is possible to follow the same course as Alignment 2 at grade, and it is also possible to use a rail road, road only, or combined multi-modal alternative along this alignment.

Alignment 2b: This alignment responds to a request to evaluate a road only or rail only tunnel option (Most likely a cut and cover tunnel). A requirement for such an option would be to minimize the length of the crossing, placing it in the vicinity of Alignments 1 and 2 above. While the resultant length of a tunnel only alignment would be excessive, there could be scope for tunnel sections in the hilly region just outside of the Gaza border and north of Sderot, for 2-3 kms, and in the vicinity of the road and rail crossings south of Kiryat Gat, a distance of approx. 3 kms, leaving approx 33 kms of sunken or at grade alignment.

Alignment 3: This rail only, road only or combined multi-modal alignment originated as an effort to follow Highway (Hw) 334 to Beit Kama to southwest, then proposed Hw 6 to the north and Hw 35 to the east. This route is longer than Alignments 1 or 2. To reduce the length, a western extremity alignment to the south of Sderot was selected. This alternative follows an easterly course to the south and east of Dorot, avoiding villages but interfering with agricultural lands. Consequently, it only parallels Highway 334 for a short distance before changing to an easterly direction far north of Beit Kama, to cross Highway 40 and the Tel Aviv-Beer Sheva Railway Line, paralleling the proposed Highway 6 and proceeding north to join the Alignments 1 and 2 north of Lahish, and hence to Tarkumiya.

Alignment 4: This rail only, road only or combined multi-modal alignment also originated as on effort to follow Highway (Hw) 334 to Beit Kama to the southwest, then Highway 325 south of Dvira and on to the southern extremity of the West Bank. It represented the first attempt to connect to the West Bank near Meitar, a location which would allow a more favorable possible future rail connection to the north through the West Bank. However, similar to Alignment 3, the western portion would traverse agricultural lands. Consequently it would only parallel Highway 334 for a short distance before changing to an easterly direction far north of Beit Kama, to maintain a 1.3 percent maximum gradient alignment to Meitar. Even then, the alignment results in a 1.5 percent gradient, and would necessitate the construction of a 600 meter tunnel several kilometers west of Meitar. The alignment terminates on Palestinian Territory at a substantial distance south from Hebron.

Alignment 5: This road only alignment originates the same as Alignment 4, and follows Highway (Hw) 334 to Beit Kama to the southwest. With less stringent requirements than a rail alignment, it could then follow Highway 325 south of Dvira and on to the southern extremity of the West Bank. Rejoining the Alignment 4 alignment at the Green Line, it would avoid the need of a tunnel through a careful selection of alignment a few kilometers west of Meitar. This alignment terminates on Palestinian Territory at a substantial distance south from Hebron. Without offering a combined rail alternative, it confers fewer benefits than the alternatives which terminate closer to the West Bank population centers.

Alignment 6: Other possibilities for further southern alignments were investigated. Existing route alignments are generally on a north-south alignment, which largely precludes the possibility of any such southern alignment being able to share a parallel alignment to these, lessening viability of any such route. The length of the route across Israeli territory also becomes longer.

Dividing the future project road into distinct workable sections containing possible alternative alignments allows for certain features of the alignments to tabulated, these are shown in Table 3-1. The table also includes an estimate of major road/rail route overpass/underpass requirements.

Table 3-1: Alternative Alignments, with Rail/Road Possibilities, Lengths, and Comments- Preliminary Evaluations

Alignment	Railway	Road	Combined	Approx. Length in Israel (km)	Project Length (km)	Length in GZ to Seaport	Length in WB to near Tarkumiya or Meitar	Length in WB to N. Hebron Jct.	Total Length: Seaport to N. Hebron	Est. # of overpass/ underpasses for major routes	Comments
Al 1	√	√	√	41	45	19	2	14	76	7	Follows existing route corridors to Tarkumiya
Al 2		√		39	43	19	2	14	74	7	Sunken Alignment to Tarkumiya, new corridor
Al 2a	√	√	√	39	43	19	2	14	74	7	At grade, New Corridor
Al 2b	√	√		39*	43	19	1	14	73	1	Tunnel sections from Gaza to Tarkumiya
Al 3	√	√	√	51	55	14	2	14	81	7	From Gaza SE & NE to Tarkumiya
Al 4	√	√	√	40	50	14	8	31	93	8	South of Sderot to Meitar: requires 800m tunnel
Al 5		√		40	49	14	7	31	92	9	South of Sderot to Meitar along existing routes
Al 6		√		50	59	8	7	31	96	9	Seaport to Meitar

* Al 2b includes approx. 10 kms of tunnel

3.5 Initial Evaluation

Using the existing maps and aerial photography and the criteria discussed in Section 3.1, maps at a scale of 1:20,000 were further analyzed to conduct a more detailed study of the corridors and to develop a preliminary road alignment. The proposed corridors along the alternative alignments were studied and compared in the Preliminary Design at this scale using the topographic maps. The terrain level and its variation along the proposed alignment corridors are shown in the longitudinal profile at scale 1:20,000/1:2,000 horizontal/vertical.

The possible alignments were next evaluated using the following criteria:

- What are the relative lengths of the alignments, within Palestinian territory, Israeli territory, and in total? Often the shortest distance is preferable.
- What are the average and mean gradients of the alignments? Often the least severe grade alignment is preferred. However, the relation of minimum grade may be the inverse to the shortest length route.
- Which alignment more closely follows an existing road or track? This makes survey and construction easier, minimizes land use impacts, and may indicate the route of least earthworks.
- Which alignment follows the least severe terrain type? An alignment through, for instance, flat terrain should be less costly to construct, have lower vehicle operating costs and maintenance costs, and less severe horizontal curves than a route through mountainous terrain.
- Which route remains for a longer period on the crest of the terrain? Such an alignment minimizes the need for drainage structures.
- Which alignment minimizes the need for land acquisition? Which alignment minimizes the need to demolish buildings and houses?
- What is the total number of overpasses/underpasses required for each alignment? What is the total aggregate length of these bridges?

- Which route results in the least environmental disturbance to the surrounding area?
- Which route has the least overall project cost, including both design and construction?

3.6 Site Visit and Survey

After potential route corridors were identified from the desk study, a reconnaissance survey was conducted to verify interpretations, to help determine the preferred corridor, and to identify factors that will influence the feasibility design concept and cost comparisons.

A site inspection visit was completed on Sunday, November 20, 2005. The field trip team consisted of the following personnel:

- Derek Sherman, Team Leader
- Jan Zicha, Railway Engineer
- Ariel Cuschnir, Environmental Specialist
- Michael Nyquist, Highway Engineer
- Kobi Satat, Senior Consultant
- Udi Yohay, Senior Engineer

During the reconnaissance survey, the following was assessed:

- terrain classification, noting the location of topographical constrains, such as gorges, ravines, rock out crops, and any other features not identified by the desk study;
- slope steepness and limiting slope angles identified from natural and artificial slopes (cutting for existing roads in the region), and slope stability;
- rock types, geological structures, dip orientations, rock strength and rippability;
- percentage of rock in excavations;
- materials sources, presence and distribution;
- water sources;
- soil types and depth, soil erosion and soil erodibility;
- slope drainage and groundwater conditions, including drainage stability and the location of shifting channels and bank erosion;
- land use and its likely effect on drainage, especially through irrigation;
- likely foundation conditions for major structures;
- approximate bridge spans and the sizing and frequency of culverts;
- flood levels and river training/protection requirements;
- environmental considerations, including forest resources, land use impacts and socio-economic considerations; verification of the information collected during the desk study;
- the possibility of using any existing road alignments including local re-alignment
- improvements; and
- information on the physical accessibility to bridge sites and the proposed corridors, including the geomorphology of drainage basins, soil characteristics, slopes, vegetation, erosion and scouring.

During the site inspection the team examined all alignments. This information was combined with the results of the desk study to determine the most appropriate alignment alternatives. The reconnaissance survey data, recorded onto topographical maps and aerial photographs, was used to modify the desk study interpretations. The geological and geomorphological study was received in early December. It did not result in any further revisions to the alignment alternatives. The drainage study, also received in early December, suggested minor modifications to certain alignments, particularly Alignments 2 and 3, in the

interest of eliminating unnecessary channel crossings, and as pertained to the location in relation to various natural drainages. The results of the field survey and related studies were used to modify the findings as follows (refer to Figure 3-5):

- For Alignments 1, 2, and 2a, the initial segment interfered with agricultural lands and a kibbutz. It was ascertained that that a preferable route would traverse a rock outcrop north and west of Sderot which entails a degree of rock cuts. Further, to avoid a subsequent curvilinear alignment and a watercourse near the junction of Highways 232 and 352, it could follow a tangent alignment close to Highways 232 and 352 before joining the Highway 352 alignment near Khelets/Tlamim, hence following the same alignment discussed earlier. A continuation of a tangent line through this said hilly section straight across and slightly south of Highways 232 and 352 would still follow the route corridor albeit up to approx. 0.5 kms south of it, and avoid the wadi in the vicinity of the Highway 232/352 junction. However, subsequent discussions with representatives of Israel Railways indicated that, in considering their alignment for the Ashkelon-Beer Sheva route, they had to avoid these rock outcrops as they contained several cemetery and burial sites.

- For Alignments 1, 2, and 2a, the western portion (past Lahish) was directed to the south of Highway 35 to avoid Nehusha, ensure sufficient space for the new alignment, and to minimize conflicts with Highway 35. However, we found in our meeting with representatives of Israel Railways that they had investigated a similar alignment for a proposed rail line and found it to be too difficult in terms of avoidance of major archeological features. Hence, we will likely need to revise our alignment to the north side of the valley, and locally to the north of Nehusha.

- For Alignments 1, 2, and 2a (road only) the study considered a continuation east of Lahish along one of several valleys south of the one traversed by Highway 35, to reduce the overall distance. However, all of these valleys are also rich in archeological artifacts; further, it is likely that opening up a new corridor here would meet with disfavor.

- For the sunken Alignment 2, the initial study evaluated an alignment which hugged the Shikma Wadi to avoid cutting access from communities to their fields, and to provide possible gravity drainage for the sunken alignment to the wadi. However, the field survey revealed that the wadi, was rather narrow and shallow (see Photo 3-1). If the sunken alignment is at a depth of approximately 6 meters, it is likely to be problematic to drain it to the adjacent wadi at a depth of 4 meters. Hence, to avoid the need of a costly pumped drainage system, it may be advantageous to consider a typical section which balances an approximate 3 meter cut with an adjacent fill (see Volume 2: Drawings, Typical Sections). This typical section would also reduce costs by reducing haul distances for excavated materials.

- For Alignment 4, although the original intent was to follow an existing corridor, the result was an alignment which traversed no existing corridor and which exited Gaza south of Sderot. Further, to give an acceptable gradient on the approach to the West Bank the alignment also follows a new corridor. The only portion of an existing corridor that remained was approx. 7 kms beginning just east of Dorot. However, even here, conflicts with park lands on both sides of the Highways 334 dictated a deviation from that route. With the resultant alignment divorced from any existing corridor, this makes it more possible to consider a sunken alignment. This "new" option has been given the name "Alignment 4a."

- For alignment 4, it is possible to separate the road alignment from the rail alignment once the Green Line is reached north of Lahav, and locate the continuation of the road on Alignment 4b

through Ramadin and Dahariya. This results in a single road/rail corridor through Israel while allowing a road distance savings to Hebron of approximately 4 kms over Alignment 4, and avoids the steep gradients near the rail tunnel location at the Givat Lahad Hill. The road alignment would end at Point G on Figure 3-5.

Photo 3-1: Shikma Wadi

- For Alignment 5, this route can also proceed as Alignment 5a through Ramadin and Dahariya, with savings similar to Alignment 4b above.

Resultant Alignments are shown in the following subsection.

3.7 Typical Cross Sections and Other Considerations

Volume 2, Drawings, contains the results of the initial analysis of various typical cross sections; they are briefly described below:

1. Alternative A1: road only with utility corridor outside of road prism
   - Shallow fill section
   - High fill section
   - Cut section in rock
   - Cut section in soil
   - Depressed section with retaining walls
   - Sunken section with side spoil embankment

2. Alternative A2: road only with utility corridor in median
   - Shallow fill section

- High fill section
- Cut section in rock
- Cut section in soil
- Depressed section with retaining walls
- Sunken section with side spoil embankment

3. Alternative B: rail only with utility corridor outside of rail prism
   - Shallow fill section
   - High fill section
   - Cut section in rock
   - Cut section in soil
   - Depressed section with retaining walls
   - Sunken section with side spoil embankment

4. Alternative C: Combined road and rail with utility corridor outside of road/rail prism
   - Shallow fill section
   - High fill section
   - Cut section in rock
   - Cut section in soil
   - Depressed section with retaining walls

Further refinement of these typical cross sections will be undertaken during the remainder of the study. In addition, tunnel cross sections will be developed for the Rail Only and Road Only alternatives.

Handling of the Utilities: The water, gas and telecommunications would be located together in a utility corridor located to one side of the transport infrastructure (road only, rail only or combination of both) when there is no median in the case of 1, 2 and 3 above. The utilities would be buried, and a gravel service road is built over them. In this way, the utility lines can be easily maintained without disrupting road traffic or rail operations. As shown on the drawings, power transmission (161 to 400 kV) can be handled utilizing overhead lines; however, a high voltage transmission line requires up to a 30-meter right of way. Alternatively, the power transmission lines would be buried, but should be separated from the other utilities such as telecommunications and gas lines, and 5 meters are allotted for this. In this case, the power lines can be buried on the opposite side of the right of way away from the other utilities; the cost of a buried power line is estimated to be up to 5 times the cost of a conventional power line for the same voltage.

Number of Road Lanes and Rail Tracks: The selection of the number of rail tracks and traffic lanes would depend on the forecasted traffic. It appears likely that in the initial years, a single track with sidings would be a rail possibility, with staged construction eventually leading to two tracks. For this initial screening, this option was not chosen due to operational considerations and to provide a more meaningful comparison of design year rail to design year road costs.

Firstly, the traffic analysis indicates that a mere two-lane road facility (one lane in each direction) would likely suffice for several years following the opening of the road. Sometime between 2020 and 2030, a four-lane facility would likely be required. Nevertheless, it would be technically expedient to provide for an initial year four-lanes (2 lanes in each direction), particularly as the lack of an existing facility and the inapplicability of previous years' traffic to our study leaves questions as to its accuracy since all traffic projections are based almost entirely on generated, diverted and induced traffic; in the present environment, they are difficult to predict.

Secondly, it would not be practical to revisit the project in the year 2030, to acquire additional right-of-way to upgrade the roadway to a six-lane facility. This leads to a staged construction solution whereby four-lanes are constructed initially, and sufficient room is left for future construction within the median. At any rate, for comparison between the at-grade, sunken, tunnel, and rail combination options, by using this configuration the "playing field" is level for all cases.

Vertical Profiles: Preliminary profiles were developed for the nine alternatives. For all but the tunnel profiles, these were selected by setting an initial line based on the ground level, and following this as close as possible while paying attention to the design standards for gradient and vertical curves. Subsequently, the controls were inserted where there was a need to consider whether to employ an overpass or underpass for crossing routes, rail routes, trails, and conduits.

With the topography being fairly flat, even within the context of the continuous gradient from Nehusha to Tarkumiya, the conflict controls became the key controls in the determination of the ultimate profile line, and determined the extent to which a "roller-coaster" effect resulted or was avoided.

3.8 Additional Discussion of the Rail Alignments

The area between Gaza and West Bank consists of a plain to moderately hilly western coastal region about twenty km wide, and of a gradually rising eastern region that gains a mountainous character towards the Palestine territory. The connector has to negotiate a rise from the low elevations of the seaboard to approximately 430 meters at the prospective terminals at the West Bank.

The shortest East-West connection between West Bank and Gaza encounters two steps in the terrain that call for a gradient of 2.5 per cent. While such a gradient is technologically achievable using advanced freight locomotives, it restricts the payload of freight trains and may become an operational impediment in the long run. For this reason, alignments of lower gradients were sought and found.

3.8.1 Rail Alignments Terminating in the West Bank

Rail corridors of the eastern region have been primarily defined by the topographic feasibility of the area. The second factor is the presence of archeological sites and areas of specific environmental significance so that the primary alignment based on topography alone may be shifted from its original location unless special structural provisions such as tunnels or viaducts are provided.

The geology of the eastern region is characterized by sedimentary rock, mainly limestone and marl. Except for areas of weak sedimentary soils, the corridors of eastern region are favorable for railway construction.

3.8.1.1 Northern Rail Alignments

Due to the favorable topography, three alternative rail alignments (Alternatives 1, 2 and 3) share a common portion of their alignment that largely parallels Route 35 and terminates in the West Bank. They all have a common eastern terminus near Tarkumyia. These alignments were modified to avoid archeological areas near Nehusha. As presently designed, the maximum gradient is 1.35 per cent.

As a result of discussions with Israel Railways, further adjustments of the alignment will be needed to avoid additional archeological sites along near Nehusha. It is anticipated that these modifications will force the alignment away from its topographically preferable route and to one further north. This change

in the alignment might require that short tunnels and bridges be built. Such changes are anticipated within a strip that defines the Northern Rail Corridor.

One important issue is whether or not the Northern Rail Corridor can continue to connect other areas of the West Bank from the vicinity of Tarkumyia. It would be impossible to continue the alignment to Hebron due to the large difference in elevation between the two locations, approximately 500 to 600 meters in 10 kilometers. Alternately, it might be possible to climb gradually along the western slopes of Judean Mountains to gain the necessary elevation rise in the direction of Bethlehem while avoiding the high elevations at Hebron. This alignment would have to cross the deep side valleys of the western mountain slope and would require building a number of bridges and/or constructing high embankments, deep cuts and/or short tunnels. For this reason, an alternative alignment that could eventually connect to other areas of the West Bank was sought further to the south.

3.8.1.2 Southern Rail Alignment

The southern alignment (Alternative 4) has been developed from the open area north of Beit Kama passing around Dvira at a four to five km distance on its north to east sides avoiding Lahav Tsafon Reserve and crossing the Green Line east of Lahav. The line continues along the Green Line southeast, crosses Har Sansana Mountain (534m) in a 600 meter tunnel and descends to a relatively flat area suitable for container terminal north of Meitar. Once Alternative 4 crosses Route 6, it heads in the southerly direction since the terrain to the east is quite rough and would require bridges and tunnels to maintain a reasonable gradient.

The maximum gradient is around 1.5 per cent and this grade can be maintained consistently through the rough terrain in this area and along the last ten kilometers of this alignment. In spite of the complex terrain with sudden vertical changes, the southern alignment does not require any large structures.

Further adjustments to the route to accommodate topographical and environmental concerns along the alignment can be accommodated if these conceptual designs are further developed and may require more tunnels and bridges.

If there is a future requirement to extend the line to the north and serve other areas of the West Bank, this can be done by the continuation of the alignment to the north following Route 60. Two anticlines of Judean Mountains leave a moderately sloping highland area between them. It could be followed by a future north-south railway connecting Jenin, Ramalla, Jerusalem and Hebron and possibly on to Jordon.

3.8.2 Design of the Rail Alignments in the Western Portion of the Study Area

A major engineering consideration is the near-to-surface geology of the western portion of the alignments, which is known to include poor soils of low bearing capacity such as loess. The proposed railway technology involves increased axle loads and high speeds both which imply designing the subgrade and subsoils to handle large dynamic loads. A major search has been initiated started to obtain and evaluate boring data from previous structural and transportation projects in addition to the general geological information. Geotechnical exploration by remote sensing methods of engineering geophysics augmented by a limited number of calibration borings is recommended for the preliminary design stage that will follow this study. This methodology may be less costly than the frequently specified geotechnical surveys based evaluation of borings that were drilled at equal distances along the alignment.

The ridges and low hills found in the area may offer quality foundation materials and provide distinct geotechnical advantages over loess and a variety of weak sedimentary soils frequently found in flat and

low lying areas. These advantages may become significant enough to choose hilly terrain over the young sedimentary plains for final alignment sections to avoid costly soil improvement or replacement efforts.

The macro-topography of the Western Region is not critical and allows numerous alternatives without a major impact on the overall design of the line. The topography of the western region allows utilization of the straight and shortest route options as well as options that follow existing roads. However, localized topography will become a major alignment factor at the advanced design stages of the line. The areas of numerous small ridges, hills and considerable terrain drops may be preferred to avoid weak foundation soils of the sedimentary plains what may present alignment challenges in the detail design stage.

The lack of major topographic restrictions provides an increased space for non-engineering alignment considerations to reflect demographic, environmental, agricultural, hydrological and land use preferences to enhance overall optimization of the final alignment option.

3.9 Results of the Initial Screening of the Alternative Alignments

As mentioned, a total of eighteen possibilities were investigated based on alignment, selection of at-grade, sunken, or partial tunnel configurations, and selection of road only, rail only, or the combined road and rail option. The descriptions are repeated in Table 3-2 below:

Table 3-2: Alternative Alignments, with Rail/Road Possibilities, Lengths, and Comments - Preliminary Evaluations

Alternative Alignments	Railroad	Road	Combined	Approx. Length in Israel (km)	Project Length (km)	Length in GZ to Seaport	Length in WB to near Tarkuiya or Meitar	Length in WB to N. Hebron Jct.	Total Length: Seaport to N. Hebron	Est. # of overpass/ underpasses for major routes	Comments
Al 1	√	√	√	41	45	19	2	14	76	7	Follows existing road and rail corridors to Tarkumiya
Al 2		√		39	43	19	2	14	74	7	Sunken Alignment to Tarkumiya, new corridor
Al 2a	√	√	√	39	43	19	2	14	74	7	At grade, New Corridor
Al 2b	√	√		39*	43	19	1	14	73	1	Tunnel sections from Gaza to Tarkumiya
Al 3	√	√	√	51	55	14	2	14	81	7	From Gaza SE & NE to Tarkumiya
Al 4	√	√	√	40	50	14	8	31	93/89**	8	South of Sderot to Meitar: requires 800m tunnel
Al 4a		√		40	50	14	8	31	93/89**	8	Sunken alignment south of Sderot to Meitar: requires 800m tunnel
Al 5		√		40	49	14	7	31	92/88**	9	South of Sderot to Meitar along existing routes
Al 6		√		50	59	8	7	31	96/92**	9	Seaport to Meitar

* Al 2b includes approx. 6 kms of tunnel
** First value is for rail and second value is for shorter road solution

However, there is a slight difference in the information in Table 3-2 when compared with that found in Table 3-1 which reflects further refinements made as a consequence of the field survey. It is necessary to reduce this number of alternatives to a more workable set of options. Accordingly all alternatives which would terminate in the West Bank at the southern terminus located north of Meitar have been eliminated from further study. This decision is based on several factors, which included:

- Based on discussions with Palestinian officials, they did not view these options favorably, questioned whether any continuation of a rail route from its southern terminus to points north would ever prove viable, and noted the possibility albeit difficulty of a rail continuation from Tarkumiya;
- Only one of the four southern options allowed for a combined road/rail possibility. For all others, if a road only alternative is the only option, it represents a 20 km increase in length between Gaza and Hebron, with no tangible advantages or benefits;
- All origin/destinations using the southern alignments would require substantially longer trip lengths and consequently increased travel costs and travel time in a new corridor. These added costs come with no tangible benefits to the Palestinians.

Alternative Alignment 3 was eliminated, for several reasons, including:

- It could not follow the Route 334 corridor as originally envisaged, due to conflicts near Sderot, and with park lands east of Dorot;
- It added 12 kms length across Israeli territory, or an increase in distance of 31%, over all other options terminating at Tarkumiya;
- It added approximately 8kms, or an additional length of 11%, over other options for total distance between Gaza City and the junction north of Hebron; and
- The additional length occurs primarily at a location in the foothills, creating a more expensive and problematic alignment in this geographic area.

The elimination of these routes resulted in the following nine Alternatives (four alignments) selected for further review, including profile development, unit costs and construction costs. The Alternatives are presented in Table 3-3.

Table 3-3: Alternative Alignments, with Modal Considerations for Further Study

Alignment	Railroad	Road	Combined	Type	West Bank Destination
Al 1	√	√	√	At Grade	Tarkumiya
Al 2		√		Sunken	Tarkumiya
Al 2a	√	√	√	At Grade	Tarkumiya
Al 2b	√	√		Full/Partial Tunnel	Tarkumiya

It should be noted that the option involving a continuous tunnel of 40 km is not considered practical and greatly exceeds the length of the longest existing road tunnel in the world (24.5 km in Norway). A partial tunnel solution, however, is a viable alternative. A road tunnel selection will need to include an occasional outlet since accidents increase substantially as the length of tunnel increases due to driver fatigue. The tunnel sections would occur at critical areas where settlement, infrastructure and environmental avoidance issues lead to its consideration. It is important to note that large diameter water pipelines and power transmission lines would not be located within the tunnels since they could be located in buried trenches above the tunnel at considerably less cost. The transport of highly flammable

materials such as petroleum products should not use the tunnel and hence would need to be transported through a different corridor.

Finally, additional revisions to the selected alignments are possible later in the study as more information becomes available. For example, for all Alignment 1 alternatives, there are potential conflicts to the north of Sderot, in the corridor between Kiryat Gat and Lahish, and environmental concerns near Nehusha, all of which could alter the alignment to a certain degree and have an impact on costs. For all Alignment 2 alternatives, conflicts with drainages, including the desire to avoid unnecessary multiple wadi crossings, and conflicts with agricultural or potential park regions could alter the alignment. Nevertheless, the corridors selected are indicative of the possibilities and are of sufficient accuracy at this stage to continue to a further investigation of their feasibility.

CHAPTER 4- UTILITY TRANSMISSION REQUIREMENTS

A transportation link connecting the West Bank to Gaza Strip would provide the opportunity to incorporate within its right-of-way the utility transmission lines for water, power (electricity), natural gas and telecommunications. This chapter assesses the economic viability of using the proposed transportation corridor to accommodate these utility lines. The cost estimates provided in this chapter, especially those for water and electricity should be considered preliminary and are subject to change as additional analyses are performed over the next several months of the project

The initial findings of our analyses lead to a recommendation that that the proposed transportation link be sized to accommodate the transmission of all four utilities. However, there is no economic basis for initiating construction of any of the transmission lines in the near future. For example, in the absence of a major discovery of natural gas reserves off Gaza, there is no economic rationale for installing a gas transmission line connecting the two areas. Similarly, the large and rapid changes in the telecommunications industry would render a current decision based on present technology for transmission of electronic data in 2015 as highly risky. Similar high levels of risk would also be associated with any decision to build electricity and water transmission lines within the corridor. Uncertainty about the timing of a future desalinization plant, for example, and the potential large changes to demographic patterns once the transportation link is built would greatly influence the economic viability of these projects. Nonetheless, one or more of these transmission lines might become important to the long-term economic development in a future Palestinian State, and therefore it would be myopic to foreclose the opportunity to construct utility transmission lines within the proposed transportation corridor as needed. The following sections describe current supply and demand issues associated with water, electricity, natural gas in the West Bank and Gaza Strip and their ramifications for building utility links between the two regions. The viability of building telecommunications links within the proposed transport corridor is also discussed.

4.1 Water Requirements

The feasibility study has estimated current and future water availability based on known resources, and future water demand. These estimates have been used to project future supply shortfalls for Gaza and the West Bank, under low, medium and high growth scenarios.

Because Gaza and the West Bank already suffer from a serious shortage of water, the only realistic options for meeting future demand will be either desalination on the Mediterranean coast or bulk importation from a foreign source. Completion of this study will include a review of realistic short and medium term options for transmission from the Gaza Coast to the West Bank, the implications for improvements in bulk supply and cost estimates for preferred options.

As a footnote to this progress report, order-of-magnitude cost estimates have been prepared for some options for transfer of water from Gaza to the West Bank. More refined estimates specific to the preferred options will be developed as the project continues.

4.1.1 Existing Water Resources and Allocation

Effectively the only source of water in the West Bank is a shared resource supplied from three groundwater aquifers. The division of this water was dictated by the 1995 interim Oslo Agreement as follows in Table 4-1:

Table 4-1: Allocation of Water According to the Oslo Agreement, 1995

Aquifer	Allocation (mcm/year)			
	Palestine	Israel	Unallocated	Total
Northeastern	42	103	0	145
Eastern	54	40	78	172
Western	22	340	0	362
Total	118	483	78*	679

* 28 mcm of potable water plus 50 mcm of brackish water

In Gaza, water supply is restricted to what can be drawn from the local aquifer plus a temporary piped supply of 5 mcm from Israel which is currently being commissioned. Gaza groundwater replenishment is currently 112 mcm, but this is being seriously overexploited with resultant deterioration of water quality.

The assumption for the future in the West Bank is that the interim Oslo Agreement will become the basis for a permanent arrangement and that West Bank demands in excess of 146 (118+28) mcm will have to be met from other sources. Similarly in Gaza, it is understood that local sources will not improve, and all needs in excess of current groundwater replenishment will have to be met by seawater desalination or importation.

4.1.2 Future Demands for Water

Population Projections: Various scenarios for future population growth have been studied and are discussed elsewhere in this report. For purposes of water demand projections, low, medium and high growth scenarios are used.

Municipal and Industrial Demand: The demand for water in the West Bank and Gaza is seriously suppressed, and the presumption must be that supply will increase to allow water usage to be commensurate with reasonable health and social standards. The assumption used is that supply will increase to meet an average domestic demand of 100 l/c/d by 2015 and 150 l/c/d by 2025. These figures equate to minimum and average rates of supply to domestic consumers in small communities as recommended by the World Health Organization. In addition, allowances for non-domestic uses plus system losses must be added to these figures. It is assumed that the current unacceptably high losses of 40 percent or higher can be reduced to the more acceptable level of 20 percent by 2025.

Agricultural Demand: Agricultural activities are presently a major consumer of potable water, but the assumption for the future, consistent with the Palestine Water Authority (PWA) expectations, is that this will reduce significantly in the future, particularly in Gaza where the expectation is that it can be cut by about 85 percent by 2030. These reductions will be brought about partly by the employment of lower quality water such as treated wastewater, wadi run-off and brackish groundwater, and partly by a shift in the Palestinian economy from agriculture to light industry and regional commerce.

4.1.3 Requirements for Augmented Water Supply

Taking cognizance of the anticipated growth in per capita demand for water, gradual reduction in losses through leakage and gradual reduction in (potable) agricultural demands; the future projections of the shortfall in available supply under high, medium and low population growth scenarios are estimated and are summarized in Table 4-2:

Table 4-2: Forecasts of the Portable Water Supply Shortfall

Year	Potable water supply shortfall (mcm/year)								
	High growth scenario			Medium growth scenario			Low growth scenario		
	W. Bank	Gaza	Total	W. Bank	Gaza	Total	W. Bank	Gaza	Total
2005	25.5	19.9	45.4	24.0	19.1	43.1	22.6	18.4	40.9
2010	65.0	35.3	100.3	60.4	32.4	92.8	56.0	29.7	85.7
2015	120.9	62.4	183.3	110.6	55.2	165.8	101.0	48.4	149.5
2020	167.5	85.9	253.4	150.1	72.8	222.9	134.1	60.8	194.9
2025	225.6	120.9	346.5	198.1	99.1	297.2	173.2	79.6	252.8
2030	256.0	139.3	395.3	219.1	108.9	328.0	186.5	82.4	268.9

Even at the modest short-term allowance of 100 liters per capita per day in the year 2005, there is already a supply deficit in both Gaza and the West Bank.

4.1.4 Conceptual Options for Augmented Water Supply

Increased exploitation of groundwater resources does not offer a long-term solution to shortfalls in supply, as this would require unsustainable "mining". Surface water and treated sewage effluent are equally unattractive, for economic and social reasons, respectively. Realistically, future supply must come from desalination of Mediterranean seawater, bulk importation from a foreign source or a major conceptual review of the existing interim agreement for division of the mountain aquifer source between Israel and the Palestinian areas. The last option is considered to be beyond the scope of this study.

Thus, future augmentation of water supply to the Palestinian areas will have to be by desalination or by bulk importation. From the perspective of the West Bank, this will require construction, operation and maintenance of major pipelines and pumping stations. From a technical perspective, there is no requirement that these be incorporated within a transportation corridor, but it is an option to be considered.

4.1.5 Options for the Immediate Future

As of late December 2005, the options for the immediate future have yet to be reviewed. Consideration will be given to the significance of the currently planned Gaza desalination plant, the option of allowing Palestinian per-capita demand for water to remain suppressed in the short term, the potential for a continued cooperative agreement between Mekoroth and the PWA, and the relative merits of constructing pipelines within the transportation corridor or constructing them independently along more economically practical routes.

In the meantime, to allow a preliminary overview of order-of-magnitude costs, some options on the likely cost of bulk transfer between Gaza and Hebron are presented hereunder. Hebron is a more logical terminal point for a major pumping system than the proposed eastern end of the transportation link, which, from a water supply perspective, is of no particular significance.

It has been assumed that pumping will be continuous, which is consistent with the way in which the proposed Gaza desalination plant will operate. Costs are inclusive of a pipeline, pumping stations, water storage equivalent to six hours of system capacity at Hebron and variable costs including power, operators and routine maintenance.

Table 4-3: Estimated Marginal Cost of Pumping One Cubic Meter of Water from Gaza to the West Bank (Hebron)

Pipe diameter	Capacity mcm/year	Capital cost $	Recovery $/Cum*	Operating cost ($/cum)			Total cost $/Cum*
				Power	O&M	Total	
20”	7.67	13,400,000	0.26	0.47	0.23	0.70	0.96
24”	11.05	17,100,000	0.23	0.45	0.18	0.63	0.86
30”	17.26	24,200,000	0.21	0.44	0.14	0.57	0.78
36”	24.85	31,900,000	0.19	0.43	0.11	0.54	0.73

For each pipeline size, the capital recovery cost is computed on a “per cubic meter basis” using an interest rate of 15% per annum. Note that all costs in this table are preliminary and subject to change.

It will be noted that there are significant economies of scale, both in relation to capital costs and operating costs.

The cost of desalination, which is currently $0.58 per cubic meter, must be added to the cost for transfer of water from Gaza to the West Bank. Total cost of bulk supply of desalinated water from Gaza to the West Bank will therefore be of the order of $1.31 - $1.54 per cubic meter. The current price charged by Mekoroth for sale of water to the Palestinian Water Authority is $ 0.58 per cubic meter.

The capacity range of the four options shown is 7.67 to 24.85 million cubic meters per year. This equates to a range of 42% to 136% of the proposed 18.25 mcm/year first phase capacity of the Gaza desalination plant or 14% to 45% of the anticipated ultimate capacity of 54.75 mcm/year.

4.2 Energy Transmission

The aim of this study is to analyze the feasibility of a transport link between Gaza and the West Bank to facilitate the movement of people and cargo between the two regions, without dependence on the existing Israeli infrastructure. The availability of reliable and continuous sources of energy and electric power is essential to maintain and expand the economy of the Palestinian region. A dedicated Gaza to West Bank link could potentially provide a corridor for the transmission of electric power and natural gas between the two regions. This section of the analysis is designed to explore the current and perspective energy and electric power resources available in this region, expected supply and demand requirements and options for utilizing this corridor for expanding energy resource transfer between West Bank and Gaza consumers. Figure 4-1 gives an overview of the present situation described below.

4.2.1 Current Situation – Electric Power Generation

Israel: The electric power supplied to the West Bank and Gaza is almost entirely produced by IEC (Israel Electric Company) generation facilities and is transmitted over its lines to the four regional companies for distribution to the consumers. The IEC, the national electric utility monopoly for Israel, has 10,190 MW [2004] of installed generation capacity from a number of generating facilities located throughout Israel with the larger facilities located along the Mediterranean coast.

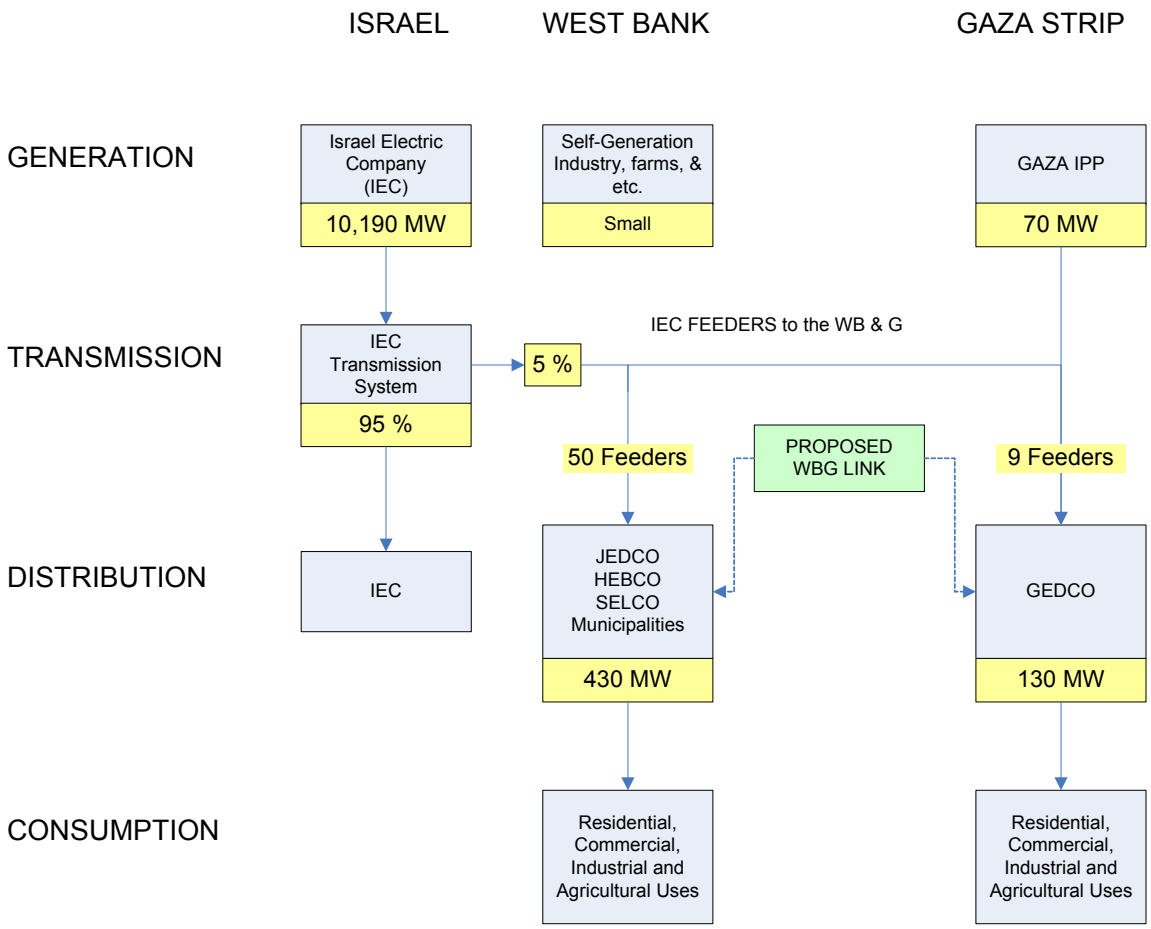
Table 4-4: Electric Generation Capacity of IEC by Facility as of January 2005

Type of Unit	Site	Capacity in MW
Coal/Fuel oil	Haifa	426
	Riding	428
	Eshkol	912
	Oret Rabin	2,590
	Eshkol 2	150
	Ratenberg	2,250
	Eshkogen 2	26
	Sub-Total	6,782
Gas Turbines	Kinoret	80
	Haifa	80
	Kesaria	130
	Raanana	22
	Hartov	40
	Eitan	40
	MD	15
	Rutenberg	40
	Eshkol	10
	Eilat	65
	Sub-Total	522
Industrial Gas Turbines	Ramat Hovov	200
	Tzafit	220
	Alon Tavor	220
	Eilat	34
	Atarot	68
	Gezer	592
	Sub-Total	1,334
Combined Cycle	Ramat Hovav	335
	Hagit	660
	Alon Tavor	240
	Eshkol	236
	Sub-Total	1,471
	Total	10,109

Source: IEC, Jan 2005

In 2003, the fuel used by IEC was predominantly coal [79%] and fuel oil [17%].

Fig.4-1: Electricity Flows in the West Bank and Gaza Strip - 2005



Palestine: A Gaza IPP was established in 1999 to meet the local electricity demand and has the capacity to produce about 140 MW from diesel fuel. There are plans to expand this facility to 490 MW; however it is currently operating at 50% capacity due to the high cost of fuel and operating constraints. Some of the municipalities in the northern West Bank have small diesel power plants, which are inoperative due to noncompetitive fuel costs and technical problems. These small facilities are utilized on an emergency basis for water pumping stations, hospitals and other sensitive loads when alternative power is curtailed. The capacity of the reserve generators is small, each normally below 1 MW.

Comparison: Compared to the diesel powered West Bank plants, the IEC power is primarily generated from low cost coal and is moving to lower cost natural gas for new facilities. The IEC bulk selling price to the distribution companies in WBG is $0.06 per kWh, compared to the recent range of $0.12 to $0.18 for the cost of the small self generated local West Bank plants. The aim of increased energy independence would require the construction of new plants similar to the Gaza model at a cost of a least US$ 250 million each. However, due to the uncertain economic conditions this is considered a high risk investment for independent investors and donor organizations do not see this as a high priority requirement.

Potential for Renewable Energy Technologies: The entire region has the potential of utilizing a range of renewable technologies for electric power generation. Strong wind levels can be captured for wind

turbines along the Gaza coast, at the Jordan-Israeli corridor near the Aqaba-Elait valley, and the GEF has plans for a joint wind generation plant. Israel is a world leader in advanced solar technologies, but passive solar hot water systems are ubiquitous. Solar technology in Israel is essential to supplement the residential electricity demand. Each new home in Israel is required by law to include a solar water heater, and 84% of homes have solar supplemental energy which reduced the demand load in this solar positive environment. A similar approach has been applied in WBG, and about 74% of new homes have solar power systems, which will reduce the requirement for hot water heating in residences and small commercial buildings. An advanced solar power facility is scheduled for the Negev.

4.2.2 Transmission – Electric Power

The transmission system operated by IEC is a 1000 km closed loop system connecting the electric generating stations to the load centers throughout Israel, the West Bank and Gaza. The current system includes EHV-400 kV transmission and 161 kV sub-station grids to distribute the power to the consumers. The Northern West Bank substations are supplied by 27 feeders of 36 kV and 3 feeders of 24 kV. The power demand is 170 MW. Due to the problems of heavy loading of the long feeders, a new substation will be operational in the Northern West Bank during 2006. The Southern part of the West Bank, (SELCO) primarily Hebron, has 10 feeders of 36 kV for a power demand of 100 MW. A new 45 MVA power transformer will be in operation at the Hebron station in 2006. The East Jerusalem distributing company (JEDCO) is fed by 10 feeders of 36 kV for a power demand of 160 MW. The Gaza district substation (GEDCO), is supplied by 9 feeders of 24 kV, with a power demand of 130 MW. A new 161 kV line is being installed to connect the Netivot substation with the Gaza North substation. At the first stage 70 MW will be supplied by this line, although an increase to 150 MW will be available to match the load demand growth.

The total peak demand of electric power supplied to WBG by IEC and transmitted to the local distribution companies is indicated in Table 4-5.

Table 4-5: WBG Peak Electric Demand (2004)

Region	*MW*
N West Bank	170
C West Bank	160
S West Bank	100
Gaza	130
Total	560

Bulk power is transmitted by IEC to the regional distribution companies located in the West Bank and Gaza. The system development is externally financed, and there has been inadequate investment in the supply chain, from the bulk supply points where IEC transfers power to the sub-stations, to the distribution lines supplying the consumers. Distribution of electricity is controlled by the existing local utilities: JDECO (The Jerusalem District Electricity Company); SELCO (Southern Electricity Company); HEPCO (Hebron Electricity Power) and GEDCO (The Gaza Electricity Company) and by the small municipalities in the northern West Bank that have not been incorporated as utilities. The distribution system in WBG is relatively inefficient with system loses of over 20% compared with 4% for Israel. This reflects the small conductor sizes, the long length of feeders and overloading of the transformers and system network. It also indicates ineffective maintenance and unauthorized consumption (theft). The most cost effective process of increasing supplies of electric power for the long term, with minimal

investments, is to reduce losses from the current high level to approach the IEC level of 4% by improved management of the system.

The following is a brief description of the distribution system for each of the four WBG sub-systems:

- The *Northern West Bank Sub-System* is the least developed. This includes the Governates of Nablus, Tulkarem, Qalqilia, Tubas and Salfeet, which collectively include about 40% of the West Bank population. The municipality of Nablus manages the electrical network within the city and the surrounding 14 villages. The grid includes 65 km of 33kV lines, and 170 km of 11 and 6.6 kV lines, and 200 km of low voltage lines. Peak demand was 35 MW and system loses were 11%. The Jenin municipality manages the system within the city boundaries and 6 surrounding villages. The grid totals 76 km with a peak demand of 12 MW and system loses of 11%. The Qalqilia Municipality manages the system within the city. The grid total 111 km with a peak demand of 12 MW and system loses of 11%. The Tulkarem Municipality manages the system within the city and nearby village. The grid totals 278 km, with a peak demand of 12 MW and system loses of 12%.

- The *Central West Bank Sub-System* (JEDCO) was created in 1927 and is co-owned by the municipalities and the private sector. It distributes electricity over a small but dense population and commercial area, including East Jerusalem, Ramallah, Bethlehem and Jericho. The JEDCO network includes 700 km of 33, 11 and 6.6 kV feeder and 350 km of low voltage lines, and 450 MVA in transformer capacity. Peak load is 160 MW, which is 37% of the West bank requirements. Non-technical loses are 18% and non-payments are high.

- The *Southern West Bank Sub-System* provides distribution services for the Hebron district which are supplied by HEPCO and SELCO. HEPCO is limited to the Hebron municipality area and supplies 30% of the area customers. It includes 131 km of high tension lines and 372 km of low tension grid. Peak demand was 12 MW with system loses of 24%. The SELCO mandate includes the other municipalities in the Governate. Peak demand was 23 MW and systems loses are 24%, exceptionally high.

- The *Gaza Sub-District* or GEDCO is the only distributor for the Gaza region. The GEDCO grid includes 310km of 22 kV lines and 350 km of low tension lines. The peak load was 154 MW with loses, primary non-technical, of 27%. Electrical outages are the longest due to the overloaded system and inadequate distribution system.

4.2.3 Demand for Electric Power

The demand for electricity grew at an average annual rate of 5.3% in Israel [1995-2004] and 7.2% [1995-2001] in WBG. The demand for electricity paralleled economic conditions and declined in WBG between 2001 and 2004. The IEC has projected a resumption of demand growth in the region after 2005, which would require an increase in generation capacity from 10 GW to 15 GW by 2010. Accordingly, IEC plans to invest over $1.2 billion per year over the next five years for an improved generation, transmission and distribution system. This will increase reserves from the current low level of 5% to the 20% level, and include the capacity to meet the anticipated demand from WBG customers.

Table 4-6: Electricity Flow in West Bank and Gaza

Region	North WB	Central WB	South WB	West Bank	Gaza	West Bank and Gaza
Population	910,000	605,000	490,000	2,005,000	1,255,000	3,260,000
Consumers	632,000	600,000	485,000	1,717,000	1,240,000	2,957,000
Accounts	57,000	117,000	52,000	226,000	120,000	346,000
Supply [GWh]	256	891	271	1,363	835	2,198
Demand [MW]	85	200	52	337	154	491
Load [%]	64	51	46	50	62	54
Losses %]	11-15	18	24	18	27	19

Source: *West Bank and Gaza Infrastructure Assessment*, World Bank, 2002

4.3 Natural Gas

Natural Gas resources are located offshore Gaza and can potentially be used to generate electric power in Gaza; however investment uncertainties impeded development of these reserves. BG (British Gas), the developer of the large Gaza Marine field gas resources, has recently signed a contract to transport the Gaza Marine 1 & 2 field gas by pipeline to El Arish in Egypt, for transshipment via an LNG tanker to the US. Gas is being used in Israel from the Yam Theis field and there are natural gas reserves located offshore Israel at the Or, Nao, Mari and Nir fields. There are substantial natural gas resources in Egypt that could potentially be linked to Gaza. The environmental, economic and security concerns of the current dependency on large coal powered electric powered facilities in Israel have prompted IEC to move to natural gas for the two planned 1000 MW facilities. The gas will be supplied by an offshore pipeline providing gas from El Arish, Egypt to Ashkelon and Ashdod that is expected to be operational by 2006. IEC has negotiated a long term contract for the import of gas to supply electric power and industry in Israel for the equivalent of $ 21 per barrel of oil. The gas line will be extended along the Israeli coast, initially to Ashdod and then it is designed to reach Nahsholim and north of Haifa. A southern loop will transport gas from Gezer to Ramat Hovav and to Sadom on the Dead Sea by 2007. This loop is designed to accelerate the move to expand the distribution of natural gas for industrial and commercial facilities and smaller consumers. Currently, about 60% of natural gas is consumed in the south, and this line could be extended to include West Bank consumers. INGL (Israel Natural Gas Lines) holds the license to construct, distribute and operate the natural gas pipeline system. The shift to natural gas for generating electric power and for industrial use will reduce electricity prices and industrial energy costs significantly while improving the environment. The INGL plans to bring the gas grid east from the major distribution points at Haifa to the Galilee region in 2007, and indicated they can directly provide gas to meet the requirements for the northern and central West Bank.

4.3.1 Power Supply through Regional Cooperation

An area of potential cooperation involves the integration of the national power grids of Egypt, Jordan, Palestine and Israel into a regional power network. The development of a regional network would allow the power companies to take advantage of the differences in daily, weekly and seasonal peak demand periods, reduce the requirement for the instillation and maintenance of new generating capacity, and provide an outlet for existing reserve capacity.

Jordan and Israel have discussed several joint electric power stations, including a $1 billion, 1000 MW plant to be located on the border, a 100 mw wind farm, a 50 mw solar thermal plant in the southern Avara desert near Eilat, and an 800 MW plant in Jordan that would supply power to the grid. This could mitigate the need to transfer electric power via the corridor since it would duplicate an existing network. Table 4-7 gives comparative data on electric power infrastructure.

Table 4-7: Comparative Infrastructure Data

Country	Population	Per Capita	Electric Supply	Capacity installed	Generated	Consumed	EP Losses
	Million	[US$]	kW per 100	GW	Bkwh	Bkwh	%
Egypt	77.0	650	21.0	17.6	81.3		14
Jordan	3.9	1120	25.0	1.7	7.5	8.0	10
WBG	2.4	1064	13.0	0.2	0.2	0.6	24
Lebanon	4.0	2500	32.0	2.0	10.7	10.7	
Syria	13.0	2800	30.0	6.1	27.2	25.3	
Israel	5.1	13500	82.0	10.1	47.2	42.9	4

Source: World Bank 2005

Arab Middle East Electrical Alliance: There are plans for an Arab Middle East Electric Alliance, or Arab Network, linking seven countries: Jordan, Iraq, Syria, Egypt, Lebanon, Libya and Turkey. The plan to include Palestine within this network could potentially provide significant external electric resources. The initial project for this grid would be to link Gaza to the Egyptian grid at El-Arish. The link could be constructed and activated with nine months after an agreement. When the tie is functional, the electricity can be transmitted via the connector link from Gaza to the West Bank. Jordan has been connected to the Egyptian electrical grid through an underwater cable between Taba and Aqaba since March 1999, providing 10% of Jordan's electricity requirements. This electrical alliance can be expanded to include a link between Jordan and the West Bank. If this becomes functional, electrical power can potentially be transferred from the West Bank to Gaza, or in reverse, via the connector. The initial plan is to provide supplemental electric power by 2007 to Gaza from Egypt and to the West Bank from Egypt via Jordan, providing power to each region independently, and bypassing the need for an electric connection between Gaza and the West Bank.

Power from Natural Gas: The natural gas available offshore Gaza and from Egypt could be used directly for a large electric power and associated degasification system in Gaza, or extended gas system via the corridor to provide industry and small electric power facilities in the West Bank. A planned 1000 MW natural gas facility could theoretically provide electricity to consumers in Gaza at a cost of $.035 per kWh, about half of the current cost from IEC. However, the uncertain situation in Gaza has defined this plan as a high-risk project and deterred foreign investments. Instead the offshore Gaza gas has been committed for a transshipment requirement in Egypt.

At present, there is no discussion of building a power plant in the West Bank using gas as a source of fuel. Consequently, there appears to be no requirement to build a natural gas pipeline to the West Bank.

4.3.2 Projected Electricity Demand

A projection of the potential peak electricity demand in the West Bank and Gaza is provided for the period to 2030. As noted above, IEC has projected that recovery of Palestinian economy from the second *Intifada* will stimulate an increased demand for electricity, reversing the severe declines from the period 2001 to2003. The West Bank is projected to grow at a faster rate than Gaza, reflecting a more diverse and vibrant economy and a larger population.

IEC production capacity is expected to increase from the 10 GW level in 2005 to the 15GW level by 2015, and will be able to accommodate the anticipated WBG demand. During the past decade here have been no restrictions on electricity supplied to the WBG from the IEC, and non-payments by the distributing companies have been deducted from the Palestine taxes and other funds available. The forecasts in Tables 4-8 and 4-9 are based on an economic recovery scenario robust economy scenario, respectively14. The forecasts indicate that the central West Bank will consume an increasing portion of the electric power in Palestine. Any new electric facilities constructed in the West Bank would be dedicated to meet local requirements, while a new Gaza electric plant may initially have excess capacity that could be transferred via the corridor the West Bank for a short period. However, over the longer period the availability of low priced and secure sources of electric power could attract vital industrial facilities to the industrial park in Gaza, reducing the incentive to transfer the residual power to the West Bank via the corridor.

Table 4-8: Economic Recovery Case: West Bank and Gaza Peak Electricity Demand (MW)

Year	North WB	Central WB	South WB	West Bank	Gaza	Palestine
2002	85	200	52	337	154	491
2005	88	212	54	353	159	512
2010	129	327	79	534	203	736
2015	180	480	110	771	271	1042
2020	242	673	148	1062	346	1408
2025	308	859	189	1356	421	1777
2030	393	1096	241	1730	512	2242

[14] The unstable situation in the West Bank and Gaza is been reflected in the uncertain validity for the baseline data and concerns for projections not only for population but economic demand and electric power requirements. These forecasts are presented with the caveats that inherent uncertainties are prevalent and the data may present a reduced confidence level.

Table 4-9: Robust Electricity Growth in West Bank and Gaza Peak Electricity Demand (MW)

Year	North WB	Central WB	South WB	West Bank	Gaza	Palestine
2002	85	200	52	337	154	491
2005	88	212	54	353	159	512
2010	135	342	82	559	212	771
2015	198	526	121	845	298	1143
2020	276	773	170	1220	399	1619
2025	372	1084	227	1683	509	2191
2030	497	1520	304	2322	649	2971

4.3.3 Marginal Costs

The IEC grid is providing power to the West Bank primarily via the existing west to east transmission links to the distribution companies. The shift to an independent self-contained electric power network in the West Bank and Gaza would require developing a new north-south transmission system in the West Bank from Jenin to Hebron, to link to the connector. Gaza has a coastal transmission network supported by IEC which can be linked to the connector system. It is also essential that the current operating system be rehabilitated to improve the effectiveness of the operations, reduce technical and non-technical losses (theft) and expand maintenance. This approach could be the most expedient process of increasing capacity at the lowest cost. The development of the new north-south West Bank and Gaza transmission network is estimated to cost US$ 188 million [World Bank 2005]. *The estimated cost of an underground transmission link as part of the connector is estimated at US$ 75 to 125 million compared to US$ 10 to 40 million for overhead lines for the same nominal 50 km distance as part of the corridor*, between Gaza and the West Bank15. An additional link must be provided to the substation at each end for the 161 kV line. The total cost for building a transmission system to provide electric power to the main consumers in the West Bank via the underground connector would range from $260 to $ 315 million. This could add an additional $0.06 per kWh to the cost of electricity provided to consumers in the West Bank region utilizing this link. The PEA cost estimates may be low since they are based on construction costs in the West Bank. IEC indicated that only IEC approved contractors are permitted to construct electrical transmission systems within Israel.

Table 4-10: Cost Estimate for Building an Electric Power Transmission Line (161 kV) in $/km

Structure	PEA	Israeli
Tower	$ 200,000	$ 500,000-$800,000
Underground	$ 1,500,000	$ 2,500,000

Note: Costs are preliminary and subject to change.

[15] As are all the costs indicated in this chapter, they are subject to change based on further analysis.

4.3.4 Summary of findings

From an energy perspective, the West Bank and Gaza can be considered two independent regions with their own production, transmission and distribution systems. The current electric power production for Israel, West Bank and Gaza is almost entirely based on facilities located in Israel. The IEC has an extensive system supplying and transmitting electricity throughout Israel, West Bank and Gaza. The bulk electricity supplied by IEC is distributed to customers in WBG via the links to the four primary distribution networks: [HEPCO, JDECO, SELCO, GEDCO, etc.] located in WBG.

From the economic perspective the transmission of power via the link would be positive if either region has an exportable surplus of electricity which can be profitable sent via the link to the other region. Based on the current dependency on electric power resources from Israel, and the extensive generation and transmission network currently available to the demand nodes in both the WBG, it does not appear that utilizing this corridor will provide a positive economic choice for either region. However, over the longer-term here might be a number of options for developing new power facilities, including a gas power electric plant located in Gaza, adjacent to the offshore natural gas reserves, imports of electricity from Jordan or Egypt, or new alternative resources provided from facilities located in the West Bank or Gaza. A generic assessment of these options indicted that any additional resources would be entirely dedicated to supplying incremental electric power to the local region within the West Bank or Gaza and the least cost approach for incremental electricity will utilize the existing transmission grid for distribution, or develop a new grid to provide power within either the West Bank or Gaza instead of constructing a new transmission line for the corridor. In the interim period, electricity will continue to be purchased from IEC to meet the anticipated demand. One goal could be to increase the self-generation capacity until the level of comfort is achieved, and improve the low quality, high loss distribution system.

Considerable more analysis and resources should be given to looking into the long-term power demand and infrastructure requirements for the WBG. A number of options exist and they are summarized in Annex 4-1.

Conclusions: Based on a review of the existing data, information, reports and studies available and analysis of the current energy and electric power situation in the West Bank and Gaza there does not appear to be an economic or technical requirement for the inclusion of an electric power transmission link as part of the corridor design. Energy autarky can provide independence at a very high economic and technical cost, and may not be financially feasible. The current high level of dependence on Israel for energy resources may be the least cost option due to the economics of scale and limited alternatives available in the near to mid term period. However, decisions factors not based on economic or technical requirements including territorial integrity could encourage the move to a more energy independent system within Palestine.

From the Israeli Perspective: There is no technical or economic requirement for a dedicated electric transmission line between Gaza and West Bank since IEC has in the past and will continue to provide any anticipated demand. In addition, there is no need for a separate natural gas line as part of the corridor since the existing and planned natural gas grid in Israel can provide gas easily to any major consumption point in the West Bank, and based on the Aqaba agreement they will not permit a direct electric power line to be constructed connecting Gaza to Hebron through Israel. The solution should be technical not geographic.

From the Palestinian Perspective: The energy connection line is essential to present territorial integrity and create energy independence even though it might not be cost effective in the short to medium term. Having multiple sources of electric power supply is prudent and desirable over the long-term and avoids

over dependence on a single supplier. Providing a means of transmitting power between the West Bank and Gaza allows for this possibility.

Recommendations: Based on the analysis to date, two general recommendations could be made at this point:

1: The corridor should not include provisions for an underground or tower electrical transmission connection or natural gas line due to economic and technical deficiencies, that this link would duplicate existing transmission infrastructure currently operational and provided by IEC, and in addition there is no existing or planned capability to generate sufficient power to transfer electricity between Gaza and the West Bank. If electric power is transmitted to a node in the southern end of the West Bank, there is no existing South-North link to transmit the electricity to the primary consumers in the north. If the transmission cable is installed there is a low probability that it will be used;

2: As indicated in the scope of work, physical provisions for an electrical and natural gas connection should be included in the design of the transportation link due to the potential for planned development, expansion and transmission of electricity and/or natural gas between Gaza and West Bank. However, the actual construction and implementation of the transmission cable and/or gas pipeline should be delayed until the required excess electric power and transfer support facilities are available in either Gaza or the West Bank. This would require provision of sufficient space within the right-of-way to accommodate a power transmission line or gas pipeline. The transmission line can be buried or built above ground.

Because of the high degree of uncertainty associated with estimates of future demand and supply, the second recommendation is preferred. It allows the greatest flexibility to accommodate any possible future need.

4.4 Telecom and Communications

Telecom using cellular and landlines, broadcasts by radio and television and computer internet connections are essential assets for a modern communication society. The WBG has consumed these assets at a very rapid pace. Cell phones are now ubiquitous and exceed the number of fixed landline telephones, in part due to flexibility of use, relative low price and expeditious access to new service. Relay towers permit cell phone operation in most of the region. Ghd Palestine Telecommunications Company (Paltel) is the domestic telecom provider for both land and cell phone via Jawwal, its subsidiary.

Computer use has expanded and internet shops are widely available. The radio and television transmission permits stations to broadcast across the region, although the hilly terrain presents some constraints for smaller radio stations. Potentially, the connector could be used to transmit landlines for telephone, radio, television and internet between Gaza and the West Bank or visa versa using existing equipment. At present there are low cost fiber optic cables, microwave transmissions and other increasing competitive priced options for communication that will probably be able to bypass the short distance between Gaza and the West Bank. However, new technologies, including VoIP (Voice over Internet Protocol), for the telecom and communication sector are evolving at a rapid rate and diverse equipment emerging now will dominate the industry by 2010. It would be difficult to select the winning communication protocols for the next decade, since they will be independently funded and not be a factor in the corridor design.

The telecommunication provider generally pays for the inclusion of telecommunication infrastructure within the right-of-way. As in the other cases, the provision of the telecommunication infrastructure should be allowed within the right of way of the transportation link.

Table 4-11: Telecommunication Indicators for West Bank and Gaza

Radio Stations	29
Television Stations	33
Land Telephones	243,500
Cell Telephones	264,100
% Homes with TV	93.4
% Homes with Radio	82.8
% Homes with Telephone Lines	40.8
% Homes with Cell Phones	72.8
% Homes with Computers	26.4
% Homes with Internet	9.2

Source: Palestine Central Bureau of Statistics, 2004

CHAPTER 5 - ENVIRONMENTAL RESOURCES

5.1 Introduction

This section of the progress report describes the existing environmental, cultural resources, and socio-economic conditions and data collected during the first months of this project; it provides an analysis of the preliminary conceptual alignments and the environmental factors that played a central role in the adjustment of the proposed routes as they were being developed by the transport engineers in conjunction with environmental experts; and describes the potential environmental issues to be considered during the subsequent impact analysis of alternatives to be presented in the Draft Final Report. It is important to emphasize the difference between analysis of proposed alignments and of proposed alternatives. The comparative impact analysis of the possible alternatives cannot be conducted at this stage of the project. It will be conducted once the alignments and engineering options are developed in more detail. The reason behind this is that an alignment can have diverse environmental effects depending on the design and construction types selected (e.g. cut- and-cover, at-grade road, sunken road, segmented tunnels, railroad vs. road).

5.2 Environmental Factors Affecting the Selection of Alignments/Alternatives

The environmental factors that were considered during this phase of the project (and that will play an important role in the future selection of alternatives) included, among others:

- Avoidance of nature reserves, national forests, and other sensitive habitats
- Minimization of alignment crossings over streams
- Compliance with environmental regulations (National and International)
- Landscape considerations (visual effects, free wildlife passage, open spaces)
- Minimization of impacts to biological corridors and biological bottlenecks
- Minimization of impacts to planned biosphere within Israeli territory
- Maximal possible distance from optimal habitats (water sources) for migratory species (birds)
- Maximal possible distance from cultural resources sites
- Maximal possible distance from population centers
- Minimization of road crossings (social impact)

Similarly to many road development projects it is expected that the proposed West Bank – Gaza Transport Connector will cause direct and indirect environmental impacts, as well as positive and negative ones. Although security and legal issues were out of the scope of this project, certain considerations (such as the possible need of a fence for at-grade road segments) were evaluated since they represent primarily negative effects for humans and wildlife crossing. On the Palestinian segments there would be primarily positive impacts associated with the construction and operation of the transport corridor since it would open traffic flow between both Palestinian territories and increase economic development. From the point of view of wildlife passage, the connector, both in Israel and in Palestine, can negatively affect the biological corridors in the region if appropriate mitigation measures are not adopted. In addition to wildlife movement and agricultural activities in the study area (Shaar-Hanegev, and the foothills of the Judean mountain ranges), the construction of the West Bank and Gaza Connector, might also affect migratory human populations (Bedouins) which throughout centuries have been freely roaming these areas with their herds.

In addition to environmental guidelines in place by Israeli and Palestinian Agencies and the evaluation of drivers discussed in this report, the study took into consideration those guidelines developed by the World Bank for the development of roads. An environmental sensitivity list for road development is provided in Table 5.1 below:

Table 5.1 Environmental Sensitivity (Roads and the Environment - A World Bank Handbook. 1997)

Urban centers	Dense urbanization	Strong sensitivity with respect to noise and changes in rights-of-way
	Sparse urbanization	Strong sensitivity to noise and changes in rights-of-way
Industrial zone	Commercial activity	Sensitive to changes in access and disruptions of interaction
Agricultural land	Good agricultural land	Strong sensitivity to severance of interactions, loss of land, groundwater alterations, and erosion
	Medium grade agricultural land	Strong sensitivity to severance of interactions, loss of land, groundwater alterations, and erosion
	Tree plantations	Vulnerable to alterations in groundwater flow
Natural habitats	Undisturbed flood plain	Valuable wildlife habitat. Sensitive to changes in water flow and quality
	Woodland Slope	Susceptible to erosion
	Significant ecosystem	Harbors rare or especially sensitive species, and as such is vulnerable to any modification
	Valuable wildlife habitat	Sensitive to encroachment and alterations in water flow and quality
	Mixed forest	Sensitive to disturbance of wildlife, alterations in groundwater flow, and encroachment
	Hunting reserve	Sensitive to disturbance of wildlife
	High-use animal corridor	Threatened by high traffic volume
	Secondary faunal corridor	Threatened by high traffic volume
	Valuable spawning grounds	Very sensitivity to changes in water quality and flow
	Good fish habitat	Sensitivity to changes in water quality and flow, access important for fishing
	Drinking water source and protective perimeter	Sensitive to contamination and alteration of groundwater flow
	Cultural heritage site	Sensitive to vibration, uncontrolled access

Future evaluation of alternatives should also take into consideration the central role conservation of open spaces, wildlife, and biodiversity, plays for the Israeli population, NGOs, and the Israeli Ministry of Environment. As an example, the recently published "The Red Book of Threatened Species in Israel – Vertebrates" should be used as part of the evaluation of alternatives, since it provides an important measure of the critical condition of Israel's local fauna and emphasizes the need for protection as well as mitigation measures for future habitat alteration. In addition, close analysis of alternatives should take into consideration the extensive scientific data on the wildlife of the study area, as well as full consultation with Israeli experts and Government officials.

Avoidance of nature reserves, forested areas, water bodies, wildlife bottlenecks (known areas heavily utilized as a passage by wildlife) and other critical habitats was used to reshape proposed alignments and will also be used to screen alternatives. However, the presence of wildlife is not limited only to the nature reserves and parks; wildlife is also known to exist in anthropogenically-modified areas such as agricultural fields and production centers, environments in which they sometimes thrive as well as in the wilderness. Impacts to areas such as existing biological corridors cannot be avoided since they usually run in a North-South direction. However, mitigation measures can be developed to reduce potential environmental impacts as long as they address the biological requirements of each assessed species. For some species the continuity of biological corridors is crucial for their survival. Other species are highly dependent on site-specific habitats and consequently susceptible to adverse effects at the local level.

In spite of its small size, and due to its geographic location, Israel plays a pivotal role in inter-continental biota migration, allowing for a rich variety of fauna and flora with greater biodiversity than other countries in the region. In reality, faunal migration patterns and the progressive advance of species along biological corridors create a condition where the country as a whole can be considered a "biodiversity spot". In general terms the guidelines of the Israeli government are to direct development outside the biological corridors so they can continue providing conduits for the passage of animals. The preliminary screening and alignment adjustment conducted for the WBG Connector took these guidelines into consideration and tried to minimize crossing of corridors. However, in many cases this avoidance or minimization of crossings was not possible, and the necessary mitigation plans should be developed for the final design of alternatives.

Streams and watersheds in the region are scarce but also the main source of water for wildlife. Habitats used by migratory species are usually concentrated almost exclusively in the vicinity of water bodies such as lakes, ponds, and running streams. Consequently, reducing proximity to these areas was a key driver in the establishment of alignments. For this stage of the study the aim was to select alignments with the fewest stream crossings. To achieve this Berger's engineers designed alignments to run as much as possible along streams and developed crossings in areas where the topography of the terrain allows for implementation of better mitigation measures.

Future environmental impact studies to be developed for the selected alternative should take into consideration the National Biodiversity Strategy and Action Plan under development. Simultaneously, the National Master Plan on Open Space will become a Law and consequently all future planning and development (including the designs of final alternatives for the West Bank and Gaza Connector) will be subject to its provisions.

5.5.2 Other Environmental Concerns

Other environmental concerns to be evaluated through the implementation of this project include:

- Land use and development policies and controls
- Use of Natural/Depletable Resources
- Urban Quality
- Reuse & Conservation
- Noise
- Other Infrastructure Systems
- Aesthetics and landscapes

These and several other factors have been accurately defined in the planning document prepared by more than 250 Israeli leading professionals (under the supervision of a joint inter-ministerial committee) that during a period of more than 6 years prepared a non-statutory master plan called Israel 2020. This important document constitutes today the backbone master plan for all local, regional, and national plans developed by the Israeli government, and it directs future development according to the principle of concentrated dispersal. This means that the Government's approved development is dispersed nationally but concentrated regionally (MOE website, 2005). The increased development seen in the central region of the country in recent decades is causing an environmental and socio-economic imbalance in which open spaces are being eliminated and economic development focuses in the central region. Consequently, Israel 2020 redirects development to the North and South of the country to decrease socio-economic disparities and preserve open space in the central region.

5.3 Objectives and Requirements

The objective of this Environmental Progress Report is to provide USAID with information that resulted from a preliminary analysis of the environmental conditions of the area to be affected by the construction and operation of the transport corridor, and to provide a pre-feasibility screening level of alignments that will assist in focusing these studies and subsequent EIA for this corridor.

5.4 Project Description

The objective of the project is to assess the feasibility of a transport corridor linking the West Bank and Gaza Strip. Berger is evaluating three basic transport links:

1. Road-Only Alternative
2. Rail-Only Alternative; and
3. Multi-Modal Alternative

Although the primary decision-making variable recommended was "cost effectiveness", there will be inevitable trade-offs because of externalities associated with each alternative. The criteria for an initial screening of the alternative corridors are:

- Shortest Distance
- Connection with Existing Points
- Minimum Interference with Israeli Activities

5.5 Existing Environmental Conditions

5.5.1 Site Visit

A detailed description of the Site Visit is provided in Section 3 of this report (Route Selection). From the environmental point of view the site visit conducted in the area of the proposed alignments revealed the presence of typical rural settings with scattered populations, forested areas, nature reserves, and a number of streams many of which originate in the Judean Hills and discharge into the coastal plains and ultimately the Mediterranean Sea. Many of these streams are only seasonal in nature but nevertheless they play an important ecological role. Consequently, the usual impacts associated with stream or nature reserves crossings, elimination of certain amounts of agricultural land, the ecological fragmentation of these lands, and, in certain cases, the physical separation of landowners from part or most of their properties, were also evaluated. However, a full description and evaluation will be provided in the Draft Final Report once the alternatives are more clearly defined. Since the study area also includes scattered population centers, and the proposed alignments will cross several of the access roads to these centers, the effects on communication between population centers will also be addressed in future socio-economic evaluations to be implemented under this study. The areas visited during this phase of the study are presented in the following Figure:

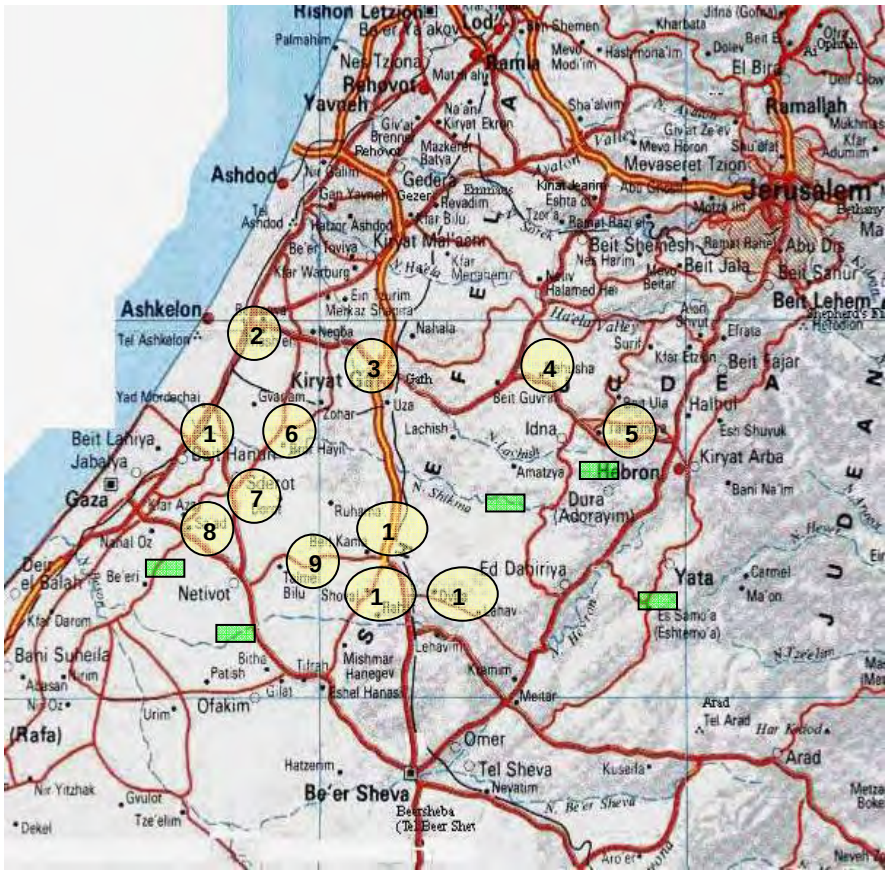


Figure 5.1:

9 Areas visited during November 2005

Planned additional site visits (January 2006)

Examples of visited areas can be observed in the following photographs (numbers correspond to visited sites described in Figure 5.1):

Figure 5.2 Site # 1 – Erez Crossing – This site is located at the entrance to the Gaza Strip and shows an active stream (Nahal Shikma) running along the Northern border of Gaza and into the Mediterranean Sea. Although a small stream, it has a high ecological value and it has been declared a protected habitat. Ecosystems like this one will require efficient mitigation measures to reduce potential impacts.

Figure 5.3 Site # 4 - Beth Gobrin area – Valley shown above includes agricultural lands, National Jewish Fund (NJF) forested areas (far right), and bush habitats on the side of the existing road. New road adjacent to existing road will require compensation of land loss or other mitigation measures.

Figure 5.4 Site # 6 - Shikma Creek – This reach of the creek is located in between two Kibbutzim lands (Or-Haner and Bror Hail). Although dry during our visit, this is one of the most important streams of the region, and environmental laws protect it. The downstream portion has been declared a nature reserve/protected watershed.

Figure 5.5 Site # 9 – Dorot-Shikma – This area is known for being important agricultural land. Crossings by the alignments will require implementation of sets of mitigation options including land-loss compensation, habitat restoration, habitat compensation, etc.

5.5.2 Interviews of Government Officials (Bio-regions, Wildlife Passages, and other Environmental Concerns)

On November 16th, 2005, a meeting took place with Israeli government officials at the Nature Reserves and National Parks Authority (Ministry of Environment / MOE). Dr Yehoshua Shkedi (Head of the Ecological Department), and Dr. Reuben Ortal (Science Division), were interviewed in order to obtain information for this study. These officials provided valuable data regarding the existing ecological conditions of the area, and also provided recommendations and names for interviews of other government agencies.

According to Dr Shkedi, the Israeli Nature Reserves and National Parks Authority focuses its activities in two ecological levels: a) The protection of rare and endangered species, and sensitive habitats; b) Protection of large ecosystems and biological corridors that help preserve large populations and genetic pools.

Dr Shkedi emphasized the concerns of the Israeli Government that the proposed Connector not only avoid nature reserves and other sensitive habitats (e.g. Shikma watershed) but also that measures be taken to minimize impacts to the region's biological corridors and wildlife bottlenecks, as well as the planned Biosphere to be developed by the MOE. The difference between a Nature Reserve and Biosphere Reserve resides in the flexibility of the system to preserve both natural processes and human interests. Biosphere reserves are areas of ecosystems, which are internationally recognized within the framework of UNESCO's Program on Man and the Biosphere (MAB). To be recognized as a Biosphere Reserve the area must meet a minimal set of criteria, having: a) a conservation function, to preserve genetic resources, species, ecosystems and landscapes; b) a development function, to foster sustainable economic and human development, and c) a logistic support function such as support demonstration projects, environmental education and training, and research, etc.(UNESCO, 1995). In addition, it should contain three elements: one or more core areas, a clearly identified buffer zone, and a flexible transition area, or area of cooperation (between economic interests, conservation needs, and NGOs and responsible agencies). Israel is creating "Biospheres" with the purpose of protecting ecosystems of special ecological value and restoring the area's historical biota. An important one has been created on the Carmel Mountain Range. A new Biosphere proposed by the MOE extends in a broad area between Beth Shemesh (northern limit) and Lahav (southern limit). Its importance in the eyes of the general public and the MOE is rapidly growing, to such an extent that 9 settlements proposed by the current Prime Minister Sharon Government have been stopped for having an adverse effect on the proposed location for the Biosphere.

The Israeli-Palestinian region is centrally located in the pathway of various historical ecological migration patterns and can be classified (from the zoogeographic point of view) according to 4 main faunistic and floral distributions, which cross the area through existing biological corridors or bio-axes. These corridors run primarily in a North-South direction however, several passages extending east to west are also located within the area of the proposed Connector. The importance of these corridors is that they represent 4 different types of fauna and flora historically linked to other regions in Africa and in Asia (Israel is known to play an important role as a transit station for migratory birds and as a migration route for other fauna and flora from Africa to Asia and vice-versa). In addition, an endemic biota component also exists in the region. These endemic populations and 4 eco-regions include the:

1. ***The endemic component:*** comprised of some of the species of flora and fauna that have remained in this country and its vicinity from prehistoric times when climatic conditions were different from those prevailing today.

2. ***The northern (Mediterranean) component*** is especially significant in Israel's world of flora and fauna and encompasses species that exist along Israel's Mediterranean coastline. These species may have invaded this area from the north at a relatively late period, when present climatic conditions began to stabilize in this region, along with the development of the evergreen scrubland.

3. ***The steppe (Irano-Turanian) component*** originated in the upland areas northeast of Israel.

4. ***The desert (Saharo-Arabian) component*** is prevalent in the Negev from which point it reaches northward in two arms: along the strip of coastal sand dunes and into the Dead Sea and Jordan Valley.

5. ***The equatorial (Sudanese) component*** includes a number of species, which originated in the forests and savannahs of Africa.

It was recommended that our team visit the Israel Ministry of Interior's Planning Division and his Chief Mr. Shamai Assif. This agency is in charge of all infrastructures planning for the entire country and has developed a 20-year development plan, which should be taken into consideration during the development of corridor alternatives.

On November 23th an unofficial meeting took place at the Ministry of Environment (MOE) offices in Tel Aviv. The meeting with Ms Valery Brachya (Director Planning Division of the Ministry of Environment) provided crucial information on the necessary regulatory and approval process required for any recommended alternative, the main concerns and critical issues as seen by the Ministry, and the main objections the Division might have in siting and design issues. Ms. Brachya presented the land use planning process and the two main approval paths the Connector might undergo. The first option might be to evaluate this project at the National level simply as a road. A second path is also at the National level but seen as a multiuse project. This means that the National Board Planning will be in charge of establishing a special multi-ministry committee in charge of reviewing and approving the project (Committee for National Infrastructure).

In both cases the required Environmental Impact Assessments are very similar with variations depending on which specific studies a member of the Committee might require. Consequently, each project has specific guidelines that are defined after the project is submitted to the Board. If the first option (path) is selected, then the Ministry of Environment would be in charge of directing the EIA requirements and would also review the submitted documents. In case the second path is selected, the structure and contents of the EIA would be decided by the National Planning Board which would hire a consultant. This consultant then would submit a report to the Ministry of Environment's representative at the National Board.

Among the main environmental concerns expressed by the Ministry are:

- The Berger Team should consider not only the protection of established nature reserves and critical areas, but also the issue of fragmentation or landscape continuity of "Open Spaces" which is of great political relevance nowadays in Israel. Open Spaces are important not only for migratory wildlife but also for aesthetic values for the Israeli population, particularly trekkers, wildlife supporters, and for recreational values for families. Any design that restricts free movement of people will not be seen positively. Consequently, they think that a "cut-and-cover" option is the most feasible one.
- A Connector alignment that cuts Israel from West to East (e.g. continuous sunken road or at-grade road) will encounter much opposition from the Ministry (quote: "…Totally Unacceptable…").

- Designs of wildlife passages are not seen as a sufficient measure to mitigate fauna's movement restrictions. This problem was already observed during the design of Highway #6 which included engineering measures that did not mitigate the problem.
- Contrary to the information in Berger's hands prior to project initiation (which indicated that the Government of Israel is interested in the shortest alignment possible), the Ministry indicated that they will be in favor of an alignment that puts environmental considerations ahead of length.
- The Ministry recommended assessing all the environmental considerations and solutions developed for Segment # 18 of Highway 6. They see this segment as a good model for replication.

In order to overcome the problem of habitat fragmentation in Israel, the Nature Reserves Authority and the Jewish National Fund have cooperated on a so called "Open Landscapes Plan" for Israel. Extensive geographical and lithological data, collected by the JNF, and botanic data, collected by the NRA, is currently being compiled, evaluated and mapped on the Geographical Information System of the NRA. The result of these efforts will be an ecosystem assessment of the remaining open natural landscapes in Israel which will include an evaluation of each area based on such criteria as unique or rare elements, biodiversity in terms of species and communities, and potential for sustainability based on size and connectivity to other areas (NRA, personal communication, Nov. 2005). Although this document will not be available by the time this feasibility study is completed, efforts will be made to obtain direct information from these agencies to be included in our final analysis.

On November 27th the Berger Team also met with the Palestinian Environmental Quality Authority (EQA) in Ramallah. Similarly to what was expressed by Israeli agencies, the EQA mentioned their limitations in providing extensive documentation until an official communication from their central government is funneled to them. As an example, they showed us a report (Emergency Plan for Protecting Nature Reserves) that would be useful in determining areas of environmental concern within the Palestinian controlled areas. A USAID document prepared 5 years ago (EIA of Hebron area) should be very useful for our project. The EQA expressed their own concerns regarding the segments of the alignments that will cross through their territory. They requested that the following issues be addressed in our assessment:

- Vehicular emissions (wind patterns moving in a west-east direction bring particulates into Hebron)
- Effects on agricultural lands, groundwater, biodiversity, and public health
- Requested avoidance of Wadi Al-Quf (there is an existing Nature Reserve there) and Khirbet Bit Khahel (archeological site)
- Effects on social life (labor, communications, fragmentation of local communities)
- Noise pollution
- Landscape (concerns about aesthetics and its relationship to and harmony with local villages)
- Open Spaces. They are concerned about the free passage of Bedouins and their herds on their way to pasture lands.
- Concerns about affecting the drainage of rainwater from West Bank to Gaza
- Concerns about deposition of excavation material and where it will be located.

5.5.3 Environmental Regulations and Guidelines

This Environmental Progress Report takes also into consideration national and international guidelines used for road development projects. Since the majority of the corridor will be located on land under the jurisdiction of Israeli law, most of the regulatory considerations are those related to the State of Israel.

In Israel the environmental legislation covers important topics such as the protection of nature and natural resources, the control and safe treatment of contaminants, pollutants, and other nuisances, and legislation related to development projects that are also strictly controlled by the Planning and Building Law in order to promote sustainable development. The purpose of this progress report is not to provide a detailed description of all environmental laws and regulations developed by Israel, but to point out many that play a direct role in the determination of the siting, design, and construction of the preferred alignment. The Draft Final Report will include an analysis of these environmental regulations and how they affect the selection of alternatives.

Some of the principal laws are described below:

- Planning and Building Law (1965) (updated in 2003)
- Planning and Building Regulations (Environmental Impact Statements) (1982; updated in 2003)
- Wildlife Protection Law of 1955 (updated in 2003)
- Roads (Affixing of Signs) Law, 1966 (updated in 2003)
- National Parks, Nature Reserves, National Sites, and Memorial Sites Law, 1998 (updated in 2003)
- Abatement of Nuisances Law, 1961 (updated in 2003)
- Abatement of Nuisances (Unreasonable Noise from Construction Equipment) Regulations, 1979 (updated in 2003)
- Abatement of Nuisances (Unreasonable Noise) Regulations, 1990
- Abatement of Nuisances (Unreasonable Noise) Regulations, 1992 (updated in 2005)
- Water Law, 1959 (updated in 2003)
- Streams and Springs Authorities Law, 1965
- Water Regulations (Prevention of Water Pollution), 1991 (updated 2003)
- Water Regulations (Prevention of Water Pollution)(Gasoline Stations), 1997 (updated 2003)
- The Forests Ordinance of 1926
- The Antiquities Law of 1978

In addition, Israel is signatory to a wide array of international environmental conventions which would be evaluated for compliance for this project. These include biodiversity and chemical related conventions:

- Convention to Combat Desertification
- International Convention for the Protection of New Varieties of Plants
- Convention Concerning the Protection of the World Cultural and Natural Heritage
- Convention on the Conservation of Migratory Species of Wild Animals
- Convention on International Trade in Endangered Species of Wild Fauna and Flora
- Convention on Wetlands of International Importance Especially as Waterfowl Habitats
- Convention on Biological Diversity
- Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal
- Endangered Fauna (IUCN)

The following environmental planning principles were developed by the Government of Israel (MOE) and will be considered during the final screening of alignments as well as the design of the alternatives:

- Using environmental resources wisely and efficiently, promoting conservation, and preventing irreversible damage to resources through planning, technological and economic measures
- Preventing processes and plans that threaten to cause irreversible and irreparable environmental damage
- Minimizing environmental damages and impacts
- Responding to building and development needs while directing most of the development to urban fabrics and minimizing suburbanization processes
- Minimizing damage to open space and preserving land reserves for future generations while protecting nature, landscape and heritage values and the rural character of agricultural settlements
- Distinguishing between areas appropriate for development and areas worthy of conservation and accentuating the continuity of open spaces
- Improving urban fabrics through renewal processes and relatively dense building and infrastructure development while emphasizing public transport, which is adapted to urban development
- Refraining from planning solutions that merely move a problem from one place to another instead of treating it
- Encouraging planning and technological solutions to environmental problems through prevention, removal or reduction at source
- Applying the precautionary principle when confronting environmental problems.

5.5.4 Physical Environment

Partial description of the physical environment is described in Section 3 of this report (Selection of Alignments). Additional maps will be provided once detailed information is obtained from various Government agencies and presented in the Draft Final Report.

5.5.5 Natural/Biological Resources

5.5.5.1 Wildlife and Endangered/Protected Species

The current status of vertebrate fauna in Israel is clearly defined in the "*Red Book of Threatened Species in Israel – Vertebrates"*, which was published in 2002 (in Hebrew) by the Nature and Parks Authority and the Society for the Protection of Nature in Israel. An English version was published in 2005. The book provides an important measure of the critical condition of Israel's local fauna (see Table 5.2) and emphasizes the need for protection as well as mitigation measures for future habitat alteration.

	Documented Species	Extinct Species	Endangered Species	Percent of Endangered Species
Mammals	104	9	57	62%
Amphibians	7	1	5	83%
Reptiles	103	3	35	35%
Stream & lake fish	32	6	6	23%
Nesting birds	206	15	39	20%

Table 5.2 – Status of Biodiversity and Endangered Species

The critical condition of many species and the areas they inhabit was already emphasized by Prof. H. Mendelssohn, one of Israel's foremost zoologists (Mendelssohn, 1988). According to this author, the biodiversity of the region has been historically high, primarily due to its strategic geographic location constituting a "bridge" between continents. The anthropogenic influence on the local wildlife has been in existence since prehistoric times but it is in recent years that the fast growth of the human population and development is creating important adverse conditions. Some of the typical animals historically found in the region were only recently extinct. The last cheetah was seen in 1958 and the last Anatolian leopards in the 1960s. Some species are still in existence today (e.g. hyenas, wolves and Arabian leopards) and their protection is of importance for the Ministry of Environment.

According to Prof. Mendelssohn, many reptile species have a very restricted geographic distribution increasing their susceptibility to extinction. An example is the lizard, *Acanthodactylus schreiberi*, which lives on sand-loam soils which are developed for agriculture and settlements, and *Acanthodactylus pardalis*, a species in the Negev that lives on loess soils that are now grain fields.

5.5.5.2 Nature Reserves, National Parks and Forests

Avoidance or minimization of crossings over or near nature reserves, national parks, and other forests (natural and planted) has been one of the driving factors that affected the design of alignments for the West Bank and Gaza Connector. This section will be fully described once official communication from the Israeli Government clearly defines the boundaries of existing and planned reserves and parks. A map describing current sites and how the alignments were designed to avoid these areas is presented and analyzed in section 5.9 of this report. A textual description of the existing nature reserves, National Parks, and forests that fall under the influence of these alignments is also included.

5.5.5.3 Biodiversity

It is estimated that the country contains some 2,500 plant species and more than 800 species of animals (amphibians, reptiles, birds, and mammals). In addition to the role Israel plays as a bridge between continents, there are also climatic reasons that enhance biodiversity. The two main climatic regions include the Mediterranean in the north and desert in the south. The area of the proposed Connector (Shaar Hanegev) is located just in between these two areas providing an opportunity for the presence of a diverse fauna and flora. As an example, the area contains Asian desert species and Irano-Turanian species.

The major threats to biodiversity include habitat destruction, habitat fragmentation, invasive species, non-sustainable exploitation of natural resources, uncontrolled development, and pollution. Due to the importance of the biodiversity of the area, the Ministry of Environment considers this issue a primary one in its national strategy. As a consequence, it is preparing a National Biodiversity Strategy and an Action Plan, which are being prepared by a joint task force of government agencies. In addition, the government of Israel is currently developing and implementing action plans for the conservation of various species of fauna. These action plans are broad in scope and implemented by various government agencies. An example of such an action plan for the country's raptors includes four components:

1. Management measures such as protection of habitats as nesting sites and establishment of feeding stations;
2. Surveys and research;
3. Captive breeding for the purpose of bolstering endangered species and vulnerable populations; and
4. Captive breeding for the purpose of reintroduction.

5.5.5.4 Biological Corridors and Bottlenecks

Biodiversity conservation is a central aim of the Israel Nature and Parks Authority. Policy documents published by the Science Division of the Authority propose that in order to conserve biodiversity, the Authority should act on two levels:

- Promote the conservation of rare species and threatened species and ecosystems that represent the biodiversity of nature in Israel, especially aquatic ecosystems and sand and other ecosystems along the Mediterranean Sea;
- Promote the preservation of large and continuous areas (corridors) that allow the well-being of large populations that exchange genetic material with neighboring populations.

Israel's fauna and flora is being severely affected by habitat fragmentation (road construction and other developments), pollution, and other adverse environmental factors. Biological corridors are those areas that play a crucial role of connecting broad ecosystems constricted by development. The protection of these biological corridors can assist in preserving the dynamics of the ecosystems they connect. Impacts to their functions can have serious environmental consequences to ecosystems that are sometimes separated by large distances. In many cases biological corridors connect legally protected spaces and open spaces and may thus connect different types of landscapes including nature reserves, forests, agriculture and rural settlements.

The idea behind the protection of these environments is to direct building and development to spaces outside these corridors and to encourage countryside recreation and open agriculture in corridor areas which are not legally protected. The corridors would then continue to provide conduits for the passage of animals and plants in a fragmented landscape.

Based on comprehensive surveys of open spaces in Israel four major zoogeographic distribution axes were recommended for protection as ecological corridors, preferably within the framework of connectivity with biosphere reserves (Dr. Shkedi, pers. comm. 2005; Shkedi and Sadot, 2000). These include:

1. The Rift Valley. This area is under protection through cooperation with the Kingdom of Jordan
2. The Mediterranean-desert axis. This area connects 3 major biogeographically zones of Israel (the Mediterranean, the Irano-Turanean, and the Saharo-Arabian) and consequently are crucial areas for preserving biodiversity.
3. A Broken Axis along the Mediterranean Sea, which will assist in preserving the threatened ecosystems previously mentioned
4. The Desert Axis, which will assist in preserving the Negev desert.

The biota connectivity axes previously mentioned are recommended for protection by the Nature and Parks Authority and are described in the following map of the country (red lines within green natural habitats) where it is possible to observe the current areas that offer continuity and those already affected by development:

(Source: Shkedi and Sadot, 2000)

Figure 5.6 - Biological corridors and axes in Israel

As it can be observed in this map of the country, the areas between Gaza and the Negev are characterized by the presence of a broad network of streams and watersheds and a partial loss of connectivity among North-South axes (A). The MOE intends to improve this condition through the implementation of conservation programs and regional planning.

The Study Area (B) falls within critical biological axes, and it is important to take these factors into consideration when designing mitigation alternatives (wildlife passages, habitat enhancement, etc.).

A more detailed description of the biological corridors and critical areas can be observed in the following enlarged map of the region (Figure 5.7).

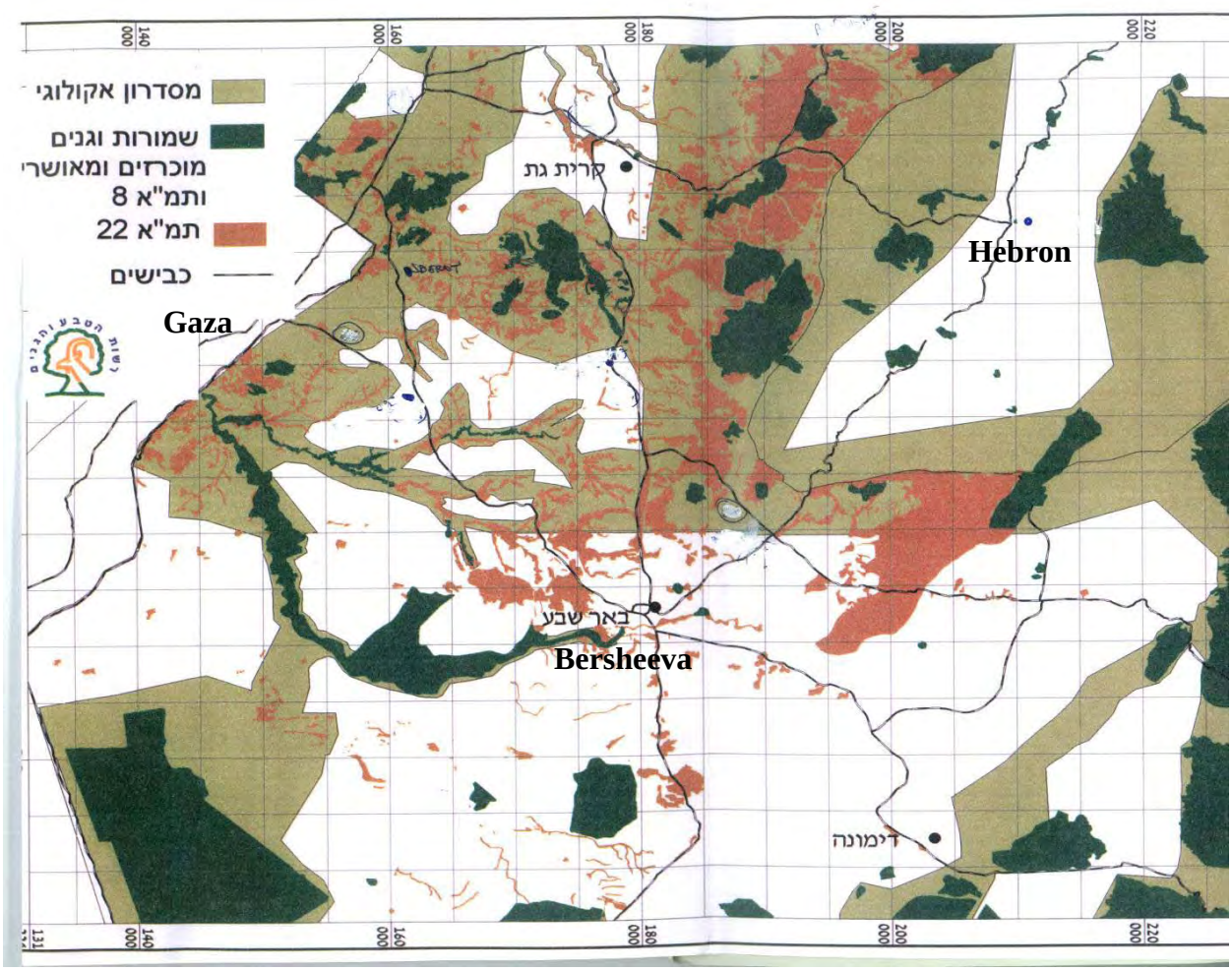


Figure 5.7 Biological Corridors and Protected Areas (Source: National Park Authority, 2002)

The map shows the biological corridors (light brown), the existing forested areas (dark green), and the proposed reforestation program (red). Due to the existence of the previously described biological corridors and their importance in the preservation of biodiversity and critical habitats, the Nature and Parks Authority conducted an in-depth investigation in order to assess the effects of development on these corridors. They identified the presence of critical passages called "Biological Bottlenecks" that serve as a bridge between constricted biological corridor areas. The elimination of these bottlenecks would cause the complete isolation of areas within a corridor.

Several bottlenecks can be observed in the Study Area (see Figure 5.8 below).

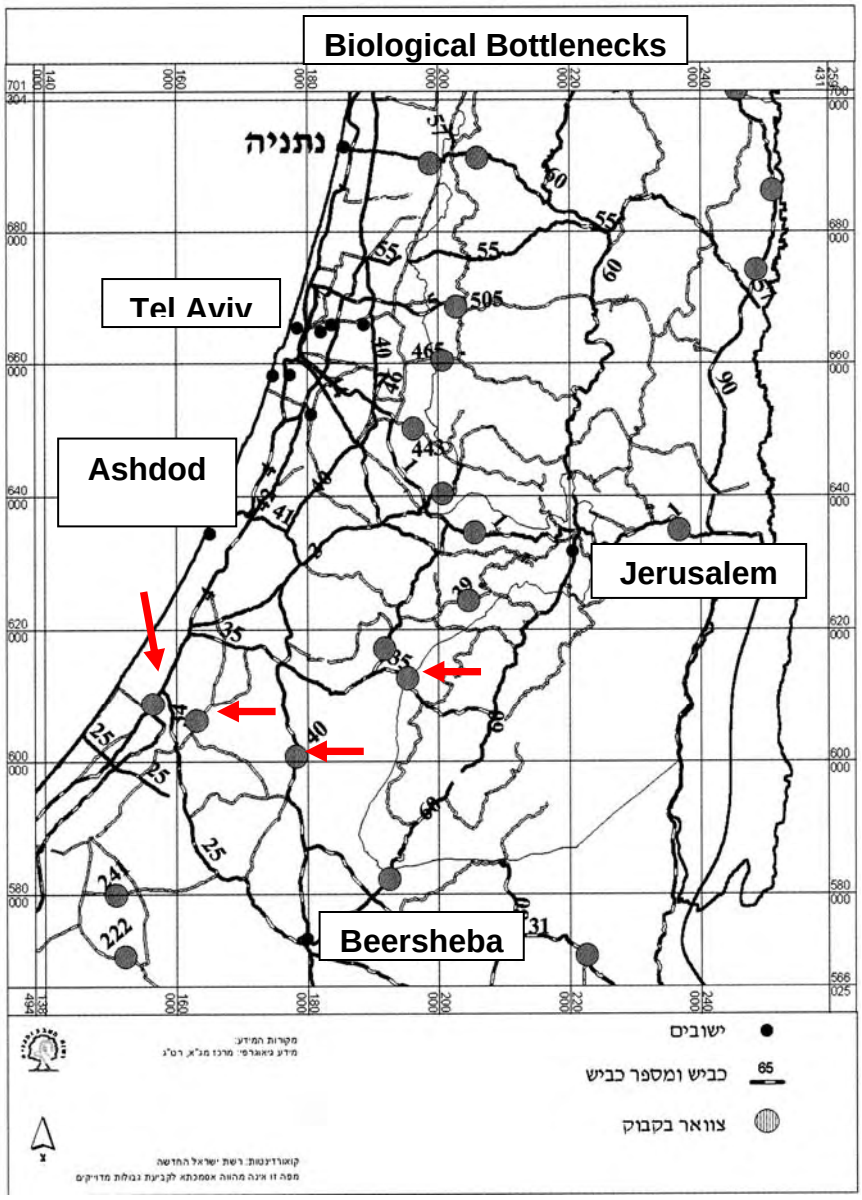


Figure 5.8 Biological Bottlenecks (Highly critical areas)
(Source: National Park Authority, 2002)

The bottlenecks shown in the map (indicated with red arrows) are areas already in critical state that must be preserved in order to avoid any habitat isolation within biological corridors.

5.5.5.5 Watersheds

Streams and watersheds in the region are scarce and influenced by the climate regime, which is usually dry during most of the summer and fall, with rains prevalent in the winter months. In recent years, water in the natural environment, as well as drinking water from wells, has been suffering a major overdraft. Annual rain averages up to 900mm/year in the north of the country and around 25mm in the southern end of the Negev. Simultaneously, in past decades, industrial discharges, over-exploitation of water resources, and poor management have created unsustainable conditions. Consequently, rivers in Israel have suffered from severe conditions that in many cases caused streams to dry up or to become very polluted.

However, the situation began to change in the past 15 years and particularly in 1993 when the National River Administration was established (source: Israel Ministry of Environment's website). The role of this administration is multiple, including: inter-governmental coordination for activities that have a direct or indirect effect on Israel's streams; management of restoration and conservation activities, as well as renovation of historic sites along river banks. In order to effectively coordinate the activities of various government agencies this Administration includes representatives of the Ministry of Interior, Tourism, Environment, National Park Authorities, the Jewish National Fund (which among other activities has a large program for reforestation along rivers), and the National Infrastructures (water commission). Due to its important role, it is crucial that any final design of alignment and alternatives that will cross over streams or creeks be developed in coordination with this Administration.

5.5.5.6 Migratory Species and their Habitats

Open spaces and water sources are key habitats used by migratory species (particularly birds), which use Israel as an international corridor for migration. Israel is a crossroads for intercontinental bird migration on a North-South axis. The conservation of these habitats is of crucial importance for the successful migration of these species. Many migratory birds depend almost exclusively on these habitats as a source of water and resting stations. During seasonal migrations it is possible to observe resting stations concentrated almost exclusively in the vicinity of water bodies such as lakes, ponds, and running streams. Other factors affecting biota migration include habitat reduction and fragmentation; disturbance; pollution and pesticides.

As a signatory member of the Convention on the Conservation of Migratory Species, Israel prepares (voluntarily) updated reports on the presence of these species. The Israel Nature and National Parks Reserve Authority is the responsible government Agency. The environmental laws under which this Agency regulates its activities and has the authority to preserve these migratory species are:

Wildlife Protection Law, 1955 (as amended in 1990)
Plant Protection Law, 1956
Water Law, 1959
Streams and Springs Authorities Law, 1965
Planning and Building Law, 1965
Prevention of Marine Pollution by Oil Ordinance, 1980
Planning and Building Regulations (Environmental Impact Statements), 1982
Prevention of Marine Pollution (Dumping of Waste) Law, 1983
Prevention of Marine Pollution from Land Based Sources Law, 1988
Hazardous Substances Law, 1993
National Parks, Nature Reserves, Memorial Sites, and National Sites Law, 1998 (first enacted 1963, revised 1992 and 1998) ("the Nature Reserves Law")

Other Conventions that Israel is signatory to and oblige the country to protect migratory species and their habitats include:

Convention on Wetlands of International Importance ("Ramsar Convention")
Convention on Biological Diversity
Convention for the Protection of the Mediterranean Sea against Pollution (Barcelona Convention)
Convention on Climate Change
Convention on International Trade of Endangered Species of Wild Fauna and Flora ("CITES")
World Heritage Convention
Convention to Combat Desertification

The national policy instruments available to the Nature and Park Authority include:

National protected areas: nature reserves and national parks.
National Strategy for the Conservation of Nature and Biodiversity
National Plan for the Conservation of Bats

In the Period 2000-2001 the Nature and Park Authority reported the following information on sightings of migratory birds:

Birds Observed Nesting or Transient in the Region

Pelecanus crispus – Common Name(s) Dalmatian Pelican
Pelecanus onocrotalus – Common Name(s) White Pelican
Anser erythropus – Common Name(s) Lesser White-fronted Goose
Branta ruficollis – Common Name(s) Red-breasted Goose
Marmaronetta angustirostris – Common Name(s) Marbled Teal
Aythya nyroca – Common Name(s) Ferruginous Pochard/Ferruginous Duck
Oxyura leucocephala – Common Name(s)White-headed Duck
Halaeetus albicilla – Common Name(s) White-tailed Eagle
Aquila clanga – Common Name(s) Spotted Eagle
Aquila heliaca – Common Name(s) Imperial Eagle
Falco naumanni – Common Name(s) Lesser Kestrel
Vanellus gregarius – Common Name(s) Sociable Plover
Numenius tenuirostris – Common Name(s) Slender-billed Curlew
Larus leucophthalmus – Common Name(s) White-eyed Gull
Larus audouinii – Common Name(s) Audouin's Gull
Serinus syriacus – Common Name(s) Syrian Serin

Some of these species were observed during the winter waterfowl census and it is important to emphasize that there is a possibility that they may be two distinct wintering and breeding populations. Some populations are showing a clear decline in numbers. In the case of *Falco naumani* (lesser Kestrel), the survey done in the year 2000 showed an estimated 550 nesting pairs, approximately 10% of the population in the 1950's.

This report also discusses migratory marine mammals and marine turtles but the information is not relevant for this study.

5.5.6 Data Gaps

At this stage of the project in which further information remains to be retrieved and evaluated (an official line of communication between our team and those Agencies holding information is being kept open), it is not possible to clearly determine any data gaps. Due to the advance level of scientific level in Israel and extensive publications on environmental and biological issues, the team believes that potential data gaps would be resolved in the coming weeks.

5.6 Existing Socio-economic Conditions

5.6.1 Outline of Intended Social Analysis

(Due to a delay in the flow of information from government agencies, this section of the report provides a brief description of efforts completed till delivery of this Progress Report and on-going and future activities)

The social analysis will consist of the following phases:

1. **Phase I:** Definition of the scope of the study and the physical boundaries of the study area, as well as initial gathering of background data (**on-going**).

2. **Phase II:** Site-visit to the study area, follow up data gathering and key informant interviews with Government of Israel (GOI) officials, local communities, research institutions and members of civil society (**January 2006**).

3. **Phase III:** Production of "scoping level" social analysis report (**end of project**), as a component of the environmental impact analysis. The social analysis will identify potential adverse social impacts within the defined study area and specify the method (recommendations) to be used for a more thorough investigation of social issues (including resettlement if necessary) in future environmental studies. Recommendations will be made on ways to mitigate potential adverse social impacts of the proposed alignments of the Gaza-West Bank Connector.

5.6.2 Activities to Date/Definition of Scope and Study Area boundaries

The social analysis commenced in November 2005 with the initial contacts established at Government Agencies. It continues in December 2005 with the mobilization of an Israeli Sociologist to assist with a survey of secondary sources and to gather other available background data. The focus of the first week of initial data gathering was the social, economic and recent historical context of the Sha'ar Hanegev (see Figure 5.9 showing the boundaries of the Sha'ar Hanegev) and adjacent areas that fall within the area of influence of the proposed alignments. Data was also gathered regarding local education and health facilities in order to ensure that the proposed alignments do not impair the surrounding community's access to these facilities.

The scope of the social analysis is defined as a preliminary or "scoping level" assessment, as a component of the environmental scoping statement. The social analysis will provide a detailed "snapshot" of the social, economic and political conditions of the study area, as well as identify the most significant potential social impacts of the proposed alignments. The social analysis will provide recommendations that mitigate adverse impacts and provide the method used for the full social analysis, including resettlement (if necessary) that will be required prior to construction.

The study area for the social analysis is defined as the area of the alignments and surrounding communities within a zone of influence[16] from the border of Gaza to the border of the West Bank. The

[16] The zone of influence (ZOI) will be defined during the expatriate Sociologist's field mission in Israel. There is no specific correct width for a zone of influence. The appropriate definition of a ZOI needs to consider a combination of factors relating to the characteristics of the road itself and the characteristics of the population around it (e.g. population density, spatial dispersion of the population, type of economic activity, etc.).

study area for the social analysis is limited to only Israeli territory, rather than including the social impact of the project in Gaza and the West Bank.

5.6.3 Preliminary Information and Background on the Sha'ar Hanegev

The Sha'ar Hanegev Region is in Israel, consists of an area of 45,000 acres located on the border of the Gaza Strip and constitutes, as it Hebrew name implies, the "Gate to the Negev" region of the country. A number of developments exist in the region, including 10 kibbutzim, one moshav settlement, "Havat Shikmim" (Prime-Minister Sharon's ranch) and the Ibim San-Diego student village**.** There are approximately 1,700 households and 6,000 citizens living in the Sha'ar Hanegev[17]. The communities have a number of accompanying educational and industrial facilities including a university, a large community center and an industrial park. The area has great appeal as a destination for hiking and camping and is considered to contain some of the premier "Open Spaces" in the northern Negev desert.

The Sha'ar Hanegev is entering a new and challenging era. The economy of the region has undergone a shift away from traditional activities in agriculture with a significant percentage of more recent employment being generated in the service and manufacturing sectors. Most of the communities are also undergoing significant structural changes including planning for new neighborhoods and additional industrial estates to attract foreign investors. Since the outbreak of the intifada in September 2000, hundreds of Kassam rockets have fallen in the backyards of local houses in the area. Security is a major concern due to the inability of the Israeli army to stop the Kassam attacks, which have intensified after Israel's withdrawal from Gaza.

[17]Source: Ministry of Industry, Trade and Labor website (http://www.moit.gov.il/).

Figure 5.9. Sha'ar Hanegev (This map does not reflect recent withdrawal of Israeli settlements from Gaza)

5.6.4 Employment and Commercial Activity

Scattered throughout the whole of the Sha'ar Hanegev are businesses supporting the employment of approximately 3000 individuals[18]. There are several factories specializing in the production of plastics, food and metal. In addition, each kibbutz has well-developed agricultural areas that extend over thousands of acres. The "scoping level" social analysis report will provide greater detail regarding which industries provide the most employment and how proposed alignments may affect agricultural and commercial activity.

One of the main commercial and manufacturing facilities is the Sapirim Industrial Park, which is located at the center of the Sha'ar Hanegev. The region is considered to be a national priority area[19], which confers tax breaks and other advantages for investors willing to locate in the region. One additional advantage is a surplus of human capital in the form of large numbers of young academics eager for new jobs.

5.6.5 Social Assistance

Due to the difficult economic situation in the region, the Department of Social Services assists up to 80% of the population in some communities. During Phase II, the social analysis will identify which communities receive the most assistance and ensure that the project does not impair access to social services. The Association for the Elderly provides for the well being of the elderly by improving the services they receive and offers various community services including a center for seniors.

5.6.6 Preliminary Survey of Education Facilities

The following is a partial listing of a number of key educational facilities in the region. The goal of the survey of education facilities is to ensure that proposed alignments do not negatively impact the access of residents to education. A more detailed survey will be undertaken during Phase II of the social analysis, as the list presented in this report is preliminary and solely based initial background research.

- Chas Sapir College of the Negev: This college was established in 1975 and is currently the largest public college in Israel with about 7,000 students.

- "Beit Chinuch": "The local community school in the Sha'ar Hanegev. Pupils in Grades 1 to 12 come from throughout the Sha'ar Hanegev region, including the towns of Hof, Ashqelon, Sderot, and other areas in the northern Negev.

- Regional Dance Studio: The Regional Dance Studio teaches different styles of dance including a classical dance curriculum based on the program of the Royal Academy in London.

- Ibim Immigrant Student Village: Since opening its doors in 1992, Ibim has been operated by the Jewish Agency for Israel's Immigration and Absorption Department. The United Jewish Federation of San Diego County adopted the village in 1998, providing for the welfare and daily lives of its residents. In addition to low-cost student apartments, the Village provides for the residents day-to-day needs with a dining room, a grocery store and a launderette.

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[18] Source: Ministry of Industry, Trade and Labor website (http://www.moit.gov.il/).

[19] The region is referred to as a "Development Zone A" by the Israeli Government, which confers tax and other advantages for investors.

- The Experimental Elementary School: Close to 700 children drawn from three regional councils attend first to sixth grades in the elementary school.

5.6.7 Preliminary Survey of Health Facilities

As stated earlier with the survey of education facilities, this is a partial list. A more complete list of facilities that may be impacted by the project will be included in the social analysis.

- Hydrotherapy Care Center: A hydrotherapy care center was built inside the area of the Sapir educational center. The physics center is fully equipped to allow diagnosis and proper physiotherapy care. These treatments embrace all fields needed for physical rehabilitation: orthopedic, pediatric, geriatrics etc.
- Women's Health Center.
- "Night Watch" Health Center that provides round the clock treatment for the Sha'ar Hanegev.

5.6.8 Outline of Initial Data Gathering Activities

The Israeli Sociologist is gathering data on the following subjects in support of this study:

- Population sizes for the entire Sha'ar Hanegev Region and adjacent areas
- Population structure (age groups, work force, occupation, settlement sizes).
- Types of industrial and commercial activity.
- Income distribution of residents in the Sha'ar Hanegev and Israel as a whole.
- Prevalence of poverty among residents in the Sha'ar Hanegev and Israel.
- Government of Israel definition of the poverty line.
- Percentage of farm land affected.
- Number and location of regional schools.
- Number and location of health centers.
- Affect on free passage of hikers and nature aficionados into "Open Spaces".
- Water supply and irrigation systems in close proximity to proposed alignments that might be affected.

The Berger Team will also contact the following organizations, as necessary, to gather data and arrange meetings ahead of the arrival of the expatriate Sociologist.

- Central Bureau of Statistics
- Ministry of the Interior
- Ministry of Transport
- Sha'ar Hanegev Regional Council
- Academic Researchers responsible for the Israel 2020 Master Plan
- Ministry of Environment
- Ministry of Tourism
- Ministry of Agriculture and Local Development

5.7 Existing Cultural Resources Conditions

5.7.1 Regulations and Guidelines

The Antiquities Law of 1978 (Israel Government 1978) was enacted in order to protect the antiquities of Israel. Antiquities are considered to be any object which was made by man before 1700 of the Christian Era (CE), or any zoological or botanical remains from before the year 1300 CE. The law is organized into the following chapters that outline the ownership, excavation, and handling of antiquities items, as well as civil penalties that can be imposed under the law:

- Chapter One: Interpretation
- Chapter Two: State Ownership of Antiquities
- Chapter Three: Excavations
- Chapter Four: Dealing in and Export of Antiquities
- Chapter Five: Collectors of Antiquities
- Chapter Six: Museums
- Chapter Seven: Antiquity Sites
- Chapter Eight: Expropriation
- Chapter Nine: Archaeological Council and Objection Committee
- Chapter Ten: Offences and Penalties
- Chapter Eleven: Miscellaneous

The Israel Antiquities Authority (IAA) was established in 1989 by the Law of the Israel Antiquities Authority (Israel Government 1989). That law states that the IAA is the organization responsible for all the antiquities of the country, including the underwater finds. The IAA is authorized to excavate, preserve, conserve and administrate antiquities when necessary. The IAA is the agency through which all cultural resources investigations within the country are coordinated.

Cultural heritage sites in the Palestinian territories of Gaza and the West Bank fall under the jurisdiction of the Department of Tourism and Antiquities. Draft Bill no.(6) of 1999 for Environment includes Article 44 banning activities that endanger "historical and archaeological sites or affect the aesthetic level of such areas" (Palestinian National Information Center 2005).

The significance of cultural heritage sites is also recognized by international conventions, particularly the International Council on Monuments and Sites (ICOMOS) Charter for the Protection and Management of the Archaeological Heritage (ICOMOS 1990) and other documents referenced therein. The provisions outlined in that charter parallel provisions contained in the Israel Antiquities Law and the Law of the Israel Antiquities Authority.

5.7.2 Interviews with Government Officials

Dr. Ariel Cuschnir, Berger Environmental Specialist, contacted Dr. Uzi Dahari, Deputy Director for Archaeology for IAA, during the month of November 2005. –He delivered a letter on behalf of the cultural resources team introducing the project and requesting his assistance in gathering information regarding known cultural resources in the study area. Dr. Dahari was subsequently contacted via telephone on 12 December 2005 by Berger's cultural resources team to further discuss the project. Dr. Dahari agreed to assist the team and provide a georeferenced GIS database and other information that the IAA has on known cultural resources in the study area. Information was emailed to Dr. Dahari on 16 December 2005 showing geographic boundaries of a study area containing all of the alternatives

(individual alternatives were not shown) and the cultural resources team is currently awaiting GIS shape files from the IAA.

No systematic cultural resources investigation has been conducted in-country by the Berger team, and none are planned for the current level of investigation. Based on the results of the current study, recommendations will be made for intensive investigations of the preferred alternative(s).

5.7.3 Cultural Resources

The term cultural resources includes individual objects as well as antiquity sites that are defined as areas declared by the Director of the IAA to contain antiquities. Individual objects include items such as statuary, a pot or metal tool, or a scroll. The most visible type of site in the study area is the *tel* or *tell*. A tel represents hundreds or thousands of years of continuous occupation at the same location that resulted in layer upon layer of debris from successive occupations. A tel is an artificial mound consisting of the accumulate remains of ancient settlements. The accumulation of debris that is the mound may range from 10-15 meters to a hundred meters or higher with a footprint that covers 10 hectares or more. The earliest and most deeply buried settlement at a tel may date back thousands of years.

Archaeological sites may also be the remnants of structures on the ground surface. Such sites are frequently prefaced with the word *Horvat*. Natural or human-made caves that were frequently mortuary chambers may be found associated with tels and ruins. Simple scatters of artifacts consisting of chipped stone tools and chipping debris, pottery, and metal artifacts also constitute archaeological sites. Extant structures including mosques, churches, synagogues, memorials, and other standing structures that are part of the cultural patrimony of the region also constitute potentially significant cultural resources.

5.7.4 Cultural Chronology

Library research was conducted in the United States to establish the basic cultural history of the region and determine, to the extent possible with publicly available information, the known cultural resources in the study area. The study area is part of a larger region that can be referred to as the Levant, encompassing an area that includes the modern nations of Israel and Jordan, and the Palestinian Territories. The culture history of the region has great time depth, extending back more than 1.5 million years, and documents much of human physical and cultural evolution over that time. Table 1 is a chronological table of the prehistoric and historical cultural context of the region following Stern et al. (1993). The dates are presented as Before Christian Era (BCE) and Christian Era (CE). Different dates may be given for periods and cultures in subregions and at individual archaeological sites, but the framework presented here is broadly applicable to the entire region (Bar-Yosef 1994).

The Paleolithic is divided into three periods. During the Lower Paleolithic, early species of the genus *Homo (ergaster, erectus, heidelbergensis)* making Oldowan pebble tools and Acheulian handaxes, emigrated from Africa through the Levant. An early population, from about 1.8 million years ago, is known from Dmanisi in Georgia; their ancestors' migration route must have taken them through the Levant. Lower Paleolithic site in Israel include Ubeidiya in the Jordan Valley (ca. 1.5 million years old) and Erk el Ahmar (about 1.7 to 2 million years old. Middle Paleolithic (Levallois/Mousterian) flake tools are associated with Neandertals in Israel (e.g., at Amud, Kebara) from about 200,000 to 50,000 years ago. There was a brief interlude at about 10,000-90,000 before present when anatomically modern *Homo sapiens* intruded from East Africa into the Levant, but they appear to have been displaced by Neandertals. A much later successful expansion of H. sapiens into the Levant and Europe about 40,000 years ago is marked by the spread of Upper Paleolithic stone tools of Aurignacian type (Shea 2005).

TABLE 5.3

REGIONAL PREHISTORIC AND HISTORICAL ARCH ARCHAEOLOGICAL CHRONOLOGY

	Period	Culture	Approx. Dates (BCE)
Prehistoric Archaeological Periods			
	Lower Paleolithic	Oldowan Acheulian	1,800,000-200,000
	Middle Paleolithic	(Levallois/Mousterian	120,000-45,000
	Upper Paleolithic	Phase I (Emireh, Boqer Tahtit)	45,000-35,000
		Phase II (Ahmarian Tradition) Phase III-V (Aurignacian Tradition)	35,000-18,000
	Epipaleolithic (Mesolithic)	Kebaran Geometric Kebaran Natufian	18,000-8300
	Pre-Pottery Neolithic	Phase A Phase B Phase C	8300-5500
	Pottery Neolithic		5500-4500
	Chalcolithic	Early Phase Ghassulian Phase	4500-3300
Historical Archaeological Periods			
	Bronze Age (Canaanite Period)	Early Bronze Age IA-B	3300-3000 BCE
		Early Bronze Age II	3000-2700
		Early Bronze Age III	2700-2200
		Middle Bronze Age I	2200-2000
		Middle Bronze Age IIA	2000-1750
		Middle Bronze Age IIB	1750-1550
		Late Bronze Age I	1550-1400
		Late Bronze Age IIA	1400-1300
		Late Bronze Age IIB	1300-1200
	Iron Age (Israelite Period)	Iron Age IA	1200-1150
		Iron Age IB	1150-1000
		Iron Age IIA	1000-900
		Iron Age IIB	900-700
		Iron Age IIC	700-586
	Babylonian and Persian Periods		586-332
	Hellenistic Period	Early Hellenistic Period	332-167
		Late Hellenistic Period	167-37
	Roman and Byzantine Periods	Early Roman Period	37 BCE-132 CE
		(Herodian Period, 37BC-70 CE)	
		Late Roman Period	132-324
		Byzantine Period	324-638
	Early Arab to Ottoman Periods	Early Arab Period (Umayyad and Abbasid)	638-1099
		Crusader and Ayyubid Periods	1099-1291
		Late Arab Period (Fatimid and Mameluke)	1291-1516
		Ottoman Period	1516-1917

The Epipaleolithic was a time when wild cereals and legumes were being "managed" by people (Bernbeck and Pollock 2005:12-15) and provided sufficient food resources to spark the transition from a hunting-gathering way of life to settled village life manifest in the Natufian culture. From that managing of wild foods came the eventual domestication of plants and animals and the so-called "Neolithic Revolution." By Pre-Pottery Neolithic times villages displayed an array of non-domestic structures (such as the stone tower at Jericho) and ritual artifacts that point to elaborate communal and regional ritual practices. At the end of the Pre-Pottery Neolithic period there appears to have been a collapse of the social order, perhaps brought about by climatic deterioration and over-exploitation of resources (Gopher 1995:207). Introduction of ceramic technology of the Pottery Neolithic was accompanied by population shifts and smaller settlements.

The Chalcolithic period saw population increase and the expansion of mixed farming/herding communities into semi-arid regions (Levy 1995). Craft specialization developed, including copper metallurgy, and archaeological sites of different sizes form a hierarchy that suggests a chiefdom level of social organization. With the Early Bronze Age came the beginning of urban culture. The term also reflects the use of the metal bronze, but in the regions of Palestine that metal was not common until early in the second millennium BCE (Ben-Tor 1992:81). The Early Bronze Age settlement pattern shifted from the semi-arid regions favored during Chalcolithic times back to the hills, plains, and valleys where a more Mediterranean climate prevailed. Gophna (1995) notes, however, that there are Early Bronze Age sites situated on top of Chalcolithic sites where there was abundant water and where the land had already been cleared and prepared for cultivation.

The Middle Bronze Age was a time of growing population, intensification of agriculture and craft production, and development of regional exchange systems. A hierarchy of settlements included regional centers, subregional centers or specialist production facilities, villages, and farmsteads (Ilan 1995). The Palestine region was clearly linked to Egypt by political and economic interests (Kempinski 1992). Canaanite rulers became so powerful that they conquered much of Lower Egypt, ruling from about 1720 to 1560 BCE The Middle Bronze Age came to an end when the native Egyptians overthrew the Hyksos and Egypt was reunited under the Pharaoh Ahmose, who began a series of military campaigns across the Sinai Peninsula (Gonen 1992). The military forays brought about a decline in the urban culture and population, but they also opened the region to Egyptian religious and artistic influence that led to changes in burial customs and developments in artistic styles during the Late Bronze Age (Gonen 1992:257). The Late Bronze Age represents a peak of cultural and economic interaction in the eastern Mediterranean basin.

The term "Iron Age" reflects the transition from bronze to iron as the dominant metal used for tools and weapons. At the end of the Late Bronze Age the international trade networks collapsed and Iron Age IA trade was much more regional (Mazar 1992). The origins of the Israelite people in the hill country are dated to this period (ca. 1250 BCE), although the relative importance of nomad invasion and native Canaanite peasant expansion in this process of ethnogenesis has been much debated. Israelite culture flourished briefly under the legendary united monarchy of David and Solomon and subsequently in the divided kingdoms of Israel and Judah (Barkay 1992). The southern coastal region was occupied around 1200 BCE by the Philistines, originally from the Aegean. The end of the Iron Age is marked by the fall of Jerusalem and destruction of the Temple in 586 BCE. The Persian and Hellenistic periods that followed saw a transition of the material culture of the Palestine region. In the coastal region (formerly Philistine territory) there are distinct Greek and Cypriot influences on material culture, while in the mountains of Judea and Transjordan the Israelite Tradition continued (Stern 1995).

After 100 years of independence under the Hasmoneans, during the Roman period an imperial government was imposed on the region. Under "*pax Romana*," the Judaeans continued to develop as a

distinct culture (Anderson 1995). Jewish resistance to Roman rule culminated in massive failed revolts in 66 CE, 115 CE (in diaspora communities), and 132 CE.

The Byzantine Period saw the transformation of the region from *Provincia Palaestina*, a remote eastern province of the Roman Empire, to *Terra Sancta*, the Holy Land (Patrich 1995). A network of holy places, churches, and memorials was established and pilgrims flocked to the region. This led to a great increase in population, particularly the Christian population. The Byzantine period was one of economic prosperity in the region, and archaeological surveys consistently turn up a high number of settlements and installations from that period (Patrich 1995:473).

The Arab conquest of the Holy Land made Islam the dominant religious and cultural power. Repeated military movements, internal revolts, and political instability led to chronic anarchy and general cultural decline (Whitcomb 1995:488). A 200-year period of Frankish rule began with the First Crusade, ca. 1099 CE, and ended in 1291 CE after the Third Crusade and the fall of Acre (Ellenblum 1995). There followed a 700-year period when the region was under the control of Ayyubid, Mameluke, and Ottoman empires (Rosen-Ayalon 1995), and the Holy Land was caught in the sway of Damascus, Cairo, or Istanbul, depending on the period. This period ended in 1917 CE with the end of World War I, dismantling of the Ottoman Empire, and the beginning of the modern era.

5.7.5 Known Cultural Resources

Pending receipt of data from the IAA, 1:250,000 topographic maps from the Survey of Israel dating to ca. 1960 were examined for known cultural resources (Survey of Israel 1961). A study area that encompasses all of the alternatives and extends approximately three kilometers beyond the alternatives was defined. Within that study area, 65 cultural sites are shown on the map. Mosques, synagogues, churches and other religious and cultural sites that are of unknown antiquity but likely in current usage are also included on the map.

The most prominent type of site is perhaps the tel. Among the most prominent of tels in the study area is Lachish in the northeast part of the study area. Lachish covers some 12 hectares at the edge of a wadi that, in antiquity, was a major route from the Coastal Plains to the Hebron Hills. Several wells provided water for the city, and the city was surrounded by fertile land. Each of those factors contributed to the development of a major urban center. Excavations began in 1932, the most recent worked ended in 1981. Occupation at the site began in the Pottery Neolithic period and extended through the Hellenistic period.

Tel Haror, in the south-central part of the study area, covers some 16 acres at the edge of a wadi and was on the main road from Gaza to Beersheba. The site consists of two superimposed tels with the upper tel occupying the northern part of the lower tel. Excavations conducted between 1982 and 1990 found evidence that the site had been occupied since the Chalcolithic period, with its main periods of occupation in the Middle Bronze Age II, the entire Late Bronze Age, and the early and late parts of the Iron Age.

Bet Gurvin is an archaeological site and National Park in the northeast part of the study area. The site dates from more recent times and flourished during the Roman period. The site includes an amphitheater, a Roman inn, a Crusader-period church, a Mameluke period fortress, and spectacular hewn caves that served as burial chambers, water cisterns, and olive presses.

Among the surface sites to be found in the study area is Gerar Site E that is a Chalcolithic and Late Bronze Age site covering some seven hectares at the confluence of two wadis. One small structure and numerous pits have been excavated. Horvat Rimmon is a 10-hectare site in the southeast part of the study area. The site was occupied during Roman and Byzantine times.

5.7.6 Data Gaps

The cultural resources team is awaiting current information on archaeological and cultural resources from the IAA. It is expected that the IAA data will provide additional data on the nature of the cultural resources already identified, as well as highly accurate locational information and data on sites recorded and investigations that have taken place since the 1960's.

Because the states of Palestine and Israel have long been studied as a single cultural area by archaeologists, it is expected that the information gathered during background research and provided by the IAA will include data on cultural heritage sites in the Palestinian territories. However, additional efforts can be made to contact the appropriate offices in the Palestinian Authority to request information they may have regarding cultural heritage sites under their control

5.7.7 Selection and Screening of Impact Drivers for Screening the Alignments and Future Alternatives.

5.7.7.1 Known and Expected Cultural Resources

Sixty-five previously recorded cultural heritage sites have been identified in the study area. Those sites are listed on Table 5.4. Pending receipt of additional data for the Israel Antiquities Authority (IAA), it is not clear how many of these cultural sites were identified through systematic archaeological survey, or even how much systematic archaeological survey has been conducted in the study area.

Additional unrecorded cultural sites can be expected in the study area. Those sites are likely to be smaller, less obvious surface structural remains and artifact scatters that will require professional archaeologists to identify and record. Such sites also have the potential to contain important archaeological data.

5.7.7.2 Relationship of Known Cultural Heritage Sites to Alternatives

Forty-two cultural heritage sites are within approximately 300 meters of one or more alternative (see Table 5.4), and no alternative is more than approximately 300 meters from a known cultural heritage site (Table 5.5). The number of sites within that proximity to a given alternative varies. The northern part of the study area is perhaps most problematic regarding cultural resources, for there is a high density of cultural heritage sites. The central part of the study area has a lower density of cultural heritage sites, and the southern part of the study area has the lowest density of sites.

Because it is not known how much systematic archaeological survey has take place in the study area, it is also not known how many unrecorded archaeological sites may be present. Lachish represents a large town with a very long occupational history that probably was surrounded by a complex settlement system. Some of that settlement system may be reflected in the distribution of known sites, but systematic survey could identify additional sites important to our understanding of regional settlement and economic systems.

TABLE 5.4

KNOWN CULTURAL SITES IN STUDY AREA

SITE NAME	MAP UNIT	ALTERNATE POTENTIALLY AFFECTING SITE
Tel el ‘Ajjul	B-21	--
Mefallesin, Tel	C-20	3, 4, 4A
Shihan, Tel	C-21	--
Berekha, Horbat	D-20	3, 4, 4A
Beror, Tel	D-20	1
Hoga, Horbat	D-20	3, 4, 4A
Kefar Se’ora, Horbat	D-20	1, 2, 2A, 2B
Neged, Horbat	D-20	1, 2, 2A, 2B
Bét haGaddi, Horbat	D-21	
Bohu, Horbat	D-21	
Kofha	D-21	
Mifsah, Tel	D-21	3, 4, 4A
Mihraqa	D-21	--
Qazin, Horbat	D-21	--
Haror, Tel	D-22	6
Shemarya, Horbat	D-22	6
Sera, Tel	D-22	
Unnamed ruin	E-19	1
Hasi, Tel	E-20	2, 2A, 2B
Bilhan, Horbat	E-20	
‘Elga, Horbat	E-20	1
Gemama, Horbat	E-20	3, 4, 4A
Leqesh, Horbat	E-20	1
Nagilal, Tel	E-20	3
Pura, Horbat	E-20	3
Qeshet, Tel	E-20	2, 2A, 2B
Sheqef, Tel	E-20	2, 2A, 2B
‘Amudeya, Horbat	E-21	5
Kelekh, Horbat	E-21	3
Milha, Tel	E-21	4, 4A
Baqar, Horbat	E-22	6
Ma’aravim, Horbat	E-22	6

SITE NAME	MAP UNIT	ALTERNATE POTENTIALLY AFFECTING SITE
Petora, Horbat	F-19	1
Unnamed ruin	F-19	--
‘Eter, Tel	F-19	1, 2, 2A, 2B, 3
Keroa, Horbat	F-19	1, 2, 2A, 2B, 3
Kefar Lakhish, Horbat	F-20	1, 2, 2A, 2B, 3
Lakish, Tel	F-20	1, 2, 2A, 2B, 3
Ma’aglan, Horbat	F-20	1, 2, 2A, 2B, 3
Ma’ahaz, Mishlat	F-20	3
Migdlit, Horbat	F-21	5
Kishor, Horbat	F-21	4, 4A
Magdil, Horbat	F-21	3, 4, 4A, 5
Moran, Horbat	F-21	3, 4, 4A
Kelekh, Tel	F-21	--
Barod, Horbat	F-22	6
Halif, Tel	F-22	6
Tilla, Horbat	F-22	6
Remalya, Horbat	F-22	6
Bét Guvrin	G-19	1, 2, 2A, 2B, 3
Kefar Bish, Horbat	G-19	1, 2, 2A, 2B, 3
Maresha, Tel	G-19	1, 2, 2A, 2B, 3
Qerumit, Horbat	G-19	--
Quqiyya, Horbat	G-19	--
Unnamed ruin	G-19	--
Unnamed ruin	G-19	--
Unnamed ruin	G-19	--
Unnamed ruin	G-19	--
Gibbor, Horbat	G-19	1, 2, 2A, 2B, 3
Bét ‘Elem, Horbat	G-20	--
Horesh, Horbat	G-20	--
Lehem, Horbat	G-20	--
Unnamed ruin	G-21	--
‘Anav, Horbat	G-22	--
Sansanna, Horbat	G-22	--

TABLE 5.5

ALTERNATIVES AND NUMBER OF CULTURAL HERITAGE SITES IN CLOSE PROXIMITY

ALTERNATIVE	NUMBER OF CULTURAL HERITAGE WITHIN APPROX 300M
1	15
2	14
2A	14
2B	14
3	18
4	9
4A	9
5	3
6	8

5.7.7.3 Recommendations for Additional Cultural Resource Investigations

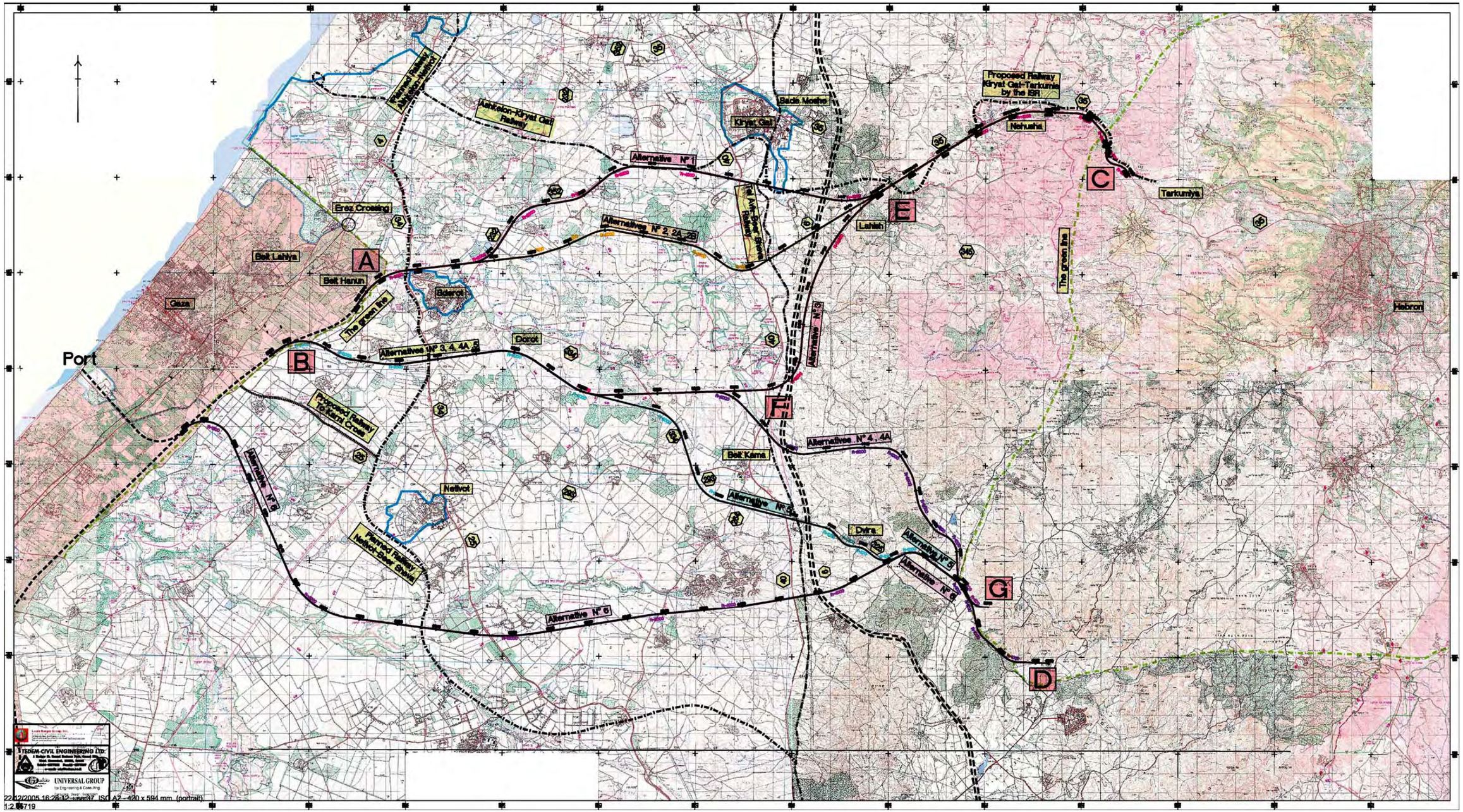
A staged approach to cultural resource investigations is recommended. All work should be done in consultation with the Israel Antiquities Authority (IAA) and appropriate Palestinian Authority agencies to ensure that provisions laid out by those agencies for the conduct of archaeological investigations are followed. Prior to beginning work, a research design and work plan describing the procedures and parameters of the cultural resource investigations should be developed and submitted to those agencies for review.

Systematic archaeological identification survey of the preferred alternative will be required. The goal of the survey will be to relocate and update information on previously identified archaeological sites, and to identify any previously unrecorded archaeological sites that may be present. Upon completion of the survey, an evaluation of individual sites and the effects of the undertaking on those sites can be made. Where possible, the undertaking should be redesigned to avoid impacts to archaeological sites that are considered to be important to understanding regional history and prehistory. If impacts to important archaeological sites are unavoidable, mitigation measures should be taken that include archaeological excavation designed to recovered significant data prior to site destruction. Appropriate mitigation measures should be determined in consultation with the IAA and the Palestinian Authority.

5.8 Preliminary Screening/Adjustment of Proposed Alignments

Throughout the past few weeks Berger's environmental experts worked closely with the transport engineers in order to defining and adjusting proposed alignments. In some cases, topography was one of the important drivers, particularly for railroad alignment selection. This was particularly true for the eastern portion of the region at the foothills of Judean Mountains where topographic conditions limited in some cases the deployment of a railroad line. In other areas such as the coastal plains, the main driving factors were avoidance of critical areas and minimization of environmental impacts. Based on the information gathered until now, it was possible to develop a map, which shows the current location of proposed alignments and the critical areas (environmental and cultural resources) that are being avoided or that will require mitigation measures. As more environmental information becomes available these alignments may suffer additional changes.

The following map (Figure 5.10) shows proposed alignments and their location in relation to nature reserves, forests, and other protected areas (green shaded), main urban centers (blue circled), and important streams and water-bodies:


Port
Gaza
Beit Lahiya
Beit Hanun
Erez Crossing
A
B
C
D
E
F
G
Sderot
Dorot
Netivot
Beit Kama
Dvira
Lehiim
Kiryat Gat
Beide Moshe
Nehusha
Tarkumiya
Hebron
The green line
Alternative N° 1
Alternatives N° 2, 2A, 2B
Alternatives N° 3, 4, 4A, 5
Alternative N° 4, 4A
Alternative N° 5
Alternative N° 6
Alternative N° 7
Alternative N° 8
Alternative N° 9
Proposed Railway Tokami Cross
Planned Railway Netivot-Beer Sheva
Ashkelon-Kiryat Gat Railway
Kiryat Gat-Beer Sheva Railway
Proposed Railway Kiryat Gat-Tarkumia by the ER
TEDEM-CIVIL ENGINEERING LTD.
UNIVERSAL GROUP
22/12/2005 16:28:12 - USER07 ISO A2 - 420 x 594 mm. (portrait)
1:2.55719

5.8.1 Proposed Alignments and Outstanding Environmental Issues

The proposed alignments are described in Section 3 of this Progress Report and were designed taking into consideration the environmental factors previously described in this document. A brief recap is provided below for the purpose of understanding outstanding environmental issues associated with each alignment.

Alignment 1: This **rail only, road only or combined multi-modal** alignment utilizes a corridor mostly defined by existing roads, and a short section of an existing freight railway. Exiting the Gaza Strip at its northeastern extremity, and avoids the vicinity of Sderot by swinging in a large radius arc from a initial northeastern heading, to an easterly heading to intersect with Highway 352 near its junction with Highway 232. Hence, it parallels Highway 352 to the south to the above-mentioned railway, paralleling this also to the south for approx. 3.5 kms. From here, to avoid the built-up area of Kiryat Gat, an agricultural region to the east of Kiryat Gat, and an unnecessarily curvilinear alignment, the route heads easterly to connect north of Lahish with Highway 35. It parallels this route to the south all the way to Tarkumiya. The mountain pass used by Hw 35 appears to offers also a suitable railway approach to Tarkumyia near Hebron without a tunnel, and under 1.3 percent gradient.

Some Outstanding Environmental Issues:

- Sufficient land-clearance area in existing roads without intrusion in new pristine habitats
- Impacts to agriculture land and economic drivers
- Proximity to urban centers and smaller settlements
- Impacts to communication/connectivity
- Impacts to Biological Corridors and Bio-Bottlenecks (explanations in subsequent sections)
- Proximity to the following Nature Reserves, Parks, and Forests:
    - Reches Gvaram Reserve
    - Kiryat Gat Forest
    - Malachim Forest
    - Beit Guvrin Forest
    - Gever Reserve
    - Nehusha Forest
    - National Park Beit Guvrin-Maresha
- Stream Crossings/Proximity;
    - HaShikma Creek
    - Guvrin Creek
    - Lachish Creek

Alignment 2: This alignment roughly follows a previously studied alignment chosen as a **sunken road only** alternative. It proceeds on the same course as Alignment 1 to the curve to the east, crossing Highway 232 and hence continuing easterly just to the north of the riverbed of Hashikma that carries water in winter time. This alignment avoids the separation of nearby communities from their fields, and could allow for gravity drainage of the sunken configuration into the Shikma Stream. Heading further east, it crosses over and parallels the Shikma Stream to the south, with similar advantages. It crosses Highway 40 and the Tel Aviv- Beer Sheva Railroad, avoiding several smaller communities south of Kiryart Gat to join the Alignment 1 alignment at highway 35 north of Lahish, and hence to Tarkumiya. In contrast with Alignment 1, this alignment studiously avoids any existing road or rail alignments.

Some Outstanding Environmental Issues:

- Impacts to agriculture land and economic drivers
- Proximity to smaller settlements
- Impacts to communication/connectivity
- Impacts to Biological Corridors and Bio-Bottlenecks (explanations in subsequent sections)
- Proximity to the following Nature Reserves, Parks, and Forests:
    - Reches Gvaram Reserve
    - Nachal Shikma Reserve
    - Beit Guvrin Forest
    - Gever Reserve
    - Nehusha Forest
    - National Park Beit Guvrin-Maresha
- Stream Crossings/Proximity;
    - Shikma Creek
    - Guvrin Creek
    - Lachish Creek

Alignment 2a: While initially conceived as a sunken alignment, it is possible to follow the same course as Alignment 2 at grade, and it is also possible to use a **rail road, road only, or combined multi-modal** alternative along this alignment.

Alignment 2b: The Consultants were asked to investigate a **road only or rail only tunnel** option, likely a cut and cover tunnel. A consideration for such an option would be to minimize the length of the crossing, placing it in the vicinity of Alignments 1 and 2 above. While the resultant length of a tunnel only alignment would be excessive, there could be scope for tunnel sections in the hilly region just outside of the Gaza border and north of Sederot, for 2-3 kms, and in the vicinity of the road and rail crossings south of Kiryat Gat, a distance of approx. 3 kms, leaving approx 33 kms of sunken or at grade alignment.

Some Outstanding Environmental Issues:

- Impacts to agriculture land and economic drivers
- Impacts associated with disposal of excavation materials
- Proximity to smaller settlements
- Impacts to communication/connectivity
- Impacts to Biological Corridors and Bio-Bottlenecks (explanations in subsequent sections)
- Proximity to the following Nature Reserves, Parks, and Forests:
    - Reches Gvaram Reserve
    - Nachal Shikma Reserve
    - Beit Guvrin Forest
    - Gever Reserve
    - Nehusha Forest
    - National Park Beit Guvrin-Maresha
- Stream Crossings/Proximity;
    - Shikma Creek
    - Guvrin Creek
    - Lachish Creek

Alignment 3: This **rail only, road only or combined multi-modal** alignment began as an attempt to follow Highway (Hw) 334 to Beit Kama to southwest, then proposed Hw 6 to the north and Hw 35 to the east. This route is longer than Alignments 1 or 2. To reduce the length, a western extremity alignment to the south of Sderot was selected. This follows an easterly course to join Highway 334 to the south and east of Dorot, avoiding villages but interfering with agricultural lands. In fact, a result is that it only parallels Highway 334 for a short distance before having to depart in an easterly direction far north of Beit Kama, to cross Highway 40 and the Tel Aviv- Beer Sheva Railroad, paralleling proposed Highway 6 and proceeding north to join the Alignment 1 and 2 alignments north of Lahish, and hence to Tarkumiya.

Some Outstanding Environmental Issues:

- Impacts to agriculture land and economic drivers
- Proximity to Sderot, Dorot, and smaller settlements
- Impacts to communication/connectivity
- Impacts to Biological Corridors and Bio-Bottlenecks (explanations in subsequent sections)
- Proximity to the following Nature Reserves, Parks, and Forests:
    - Givat Ruhama Reserve
    - Bitronot Ruhama Reserve
    - Dorot Forest
    - Pura Reserve
    - Beit Guvrin Forest
    - Gever Reserve
    - Nehusha Forest
    - National Park Beit Guvrin-Maresha
- Stream Crossings/Proximity;
    - Shikma Creek
    - Guvrin Creek
    - Lachish Creek

Alignment 4: This **rail only, road only or combined multi-modal** alignment began as an attempt to follow Highway (Hw) 334 to Beit Kama to the southwest, then Highway 325 south of Dvira and on to the southern extremity of the West Bank. It represented the first attempt to connect to the West Bank near Meitar, a location which would allow a more favorable possible future rail connection to the north through the West Bank. However, as was the case for Alignment 3, the western portion interferes with agricultural lands. In fact, a result is that it only parallels Highway 334 for a short distance before having to depart in an easterly direction far north of Beit Kama, to maintain a 1.3 percent maximum gradient alignment to Meitar. Even then, the alignment results in a 1.5 percent gradient, and necessitates the construction of a tunnel of a length of approx. 600 meters a few kilometers west of Meitar. It ends on Palestinian territory at a substantial distance south from Hebron, offering a connection to the West Bank that may have its own advantages from the point of view of future Palestinian rail transportation policies.

Some Outstanding Environmental Issues:

- Impacts to agriculture land and economic drivers
- Proximity to Sderot, Dorot, and smaller settlements
- Impacts to communication/connectivity

- Impacts to Biological Corridors and Bio-Bottlenecks (explanations in subsequent sections)
- Proximity to the following Nature Reserves, Parks, and Forests:
    - Givat Ruhama Reserve
    - Bitronot Ruhama Reserve
    - Dorot Forest
- Stream Crossings/Proximity;
    - Mefalsim Creek
    - Sad Creek
    - Shikma Creek
    - Migdalit Creek

Alignment 5: This **road only** alignment starts the same as Alignment 4, and follows Highway (Hw) 334 to Beit Kama to the southwest, and with the lower standards than a rail alignment can then follow Highway 325 south of Dvira and on to the southern extremity of the West Bank. Rejoining the Alignment 4 alignment at the Green Line, it can avoid the need of a tunnel through a careful selection of alignment a few kilometers west of Meitar. It ends on Palestinian territory at a substantial distance south from Hebron. Without offering a combined rail alternative, it offers arguably a less palatable alternative to those road alignments which terminate closer to the West Bank population centers, i.e.- at Tarkumiya.

Some Outstanding Environmental Issues:

- Impacts to agriculture land and economic drivers
- Proximity to Sderot, Dorot, and smaller settlements
- Impacts to communication/connectivity
- Impacts to Biological Corridors and Bio-Bottlenecks (explanations in subsequent sections)
- Proximity to the following Nature Reserves, Parks, and Forests:
    - Givat Ruhama Reserve
    - Bitronot Ruhama Reserve
    - Dorot Forest
    - Lahav Forest
    - Lahav Reserve
- Stream Crossings/Proximity;
    - Mefalsim Creek
    - Shikma Creek
    - Gerar Creek

Alignment 6: Other possibilities for further southern alignments were investigated. Existing route alignments are generally on a north-south alignment, which largely precludes the possibility of any such southern alignment being able to share a parallel alignment to these, lessening the attraction of any such route. The length of the route across Israeli territory also becomes longer.

Some Outstanding Environmental Issues:

- Impacts to agriculture land and economic drivers
- Proximity to smaller settlements
- Impacts to communication/connectivity
- Impacts to Biological Corridors and Bio-Bottlenecks (explanations in subsequent sections)
- Proximity to the following Nature Reserves, Parks, and Forests:

    - Michrot Beeri Reserve
    - Lower Gerar Creek Reserve
    - Lehavim Forest
    - Lahav Reserve
- Stream Crossings/Proximity;
    - Bohu Creek
    - Gerar Creek
    - Shmaryia Creek

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ANNEXES TO CHAPTERS 1, 3, AND 4
AE SERVICES FOR THE TRANSPORTATION FEASIBILITY FOR LINKING THE WEST BANK AND GAZA STRIP

ANNEX 1- 1
SCOPE OF WORK

(b) Within the estimated cost plus fixed fee specified in paragraph (a) above, the amount currently obligated and available for reimbursement of allowable costs incurred by the Contractor (and payment of fee) for performance hereunder is $1,066,856.00. The Contractor shall not exceed the aforesaid obligated amount.

(c) Funds obligated hereunder are anticipated to be sufficient through March 01, 2006."

b. The following changes are made to Section C:

1. In the first sentence of paragraph C.3, Scope of Work, change "nine activities" to read "ten activities".

2. In the tenth paragraph of C.3, change the word "Finally" to read "Ninth".

3. At the end of paragraph C.3, add the following

"Tenth, the Consultant will prepare an independent report entitled "Concept Design of a Tunnel Option" in accordance with the following Scope of Work:

"Concept Design of a Tunnel Option

1. Background

One of the possible methods of connecting the West Bank and Gaza Strip through Israel is through the construction of a tunnel. There are two possible types of tunnel configurations: all road solution and all railway solution. There are presently no long combined rail and road tunnels.

Four concept designs for a tunnel alternative shall be prepared with the following considerations:

a. An all railway solution;
b. A road solution (Note that a 40 km tunnel is not a practical solution and surface outlets will required.);
c. Partial construction of a tunnel with surface or other connections for all railway alternative and for all road alternative to avoid major settlements, environmental impacts and/or infrastructure.

2. Overview of the Tunnel Option

Review International Long Tunnels: There are a number of long tunnels that have been recently built over the past ten years that have resulted from improved tunneling technology. The Contractor shall review and list the long (> 10 km) road and rail tunnel

completed or presently under construction. Where possible, the cost of these tunnels will be indicated.

In addition, there are long metro or subway tunnels. These tunnels tend to be constructed at shallower depths than the long rail and railway tunnels. The long tunnels are built to overcome specific topographical obstacles to reduce travel time and cost. In this respect, the experience and cost associated with subway tunnels are more relevant to the specific problems that are likely to be encountered in building a rail tunnel for West Bank-Gaza Link. The Contractor will obtain costs for these types of tunneling projects and attempt to segregate tunnel costs from those costs associated with building stations.

Review of Tunneling Experience in Israel: The Contractor shall summarize the past experience and planned tunneling projects in Israel including the costs associated with these projects. Taking these costs the Contractor shall estimate the cost of a West Bank – Gaza Link built as a road or rail tunnel assuming a length of 40 kilometers. These costs will be compared to building a road or railway of similar length.

Technical Issues Involved in Building a Long Tunnel: The Contractor shall summarize the problems that are likely to be encountered in building a long underground tunnel and in operating and maintaining it. A comparison of the advantages and disadvantages of building a tunnel with surface road and railway solutions will be made in terms of:

- Initial Capital Cost
- Operating and Maintenance (O&M) Costs
- Safety;
- Environmental Impact.

3. Concept Designs for the Alternatives

Taking in consideration the technical issues discussed above and the potential difficulties encountered due to geotechnical and geological conditions that are likely to be encountered, the contractor shall prepare conceptual designs and capital and O&M costs for each alternatives. Project schedules for each alternative shall be developed. The most cost effective solution shall be determined.

The Contractor shall summarize the advisability of building a tunnel from a technical and cost perspective.

Note that the accommodation of utility corridors within the tunnel solution is not cost effective and shall be excluded from this analysis."

c. Paragraph C.5, REPORTING AND CONSULTATION: 1.) In Item 2, Progress Report, change "(12 weeks from contract signing)" to read "(14 weeks from contract signing)".

2.) In Item 3, Draft Final Report, change "20 weeks from contract signing)" to read "22 weeks from contract signing)".

3.) In Item 4, Final Report, change "24 weeks from contract signing)" to read "26 weeks from contract signing)".

d. The following new paragraphs are added at the end of C.14, SPECIAL CONSIDERATIONS:

"The Consultant will not evaluate, analyze, or otherwise discuss the security requirements for each transportation option.

The Consultant does not discuss ownership, management, or operational rights or responsibilities for the transportation options in the reports."

----------END OF MODIFICATION NO. 01----------

SECTION C - DESCRIPTION/SPECIFICATIONS/STATEMENT OF WORK

C.1 BACKGROUND

A critical requirement for the recovery of the Palestinian economy is the reintegration of the domestic market. This needs to be achieved through both a dismantling of the closure regime which disrupts domestic commerce between towns and cities within the West Bank as well as through the reconnection of transportation links between Gaza and the West Bank. Without a reliable, efficient, low-cost and secure trade and transport link between the two Palestinian areas, economic prosperity and the fulfillment of national aspirations will be elusive. In the short-term, it is expected that a privately secured convoy system will be established to link the two parts of the Palestinian economy. However, a more permanent solution for ensuring the physical interconnection between Gaza and the West Bank for people, goods and utilities is being sought by both parties. Some initial work was done by the Government of Israel (GOI) on a rail connection that would use the Israel Network and rolling stock. However, the systems to be included in the interconnection should be owned and operated by the Palestinians.

Since it is likely that the number of corridors linking Gaza and the West Bank will be severely limited, it is important that the physical interconnection meet critical requirements:

This physical interconnection should, to the extent possible:

- Provide access to the major Palestinian production and population centers and transport network in the West Bank and Gaza;
- Limit the length of the interconnection located within Israel;
- Avoid urban and heavily trafficked areas in Israel, so as to minimize delays and security concerns, as well as any known environmental, archaeological and cultural heritage sites;
- Provide security for Israel (i.e. ensure that the link is designed in a way to preclude the infiltration of goods or people into Israel);
- Provide direct movement between Gaza and West Bank for trucks, buses and automobiles with a road connection and for passengers, freight and trailers with a rail connection;
- Minimize the time to complete infrastructure;
- Minimize the total cost for transit of goods and passengers, and
- Provide adequate space for the location of utility services.

In order to help the parties agree on the required width and best alignment of the right of way and most efficient transportation mode for long term requirements, as well as the infrastructure and services to be established in the medium term, USAID, working collaboratively with the World Bank, is seeking to employ a Consulting Firm (hereafter referred to as Consultant) to undertake a rapid review of the most promising alternatives.

C.2 PROGRAM OBJECTIVES

This study would evaluate alternative configurations of a physical connection between the West Bank and Gaza. It has four objectives:

1. to determine the right-of-way required for sufficient capacity of transport and utilities services interconnecting West Bank and Gaza in the long term;
2. to evaluate alternative alignments for the interconnection;
3. to determine the transport system requirements in the medium-term and approximate cost for construction of infrastructure including the relative costs for at grade and below grade systems; and
4. to estimate the life cycle costs for transport services to meet projected demand in the medium.

C.3 SCOPE OF WORK

To accomplish these objectives, the Consultant would undertake nine activities. First, the Consultant would identify criteria for the review and conceptual design of alternatives including but not limited to the following:

a. utilizing the shortest distance between the two geographic areas, with most suitable alignment for road transport, freight train and/or medium weight passenger train;
b. connecting with an existing access point in the West Bank which links to a regional road;
c. minimum interference with existing Israeli built up area; Israeli agricultural land, forestry and Israeli traffic;and
d. allowing for the installation of infrastructure and utility lines such as national water carrier, telecommunication, electricity and gas connections.

Second, the Consultant will develop forecasts of both passenger and freight traffic between West Bank and Gaza over the next 25 years. The forecasts would be based on alternative scenarios concerning the rate of growth of the Palestinian economy, trade with its neighbors and traffic through the proposed Gaza seaport. They will take into account cargo flows generated by the potential development of a Gaza seaport and transit trade with Egypt through Gaza and Jordan through the West Bank. For transmission of water, gas, power and communications, the Consultant will review the forecasts prepared by the Palestinian Authority. This would include data to be collected during the period of the consultancy. The forecasts will be extended to determine long-term requirements. The consultant will prepare alternative scenarios based on both the rate of growth of the Palestinian economy and major investments related to the supply of or demand for water and energy.

Third, the Consultant will examine alignments identified earlier as well as new alignments that reduce the distance between the crossings in Gaza and West Bank. The initial examination will be made using the topological data available in the geographical information system maintained by Palestinian Ministry of Planning. This will be used to determine the general alignments taking into account the limitation on grade assuming that the right of way can accommodate both freight and passenger railroad operations. The Consultant will then conduct a visual inspection of the routes to identify any difficulties with existing land use or ground conditions.

Fourth, the Consultant will use the results of the first two activities to develop conceptual designs and determine the spatial requirements for the infrastructure required for the alternative transportation and utility transmission systems to be located in the right of way. The appropriate location of the latter will be determined taking into account the configuration of the former and the potential conflicts between the two. The location should allow easy access for maintenance and expansion and limits risks of disruption of services or accidents involving transport and utilities. In order to insure secure operations in the corridor, the Consultant should include a security barrier of sufficient height to separate the right of way from its surroundings in Israel.

Fifth, the Consultant will determine the cost and time for developing alternative alignments at grade and the marginal cost and time associated with developing the physical connection below grade for the entire route or for that portion that is projected to have significant population and economic activity. The developments include construction of the right-of-way, the road and rail infrastructure including the railway passenger and freight terminal, and the utility transmission systems. Based on the results, the Consultant will determine the relative advantages of the different alignments and prioritize them.

Sixth, the Consultant will determine the operating and maintenance costs for road and rail services operated by Palestinians in the right of way. This would include the fixed costs for equipment and maintenance based on the capacity required.

Seventh, the Consultant will determine the most cost-effective transport mode or combination of modes for handling the projected demand in the medium term (over next 5-15 years

the options to be considered are a road transport system with dual carriageway, a passenger and freight train service on a dedicated broad gauge track, and a multimodal system with separate road and rail services. The comparison of alternative transport modes will be based on the life cycle costs for the infrastructure and services needed to provide a reasonable level of service for the different traffic scenarios identified in the first activity. The calculation shall include the costs and time for passengers and cargo to move through the interconnection. In the case of rail service, this would include the time and cost for transferring passengers and goods at the terminals at either end of the interconnection. Similarly, the Consultant will determine the most cost-effective utility transmission system required to meet demand in the medium and long term.

Eighth, the Consultant will use the conceptual designs for these alternatives to determine the time and cost for construction and startup, and issues which may be faced during planning and construction stages related to land acquisition, significant hydrological and geotechnical issues, environment/natural resources and known archaeology and cultural heritage;

Finally, the Consultant will prepare a report summarizing the results of these activities and providing answers to the following questions:

a) What is the width of the right of way required to meet the long term requirements for interconnection of the West Bank and Gaza?
b) What alignment has the lowest cost or the best combination of cost and construction time?
c) What would be the marginal cost and time for constructing along this alignment either partially or totally below grade
d) What transport system or combination of systems will offer the lowest life cycle cost to serve the projected demand in the medium term

Given the need to complete this assignment as quickly as possible, the Consultant will have to rely heavily on existing data and plans. However, collection of new data may be required in instances where critical information is lacking, and these data can be collected within the available time frame. To the extent possible, the data should be disaggregated in order to clarify how it is being used in the analysis.

C.4 DETAILED TECHNICAL REQUIREMENTS

The assignment should be completed no later than March 15, 2006. The main outputs of the assignment will include:

(a) Conceptual Designs. Present conceptual designs and drawings for each alternative alignment describing the characteristics in terms of length, topography, geology, and interface with urban and rural activities including road and rail crossings;

(b) Implementation Cost. Provide an estimate for each alternative broken down into components of land acquisition, detailed designs, construction related items based on a preliminary bill of quantity and construction supervision;

(c) Transport Cost. Provide an estimate for each alternative of the costs for transport of freight and passengers using road and rail transport services**;**

(d) Issues which may Impact Implementation. Present a review of the environment, archaeology and cultural heritage related issues which may impact the implementation, discuss proposed mitigation measures and associated cost estimates.

(e) Implementation Timeframe for Each Alternative. Present a comparison of estimated time needed to implement each alternative taking into consideration the possibility of emphasizing multiple and parallel contracts (where feasible);

C.5 REPORTING AND CONSULTATION

The Consultant shall receive technical direction from the USAID Cognizant Technical Officer (CTO) or Contracting Officer. However, there will be close coordination between USAID and the World Bank. The Consultant will report to and discuss with the designated USAID and World Bank project team the following:

1. Inception Report (6 weeks from contract signing or 2 weeks from mobilizing the team leader);
2. Progress Report 1 (main outputs: traffic forecasting, land acquisition, rail and road way route and alignment, environment, archaeology and cultural heritage related concerns, transmission requirements and configuration for electricity, telecommunication, water and gas, road and rail costs (12 weeks from contract signing);
3. Draft Final Report (main outputs: detailed costing of alternatives and recommendations (20 weeks from contract signing);
4. Final Report (24 weeks from contract signing).

The Consultant will be required to present their final report and analysis at a workshop with both parties and thereafter with interested donors.

C.6 TIMEFRAME

The Consultant shall mobilize key specialists within four weeks of contract signing and complete the assignment on or before March 15, 2006.

C.7 LEVEL OF EFFORT

The indicative level is 16 person months exclusive of back office support + 9 person months of local professional support.

C.8 KEY PERSONNEL :

USAID and the World Bank have identified the following expertise and levels of effort as critical to successfully accomplishing this scope of work. The Consultant may, however, propose alternate positions or skills and levels of effort to meet the requirements of the scope of work.

- Transport Economist and Team Leader (6 person months). A specialist with a minimum of 10 years of experience in traffic forecasting, rail and trucking services, operations and related life cycle costs evaluation. This specialist should also act as the Consultant's team leader and therefore should have the necessary project management and team leading skills. This is a "Key Personnel" position.

- Railway Engineer (2 person months). A specialist in the area of railway engineering with a minimum of 15 years of practical experience in route alignment, track construction, signaling systems and equipment costing. This is a "Key Personnel position.

- Railway Cost Expert (1½ person months). A specialist in the area of rail engineering with a minimum of 15 years of practical experience in route alignment, rail services and rail operating costs. This is a "Key Personnel" position.

- Railway Engineer (1 person month). A specialist in the design of rail terminals for freight and passengers with a minimum of 15 years of with practical experience in layout planning, design of structures and costing. This is a "Key Personnel" position.

- Roads Engineer (1½ person months). A specialist in the area of road engineering with a minimum of 15 years of practical experience in designing route alignment and road construction and maintenance costing. This is a "Key Personnel" position.

- Utilities Expert (1½ person months). A specialist in the area of utility planning and management with a minimum of 15 years of practical experience in analyzing gas, water and electricity transmission systems, their configurations and capacities and life cycle costing. This is a "Key Personnel" position.

Environment Specialist (1½ person months). A specialist in the area of environment protection with a minimum of 15 years of practical experience in assessment of transport (roads/rail)

- project's impact on the natural environment (flora, fauna and natural water drainage system), design mitigation measures and estimating related costs.

- Social Scientist (1½ person months). A specialist in the area of social science with a minimum of 15 years of practical experience in assessment of which transport modality (road or rail) will have a greater positive impact on the social behavior and improvement of quality of life with a particular emphasis on the 'ability to pay' principal in the medium to the long term time horizon.

- Local Engineers (9 person months) professional support staff to include two junior engineers for three months each and a senior engineer for three months to assist in costing construction of alternative configurations and preparation of engineering drawings and specifications.

C.9 LOCAL SUB-CONTRACT – PALESTINAIN TEHCNICAL SERVICES

A Palestinian engineering firm, presently operating in West Bank/Gaza, may be subcontracted to provide technical services for work conducted in the West Bank and or Gaza.

C.10 LOCAL SUB-CONTRACT – ISRAELI TECHNICAL SERVICES

An Israeli technical services company may be subcontracted to provide services conducted in Israel for one or more of the following:

- Appraisal of property values and expropriation costs
- Field surveys
- Other duties requiring investigation and assessment of land use, environmental-cultural-economic factors, and other related factors.

C.11 SUPERVISION

The Consultant will receive technical direction from an assigned USAID Cognizant Technical Officer (CTO). At the early stage of mobilization, the Consultant shall identify, in close coordination with the CTO and World Bank team, key stakeholders to secure the understanding of the assignment and source of data and information that are needed for a successful completion of the assignment.

C.12 MATERIALS TO BE MADE AVAILABLE

The CTO will make available all relevant studies and project documents that may assist in a successful implementation of this assignment. The World Bank will also make its best efforts to obtain the material available as described in paragraph C.16 below.

C.13 SECURITY, RISK AND SITE ACCESS

Some of the activities related to this program may be conducted in the Gaza Strip or the West Bank in areas under the control of the Palestinian authorities, but also under the influence of the government of Israel. U.S. citizen personnel are not currently allowed to enter Gaza or to reside in Gaza, but that may change as conditions warrant.

C.14 DELIVERABLES

Deliverables shall be presented to USAID for review and approval according to the reporting schedule.

1. An entrance conference with the relevant USAID and World Bank staff
2. An entrance interview with the USAID and World Bank Front Offices
3. An inception report (to include but not limited to (a) a project work plan, (b) a detailed schedule of meetings, including weekly progress meetings, (c) a detailed performance schedule with milestones, (d) a draft table of contents
4. A progress report
5. A draft final report
6. A final report
7. Exit interview with Front Office
8. Workshops with relevant stakeholders.

C.15 SPECIAL CONSIDERATIONS

The contractor shall provide all necessary staff for office support and specialized technical and engineering tasks.

C.16 INFORMATION AVAILABLE FOR THE CONSULTANTS

1. Topographical Maps with 25 meter contours covering the area of Israel where the interconnection would be located.
2. Maps showing the geology of the area.
3. Calculations of the Operating Costs for Palestinian trucks, buses and automobiles,
4. Traffic data for convoy movements.
5. Traffic counts for selected roads prior to the Intifada.
6. Economic data for Palestine.

ANNEXES 3 & 4

ANNEX 3-1

ROAD DESIGN STANDARDS

1.0 Selection and Application of Standards

The Consultant developed the design parameters by comparing Israeli standards as given in the Israeli Standards for Geometric Plan of Rural Roads, Junctions and Interchanges of Ma'az, June 1994, updated Sept 2002, to AASHTO standards as presented in A Policy on Geometric Design of Highways and Streets, 4th Edition, 2001, American Association of State Highway and Transportation Officials, (AASHTO). At present, there have been no local standards for roads set by Palestine, which in the interim uses AASHTO for guidance. Certain project-related design parameters were gleaned from the Report "Gaza Strip & West Bank Linkage," from the Ministry of Transportation, Palestinian National Authority.

The various references generally define geometric standards in terms of "general design elements" and "critical design elements," with "general design elements" generally having less stringent application.

In summary, the Israeli standards have been selected over the AASHTO standards, due to several considerations:

- The route crosses Israeli territory, even if it may not have Israeli traffic;
- Israeli standards are higher than AASHTO standards while imposing little additional costs;
- Israeli standards use a value larger somewhere between the stopping sight distance and passing sight distance for vertical curves, which is a safer design;
- Higher standards would be the result at any event if the combined road/rail facility is chosen. Note that for combined road/rail alternatives, the geometrics are even further constrained. Also note further that we have chosen rail design values which exceed present Israeli RR guidelines- see Subchapter 3.2- Rail Alignments.

2.0 Road Classification

The various design standards provide differing parameters and in particular differing design speeds according to both the functional classification of the road, ie-international, regional, etc., and the design traffic volume. While there is often less than a perfect match between these two parameters, in the case of the project road, the interpretation is as follows:

For the proposed multi-lane dual carriageway the following definitions are applied:

Israeli Definition: Rural freeway

AASHTO Definition: Rural principal arterial (freeway), including interstate travel, movements between urban areas with population exceeding 50,000.

3.0 Summary of the Major Design Parameters

While text in subsequent sub-chapters herein will address the development of the various design parameters, the main parameters associated with each of these design standards for the multi-lane dual carriageway road section, through flat to rolling/mountainous terrain, are summarized and presented in Table 3.1-1 and 3.1-2, respectively.

To the following design standard tables, a column showing pertinent railroad standards obtained from the Port and Railways Authority, Israel Railways, Engineering Department, 2000, has been added. The rationale for this is that in the event that a combined road and rail configuration is chosen, the road standards will be influenced within the right-of-way constraints to a large extent by the more demanding rail standards. A full discussion of the railway design standards is found in Annex 3-2.

Table 3.1-1: Geometric Standards for Road Section: Multi-Lane Dual Carriageway, Flat Terrain

Designation	Israeli	Israel RW	Palestinian	AASHTO	Selected for Road
Design speed (km/h)	120	160 (200)	120	120	120
Minimum horizontal radius (m)	870	2000	755	755	870/2000
Maximum superelevation (%)	6.0	10.0	6.0	6.0	6.0
Min. vert. Curve radii: Crest (m)	22600	NA	9500	9500	22600
Min. vert. Curve radii: Sag (m)	7700	NA	6300	6300	7700
Maximum gradient (%)	3.0	1.3-2.5[6]	3.0	3.0	1.3/3.0
Min. stopping sight distance (m)	300[1]	NA	250	250	300[1]
Lane width (m)	3.75	NA	3.8	3.6	3.75
Median width (m)	6.8/8.0	NA	14	3/9	6.8/8.0
Cross-fall (%)	1.5/2.0/2.5[2]	NA		1.5/2	1.5/2.0/2.5[2]
Outside Shoulder paved width (m)	3.0/4.0[3]	NA	3.0	3/3.6	3.0/4.0[3]
Inside Shoulder paved width (m)	3.0[4]	NA	1.0	3.0	3.0[4]
Shoulder cross-fall: Sealed (%)	2.0/4.0[5]	NA	2-6	2-6	2.0/4.0[5]

[1] vertical slope less than 4.0%
[2] 1.5- concrete, 2.0 asphalt, 2.5 asphalt with vertical slope less than 1.0%
[3] including safety barrier
[4] three lanes
[5] 4.0%- gravel shoulder
[6] 1.3% is for heavy freight and passengers, and 2.5% is for lighter passenger only. For combined freight and passenger service, the lower value is selected.
NA – not applicable to railway.
RW - Railways

Table 3.1-2: Geometric Standards for Road Section: Multi-Lane Dual Carriageway, Rolling/Mountain Terrain

Designation	Israeli	Israel RW	Palestinian	AASHTO	Selected for Road
Design speed (km/h)	100	100	100	100	100
Minimum horizontal radius (m)	530	1000	435	435	530/1000
Maximum superelevation (%)	7.0	100	6.0	6.0	7.0
Min. vert. Curve radii: Crest (m)	10000	NA	5200	5200	10000
Min. vert. Curve radii: Sag (m)	4900	NA	4500	4500	4900
Maximum gradient (%)	5.0	2.5	6.0	6.0	2.5/5.0
Min. stopping sight distance (m)	200[1]	NA	185	185	200[1]
Lane width (m)	3.75	NA	3.8	3.6	3.75
Median width (m)	6.8/8.0	NA	14	3/9	6.8/8.0
Cross-fall (%)	1.5/2.0/2.5[2]	NA		1.5/2	1.5/2.0/2.5[2]
Outside Shoulder paved width (m)	3.0/4.0[3]	NA	3.0	3/3.6	3.0/4.0[3]
Inside Shoulder paved width (m)	3.0[4]	NA	1.0	3.0	3.0[4]
Shoulder cross-fall: Sealed (%)	2.0/4.0[5]	NA	2-6	2-6	2.0/4.0[5]

4.0 Design Speed

4.1 Flat Terrain

All referenced standards indicate that an appropriate design is 120 km/hr. However, the Consultant is sensitive to a possible argument for higher design speeds, both in terms of travel time savings and security issues. In actuality, topography, drainage, urban area avoidance and land use patterns are such that a much higher design speed could readily be employed.

As this project includes consideration of a joint road and rail alignment, it is necessary to also review briefly the rail speed standards. Presently, the Israeli Railways have a maximum design speed of 160 km/hr. As indicated in the Inception Report, this design speed could be increased to the upper limit of the conventional medium speed range for mixed traffic operations, which is normally considered to be 200 km/hr. Even though only passenger trains could reach this limit, the railway quality necessary to accommodate 200 km/hr speeds will minimize track maintenance expenses without an associated major cost increase in comparison with lower speed track design options.

Accordingly, the selection of the rail speed has been set at 200 km/h for all terrain sections except those in the last 12kms before the West Bank border, where topographical constraints reduce the minimum radius to 1000m. Using the selected maximum superelevation rates for the road, this radius translates into a road speed of 130 km/hr.

4.2 Rolling/Mountainous Terrain

All referenced standards indicate that an appropriate design is 100 km/hr. The rail desk study indicates that the sharpest radius without considerable cuts is 500m, which in the case of rail design equates to 110 km/hr. Within a combined road/rail right-of-way corridor, the roadway alignment could employ a slightly more curvilinear alignment in the interest of economy, perhaps even with the inclusion of independent eastbound and westbound alignments within a right-of-way; however, it is likely that such compromises would still result in a design speed of approx. 100 km/hr.

Coincidentally, all of the possible alternative alignments traverse flat terrain except for the extremities, i.e.- the approach to Gaza near Sderot, and the approach to West Bank in a band from near Kiryat Gat to Beit Karna. This augers well for any compromises for design speeds pertaining to terrain, as a reduction in speed may be advisable at any rate as we approach the borders and the terminals of the project.

5.0 Horizontal Elements

5.1 Maximum Superelevation

Israeli standards call for 6-8%, and AASHTO also has values between 6-8%. Values of 8% can create problems with overloaded trucks with protruding loads. The AASHTO values compared to several worldwide standards are comparatively high, and are based on rather dated test references.

At the extremities of the route, i.e. in urban areas where traffic congestion or extensive marginal development acts to curb speeds and superelevation rates, it is common practice to utilize a lower maximum rate of superelevation, usually 4 percent. Similarly, either a lower maximum rate of superelevation or no superelevation is employed within important intersection areas or where there is a tendency to drive slowly because of turning and crossing movements, warning devices, and signals.

5.2 Minimum Horizontal Radius

The same formula is used in both references for computing the minimum horizontal radius. It is dependent upon the maximum superelevation rate employed, and the friction factor. In the final selection for this radius parameter, both references indicate a 6% maximum superelevation rate. For design speeds of 120 and 100, this translates into a minimum radius of 755m and 435m, respectively, for AASHTO, and 870m and 530m, respectively, for Israeli standards. Note that both references use the same formula, while the higher resultant radii for the Israeli standards is explained in that they lowered friction factors for the range of speeds based on accident statistics.

Spiral curves will be employed as per AASHTO standards. For the road/rail combination alternative, it should be noted that high speed rail uses a slightly different spiral formula than that typically used for roads, and, as the road would parallel the tracks, it is possible that this formula will also apply de facto to the roads. The effect is insignificant.

Flat Terrain: There is no problem anticipated with meeting the radius standard. In fact, the radius could be readily designed with a minimum of greater than 755m, equating to a 120 km/hr design speed.

Rolling/Mountain Terrain: It appears that the radius could be readily designed with a minimum of greater than 435m, equating to a 100 km/hr design speed. In this terrain, it may be that the road alignment could deviate substantially from the required rail alignment, resulting in two separate alignments for the two facilities.

5.3 Other Constraints

Israeli standards set further constraints on the horizontal alignment which are above the requirements for AASHTO. These include:

- Minimum tangent distances between compound curves, broken-back curves and reverse curves
- Maximum length restrictions on curves

It is not considered difficult to met these additional standards, nor do they appear at this stage to have a significant impact on construction costs.

6.0 Vertical Elements

6.1. Minimum Vertical Curve Radii

Minimum lengths of crest and sag vertical curves have been recommended based on design speeds and stopping sight distance requirements. They provide for ride comfort, appearance, and most importantly, safety.

Israeli standards express the crest and sag vertical curves in terms of circular radii, while AASHTO expresses these curves in terms of K-values, i.e. a measure of the rate of change in a parabolic curve. The AASHTO design is based on minimum allowable "K" values, as defined by the formula:

$$K = L/A$$

Where K = limiting value, horizontal distance required to achieve a 1% change in grade
L = length of vertical curve (m)
A = Algebraic difference in approach and exit grades (%)

For the band of changes in gradient common in highway design, the AASHTO k-values can be converted to the approximate corresponding radii values, using a factor of 100.

Tables 3.1-1 and 3.1-2 are based on stopping sight distance rather than passing sight distance as this is a divided multi-lane highway. However, the values for stopping sight distance are very conservative and decision sight distance values or higher ones should be used where possible for increased safety and driver comfort.

6.2. Maximum Gradient

Vehicle operations on gradients are complex and depend on a number of factors: severity and length of gradient; level and composition of traffic; and the possible addition of climbing lanes. Maximum vertical gradient is an extremely important criterion that greatly affects both the serviceability and cost of the road.

The Consultant anticipates no difficulties in staying within the maximum gradient requirements of 3% and 6% (Israeli = 5%) for flat and rolling/mountainous terrain, respectively.

Where it is anticipated that the roadway is designed adjacent to a rail line, it is of interest to note the gradient limitations of the rail line, selected, using Israeli standards, at 1.3 percent. This requirement is more stringent than it is for roads, and hence enters into the design consideration for combined right-of-way facilities. As was the case in considering horizontal curves, it may be that the road alignment could deviate substantially from the required rail alignment, however it is unlikely that two entirely separate alignments for the two facilities, in more severe terrain, would be a possibility.

6.3. Climbing Lanes

Climbing lanes have not been considered, as they are generally excluded from consideration in a multi-lane divided route.

7.0 Cross Sections

7.1. Lane Widths

The cross-section design is in accordance with guidelines indicated in both selected standard references. Lane widths can be set at:

- 3.6m traffic lanes for the dual carriageway section (AASHTO)
- 3.75m traffic lanes for the dual carriageway section (Israeli)
- 3.8m traffic lanes for the dual carriageway section (Palestinian)

7.2. Cross- Fall (%)

The cross slopes recommended, which represent a fair fit to both referenced design standards, are as follows:

- 2% for roadway surface
- 2% for paved shoulder
- 4% for gravel shoulder

7.3. Shoulder Widths

A shoulder is the portion of the roadway contiguous to the carriageway for the accommodation of stopped vehicles; traditional and intermediate non-motorized traffic, animals, and pedestrians; emergency use; the recovery of errant vehicles; and lateral support of the pavement courses.

The Israeli standards call for 3.0 m shoulders, which does not include any required safety barrier width.

The Highway Capacity Manual suggests that a paved shoulder width of 1.8m or greater is ideal to enhance operations and capacity.

For divided highways, AASHTO suggests 3.6m paved outside shoulders and 3.0 paved inside shoulders.

7.4. Sideslopes and Backslopes

The guidelines for sideslopes and backslopes are applicable to new construction. Here, sideslopes should be designed to insure the stability of the roadway and to provide a reasonable opportunity for recovery of an out-of-control vehicle. Embankment or fill slopes parallel to the flow of traffic may be defined as recoverable, non-recoverable, or critical:

Recoverable slopes include all embankment slopes 1:4 or flatter. Motorists who encroach on recoverable slopes can generally stop their vehicles or slow them enough to return to the roadway safely. Fixed obstacles such as culvert headwalls should not extend above the embankment within the clear zone distance on recoverable slopes.

A non-recoverable slope is defined as one which is traversable, but from which most motorists will be unable to stop or to return to the roadway easily. Typically, vehicles on such slopes typically can be expected to reach the bottom. Embankments between 1:3 and 1:4 generally fall into this category. Since a high percentage of encroaching vehicles will reach the toe of these slopes, the clear zone distance extends beyond the slope, and a clear runout area at the base is desirable.

A critical slope is one on which a vehicle is likely to overturn. Slopes steeper than 1:3 generally fall into this category.

The selection of a side slope and back slope in new construction sections is dependent on safety considerations, height of cut or fill, and economic considerations.

Table 3.1-3 indicates the side slope ratios adopted for use in the design, according to the height of fill and cut, and the material.

Table 3.1-3: Slope Ratio Table – Vertical to Horizontal

Material	Height of Slope	Side Slope		Back Slope	Zone Description
		Cut	Fill		
Earth or Soil	0.0 – 3.0m	1:4	1:4	1:2	Recoverable
	Over 3.0m	1:2	1:2	1:2	Critical
Rock	Any height	See Standard Details			Critical

However, this table should be used as a guide only, particularly as concerns applicable standards in rock cuts, where a controlling influence is cost. Note also that certain soils that may be present at subgrade may be unstable at 1:2 side slopes, and for these soils a higher standard will need to be applied. Slope configuration and treatments in areas with identified slope stability problems should be addressed as a final design issue.

7.5. Medians

A band of median widths is possible with AASHTO. To provide for the minimum resultant width of the right-of-way, while providing for median lighting, a median width of 8 meters (inclusive of two 3m inside shoulders) has been specified for Alternative A1 (see typical sections). For safety, this includes a pair of jersey barriers along the shoulder edges.

This configuration does not allow the inclusion of utilities in the median. If the decision is made to place the utilities in the median, the median width would need to be increased to 12 meters (inclusive of two 3m inside shoulders) as indicated in the attached typical sections, Section 10.

Another possibility is to place the rail component of a combined road/rail facility in the median.

7.6. Clear Zone

Once a vehicle has left the roadway, an accident may occur. The end result of an encroachment depends upon the physical characteristics of the roadside environment. Flat, traversable, stable slopes minimize accidents. Elimination of roadside furniture or its relocation to less vulnerable areas are options in the development of safer roadsides. If a fixed object or other roadside hazard cannot be eliminated, relocated, modified, or shielded, for whatever reason, consideration should be given to delineating the feature so it is readily visible to a motorist.

For adequate safety, it is desirable to provide an unencumbered roadside recovery area that is as wide as practical on a specific highway section. The cleared width should be a minimum distance from the edge of the roadway. For the at-grade alternatives, this clear zone can be set at 10 meters. For the sunken alignment, the clear zone is defined as the distance to the retaining walls, and has also been set at 10 meters. This typical section is less desirable than others from a safety aspect.

7.7. Barriers

A feature of any typical section will be a barrier. The design of such a barrier is deemed to be beyond the scope of this project.

7.8. Combined Road/Rail Cross Sections

Where rail is contiguous to the freeway traveled way, the entire highway design is affected. The design should ensure the safety of both highway and transit users. The most common arrangement is to place the rail line within the median of a depressed or ground-level freeway. Where a rail line is placed on the side of a freeway, access is simplified but the construction of interchanges becomes more costly. It may be possible to provide the rail in the median and switch to a side location within Gaza and the West Bank.

7.9 Typical Sections

For typical sections, see Volume 2, Typical Sections.

8.0 Junction/Overpass/Underpass

The scope of work limits the length of the project to terminal points very close to the borders within the West Bank and Gaza. The Terms of Reference mention a connection to an existing access point in the West Bank which links to a regional road, and our proposal mentions a link to road networks in both locations.

8.1. Interchanges

In Gaza, the two possibilities investigated are an entry near the NE corner of Gaza or near Karni crossing. It is further anticipated that the route can follow an alignment along the border further southwest. For the NE corner selection, the project route would remain the main route while a possible junction towards the Erez area, or on a route towards Gaza, is a possibility. This would likely take the form of a possible roundabout as the route transitions to the regional network, or three-leg trumpet interchange (Layout B of Figure 3.1-1). Note however that the capacity of a roundabout is limited to a maximum of approx. 20,000 ADT for the main route and 8,000 ADT for the cross route, which may indicate that it could perform for significant portion of the design life of the project if an option was to employ staged development construction, whereby the junction is converted to an interchange at some future date.

In the West Bank, the two possibilities are an entry near Tarkumiya and near Meitar. The design considerations are similar to those at Gaza. Some schematic drawings of possible interchanges are given in Figure 3.1-1

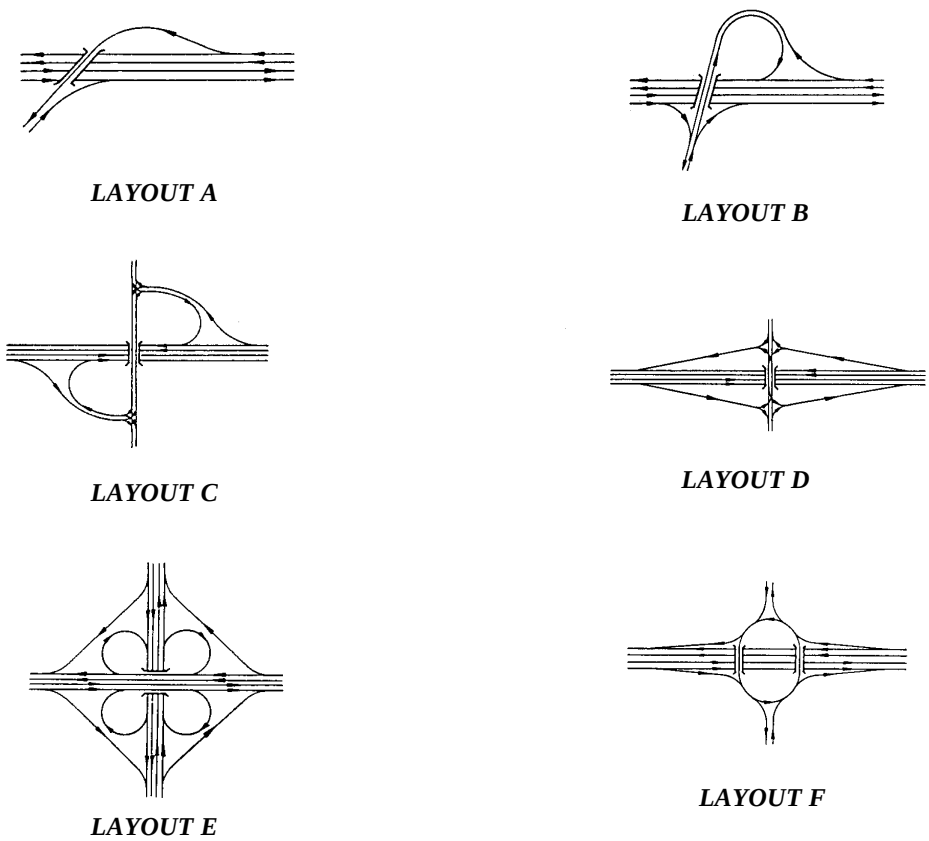


Figure 3.1-1: Interchange Configurations

There will be no junctions with any other routes within the length of the project.

8.2. Overpasses vs. Underpasses

A design consideration is the interface of the route with the various other routes it crosses. Each alternative alignment must cross:

- Route 34
- The proposed Ashkelon-Beer Sheva Railroad
- The underground Kinneret Negev Conduit
- Route 40
- The Tel Aviv- Beer Shiva Railroad, including the proposed double-tracking
- Proposed Route 6
- The Israel Track

A detailed study shall be made at each proposed highway grade separation to determine whether the project road should be carried over or under the crossroad. This decision is based partially on features such as topography or highway classification. General guidelines for over-versus-under preference follow, but such guidelines should be used in combination with detailed studies of the grade separation as a whole.

At any site, the issues governing whether a road should be carried over or under usually fall into one of three groups:

- the influence of topography predominates and, therefore, the design should be closely fitted to it;
- the topography does not favor any one arrangement; and
- the alignment and gradeline controls of one highway predominate and, therefore, the design should accommodate that highway's alignment instead of the site topography.

As a rule, a design that best fits the existing topography is the most pleasing and economical to construct and maintain. Where topography does not govern, as is common in the case of flat topography, such as constitutes most of the length of the project route, it is appropriate to study secondary factors, and the following general guidelines should be examined:

- For the most part, designers are governed by the need for economy, which is obtained by designs that fit existing topography.
- Through traffic is given aesthetic preference by a layout in which the more important road is the overpass.
- In rolling topography or in rugged terrain, major-road overcrossings may be attainable only by a forced alignment and rolling gradeline. Where there otherwise is no pronounced advantage to the selection of either underpass or an overpass, the design that provides the better sight distance on the major road (desirably passing distance if the road is two-lane) should be preferred.
- Troublesome drainage problems may be reduced by carrying the major highway over without altering the crossroad grade. In some cases, the drainage problem alone may be sufficient reason for choosing to carry the major highway over rather than under the crossroad.
- Where topography control is secondary, the cost of bridges and approaches may determine whether the major roadway underpasses or overpasses the minor facility. A cost analysis that takes into account the bridge type, span length, roadway cross section, angle of skew, soil conditions, and cost of approaches will determine which of the two intersecting roadways should be placed on structure.
- Grade separations near urban areas constructed as parts of a depressed expressway, or as one raised above the general level of adjoining streets, are good examples of cases where decisions regarding individual grade separations are subordinated to the general development.

- Where a new highway crosses an existing route carrying a large volume of traffic, an overcrossing by the new highway causes less disturbance to the existing route and a detour is usually not needed.
- In some instances, it may be appropriate to have the higher volume facility depressed and crossing under the lower volume facility to reduce noise impact.
- Security issues.

In the case of a combined road and rail facility, the controlling maximum rail gradient would generally result in the project route being the route that would remain closest to at-grade at road crossings. For rail crossings, the solution is more problematic.

In addition to the above, each alternative would need to consider other crossings such as minor routes, water courses, and utility lines.

8.3. Aesthetics

It is suggested that certain low cost measures could be applied to greatly enhance the aesthetics of both bridges and retaining walls and to provide for a more pleasing driving environment. The consultants refer to varied measures such as the use of tinted concrete and/or special formworks for concrete for over/underpasses and walls. An indication as to what can be accomplished can be seen in Photos 3.1-1 through 3.1-3. The use of such colored concrete and special forms has as an added advantage that it precludes the ability of the Contractor to hide defects such as honeycombing under surface plastering, and hence guarantees a more satisfactory construction.

Photo 3.1-1: Bridge Form Patterns and Paint

Photo 3.1-2: Bridge Form Patterns and Paint

Photo 3.1-3: Retaining Wall Form Patterns and Paint

8.4. Depressed (Sunken) Sections

A possible configuration for the route is a depressed (sunken) freeway. Often selected in an urban environment and parallel to a street grid, the roadway is typically at an approximate depth of 4.9m in addition to the clearance for structural depth below the surface of the adjacent streets, and with a further allowance for future pavement overlays. A depressed freeway is normally located approximately 4.9 to 5.5 meters below the surrounding ground level.

The depressed freeway can be advantageous, particularly in an urban environment, in that they reduce the impacts of the freeway on adjacent areas. They are less conspicuous than ground-level or elevated freeways, permit surface streets to cross at their normal grade, can minimize right-of-way, and reduce freeway noise. However, these advantages have to be balanced against the increased cost of providing for drainage. While gravity drainage facilities are sometimes feasible to accommodate the design storm without inundating the traveled way, pumping stations may be needed.

In the project context, the depressed section is an option mainly due to other considerations: safety and security, and the minimizing of a visual suggestion of a barrier across Israel. These factors would also suggest a depth of approximately 5 or more meters.

Although the study team began with consideration of a depressed section at such a depth, it went through several iterations before settling on a typical depressed (sunken) section. The first constraint was due to drainage considerations. The team searched for an alignment corridor, which would allow for the much lower cost and low maintenance alternative of a depressed section with a gravity drainage system, rather than a pumped system. This idea was largely defeated when it was determined that the ultimate outlet to such a gravity drain system, the nearby Shikma Wadi, appeared to be of insufficient depth (4m, and perhaps insufficient cross section) to serve as the outlet (see Photo 3-1 of Chapter 3). It was subsequently determined that Shikma Wadi may still serve in some areas as the drain if the road were depressed to some value less than 5 meters.

The study team also began to address the issue of the spoil earthworks resulting from a depressed freeway section. For instance, for Alternative A2 (see typical sections in Volume 2), a road only sunken section, the width between retaining walls would be approximately 50 meters. At a depth of 5 meters and a length of approximately 40 kms, this would result in approximately 10,000,000 m^3 of excavated materials to waste: enough to fill an area of one square kilometer to a depth of 10 meters. The disposal of such a volume of material becomes a major constraint. It can be addressed by spoiling the excavated material to an embankment on both sides of the sunken section, which allows for the creation of a 5.5 meter barrier to the surrounding land through a partially sunken road and the two embankments. A goal is to balance the earthworks such that the excavated material equals the embankment material (see typical sections at end of this section). Using a 50m width, and embankments with 1:3 side slopes and a 5m wide top, the quadratic equation indicates that a balance, allowing for shrinkage, and to be further tuned in a preliminary design step, appears to occur with a selected depth of approximately 2.3 meters at the subgrade, with partial height retaining walls, giving embankments of 3.2 meters. A resultant problem with this cut to fill section is that it consumes significantly more right-of-way than an at grade alternative. This solution also provides the potential basis to create an aesthetic barrier through vegetating the low embankment with the native vegetation so that it looks less like a barricade and more like the natural landscape.

Structures passing over the depressed freeway and retaining walls located in close proximity to the traveled way should be fenced to prevent objects being dropped or thrown onto vehicles below.

8.5. Tunnel Sections (Preliminary)

Development of a project route may include sections constructed in tunnels either to carry highway under or through a natural obstacle or to minimize the impact of the freeway on the neighboring communities. General conditions under which tunnel construction may be warranted include:

- Long, narrow terrain ridges where a cut section may either be costly or carry environmental consequences
- Large intersection areas or a series of adjoining intersections such as is found near Route 34/ proposed Ashkelon-Beer Sheva Railroad/ underground Kinneret Negev Conduit; and Route 40/ Tel Aviv- Beer Shiva Railroad/ Proposed Route 6
- Parks or similar land uses, existing or planned
- Where right-of-way acquisition costs exceed cost of tunnel construction and operation
- Where security issues are a concern.

The costs of operation and maintenance of tunnels including ventilating, lighting, pumping, and other mechanical or electrical considerations should be considered.

Tunnels can be classified into two major categories:

- tunnels constructed by mining methods, and
- tunnels constructed by cut-and-cover methods.

The first category refers to those tunnels that are constructed without removing the overlying rock or soil. Usually this category is subdivided into two groups: hard rock and soft ground.

Of particular interest to the highway designer are the structural requirements of these construction methods and their relative costs. As a general rule, hard-rock tunneling is less expensive than soft-ground tunneling. A tunnel constructed through solid, intact, and homogeneous rock will normally represent the lower end of the scale with respect to structural demands and construction costs. A tunnel located below water in material needing immediate and heavy support will require extremely expensive soft-ground tunneling techniques.

The second category of tunnel classification is the cut-and-cover method. This is by far the most common type of tunnel construction for shallow tunnels, which often occurs in urban areas. As the name implies, the method consists of excavating an open cut, building the tunnel within the cut, and backfilling over the completed structure. Under ideal conditions, this method is the most economical for constructing tunnels located at a shallow depth. However, it should be noted that in an urban context surface disruption and problems with utilities generally make this method expensive and difficult.

Tunnels should be made as short as practical because the feeling of confinement and magnification of traffic noise can be unpleasant to motorists, and tunnels are the most expensive highway structures to construct. The horizontal alignment through the tunnel is an important design consideration as well. Keeping as much of the tunnel length as practical on tangent will not only minimize the length but also improve operating efficiency.

The vertical alignment through the tunnel is another important design consideration. Grades in tunnels should be determined primarily on the basis of driver comfort while striving to reach a point of economic balance between construction costs and operating and maintenance expenses.

9.0 Right-of-Way Considerations

9.1. ROW Widths

Right-of-ways are provided in order to accommodate the road width and to enhance the safety, operation and appearance of the roads. The width of the right-of-way depends on the cross section elements of the highway, whether of not rail and utility corridors are included, topography and other physical controls, together with economic considerations.

In mountainous terrain, a cut section may be of such depth that the right-of-way width is exceeded from the top of cut on one side to the other top of cut or toe of fill on the other side. This may require either a localize increase in the right-of-way width, or the construction of structures to limit the opening size.

9.2. Utility Corridor

In the event that a utility corridor is also placed within the right-of-way, further width will be required. Utilities could be placed either on one side of the right-of-way or in the median. A median placement would be desirable from the standpoint that it would necessitate a greater than otherwise median width and hence separation between the opposing traffic lanes, and would require less right-of-way; the disadvantage may be ease of access and safety during maintenance.

The addition of an underground utility corridor to one side of the right-of-way would add approx. 10m to the right-of-way width. The addition of an underground utility corridor in the median would add approx. 4m to the right-of-way width.

The above text covers water, telecommunications, and gas utilities. The study also includes the investigation of an electric power transmission in the corridor. An above ground high voltage power transmission line would add approx. 30m to the right-of-way requirements, given the width of the supports and the clearance requirements. The more expensive underground power transmission alternative would add approx. 5m to the right-of-way requirements.

Road reserve widths applicable for the different road sections are indicated in Table A12-4 and are shown in the typical section drawings, and are generally:

- 70 meter in width for road only sections with utilities on one side, except for a partially sunken/side fill configuration which results in an approx. 30m additional width, and a depressed alignment which results in an approx. 10m reduced width
- 69 meter in width for road only sections with utilities in the median, except for a partially sunken/side fill configuration which results in an approx. 30m additional width, and a depressed alignment which results in an approx. 10m reduced width
- 40 meter in width for rail only sections with utilities on one side, except for a depressed alignment which results in an approx. 10m width reduction
- 85 meter in width for road/rail combined sections with utilities on one side, except for a depressed alignment which results in an approx. 10m reduced width

Table 3.1-4: Minimum Right-of-Way Widths for Various Configurations

Alternatives	Basic ROW Width (m)	Add Utilities @ ROW	Add Utilities @ Median Without power	Add above-ground power	Add below-ground power	Max. Total[1]
Alternative A: Road Only	60	10	4	30	5	69-100
Alternative B: Rail Only	30	10	-	30	5	45-70
Alternative C: Road/Rail Combination	75	10	-	30	5	90-115

[1] lower value for buried power line, and higher value for above-ground power line.

Note: All these values are under review and are subject to change.
Note that due to the additional right-of-way requirements, we suggest that the above-ground power line not be considered.

10.0 Typical Sections

The combined road/rail configurations, the typical sections show the rail facility between the road sections for road only, typical sections are developed with the utility corridor outside of the road and rail only typical sections.

Typical sections for these various alternatives, for combined road/rail, and for at-grade, cut/fill, and sunken alternatives, and tunnel, are given in Volume 2 prism and with the utilities in the median, as follows:

1. Alternative A1: road only with utility corridor outside of road prism
   - Shallow fill section
   - High fill section
   - Cut section in rock
   - Cut section in soil
   - Depressed section with retaining walls
   - Sunken section with side spoil embankment

2. Alternative A2: road only with utility corridor in median
   - Shallow fill section
   - High fill section
   - Cut section in rock
   - Cut section in soil
   - Depressed section with retaining walls
   - Sunken section with side spoil embankment

3. Alternative B: rail only with utility corridor outside of rail prism
   - Shallow fill section
   - High fill section
   - Cut section in rock
   - Cut section in soil
   - Depressed section with retaining walls
   - Sunken section with side spoil embankment

4. Alternative C: Combined road and rail with utility corridor outside of road/rail prism
   - Shallow fill section
   - High fill section
   - Cut section in rock
   - Cut section in soil
   - Depressed section with retaining walls

ANNEX 3-2

RAILWAY DESIGN STANDARDS

1. Design Speed

The recommended maximum design speed is 200 km/h. This speed is a conservative limit of the advanced conventional mixed traffic category that includes passenger and freight operations. The design speeds in excess of 250 km/h belong to the high-speed category that requires qualitatively different technology utilized primarily by dedicated passenger transportation systems accompanied by small quantities of very light freight. In reality, the stated limits are not precisely set, and the both categories overlap within the 200 to 250 km/h speed range. It should be noted that this design speed is higher than the present Israeli Railways maximum operating speed of 160 km/h.

Even when the recommended 200 km/h design may be seldom used in the initial years or decades of operations, the following advantages support an adoption of the design speed corresponding to the high end of the advanced conventional category:

- Increased operational capacity, accelerated turn-around of rail vehicles, and operational reserve to facilitate future operational growth.

- Life expectancy enhancement and track/wheel maintenance intensity reduction of the track structure

  Trains operating at low to medium speeds on a line that does not include tight curves generate much less wear than trains operating on a line equipped with curves of radii that just meet the minimum geometric requirements for the actual reduced speed. This is particularly significant in the case of freight trains. The intensity of track/wheel maintenance is a major factor in the overall economic performance of a railway.

  The design and construction standards corresponding to the upper conventional speed range will thus minimize the track maintenance intensity, and the associated presence of infrastructure maintenance personnel and equipment on and along the railway line.

- Comfort and speed of rail travel

  Higher speeds reduces travel times and result in time savings for passengers and freight. The relaxed environment of contemporary fast trains offers comfortable and greater passenger satisfaction with this mode of transport.

- Safety

  The safety-related features of the contemporary fast train which is the safest transportation mode are derived from high-speed rail technology. About three trillions of passenger trips have been accomplished without any injury or fatality since 1963 in dedicated high-speed right of ways. The conventional railways and conventional lines upgraded for high speed operations have much less favorable record. The proposed concept of advanced conventional technology implies the utilization of state-of-the-art safety features developed for high-speed rail systems.

- Security

  The fast train concept provides an option to select rather high minimum train speed to discourage unauthorized exits from trains.

- The marginal increase in capital investment cost is small when compared with standards which would result in lower speeds.

2. Curves of Constant Radii

2.1 Radius

The radii should be as large as possible. The preferred minimum radius is 2,000m. However, near the end of the line where all trains slow down, a 1,000m radius can be used. Smaller radii are not recommended because they increase rail wear and require intense track maintenance.

2.2 Superelevation on curves of constant radius

The superelevation should correspond to the speed/radius relationship using superelevation factors K from the Israeli Railways' standards as follows:

K = 5.9 for 160 km/h < V < 200 km/h
K = 6.5 for 120 km/h < V < 160 km/h
K = 7.1 for V = 120 km/h

Maximum superelevation = 140 mm: The 140 mm maximum superelevation is used only on curves sharper than 1685m. The superelevation corresponding to the preferred minimum radius curve of R=2000m is 120mm. Since the speed of standard freight operations will be reduced and limited by other factors, the actual superelevation provided in the track may be further reduced.

Maximum superelevation = 85 mm: A superelevation reduced to 85 mm maximum may be required for operations of heavy oversize shuttle trains. The speed of standard passenger trains on a typical R=2000m curve will be then limited to 160 km/h. However, certain passenger trains of advanced technology can operate on curves at increased values of unbalanced superelevation so that the 200 km/h speed is achievable on the curves of shuttle track provided with the 85 mm superelevation like in the case A.

3. Transition Curves (Spirals)

The inclusion of recent developments in the design of transition curves is recommended in accordance to the European Standard prENV 13803-1, February 2001 in Annex A, Article 3.3, Progressive track alignment design and in the Annex A, Supplementary information for track alignment design. The recommended replacement of the clothoid transition curve by a Vehicle Stability Based (VSB) curve will increase stability of track superstructure, increase the interval between re-tamping curves by factor of three to four and reduce rail wear on curves as proven by resent research.

3.1 Reasons for Recommended Replacement of Clothoid Spiral

The most frequently used transition curves provided between the tangent track and the track of constant radius are of the traditional parabolic and clothoid design. However, their use has been successfully challenged during the development of EU interoperability standard ENV 13803-1 along with less frequent transition curves based on sine and cosine geometry.

The problem with the traditional approach to spiral design is the representation of a rail vehicle as a non-dimensional point of mass moving along the track centerline. In reality, the vehicle is not a non-dimensional point, and the distance of the center gravity from the track centerline is considerable. The spiral should be placed at the center of gravity typically found 1.8 to 2.0 m above the track centerline, and not at the centerline of the track at the elevation of the rail tops that is meaningless from the vehicle stability point of view.

The consequences of the oversimplification afforded by the traditional design theories have been observed. The center of gravity of a vehicle entering the curve is thrown sideway. This undesirable motion is described in terms of roll acceleration and its change in time called roll jerk. The vehicle oscillates and wobbles along the curve. The dynamic forces that are generated destabilize the track requiring more intensive maintenance[2] to Figure 3.2-1 thru 5.

3.2 VSB Geometry in the Track

The projection of this spiral into the plane defined by the rail tops is quite complex and different from the traditional spirals typically provided at this plane.

This projection is needed for plotting the new spiral geometry in the track.

Rather complex mathematical functions describe the VSB spiral. This complexity is not an impediment because the geometry is no longer manually surveyed. It is pre-programmed in the automatic tamping machine.

The European standard provides mathematical conditions that must be met by a VSB spiral. It does not give the final formulas of the spiral's projection into the track plane. Such formulas are proprietary and sold as computer control software for automatic tamping machines except for the VSB spiral developed by Igielski that is available from Louis Berger Group.[3]

3.3 Bloss Curve

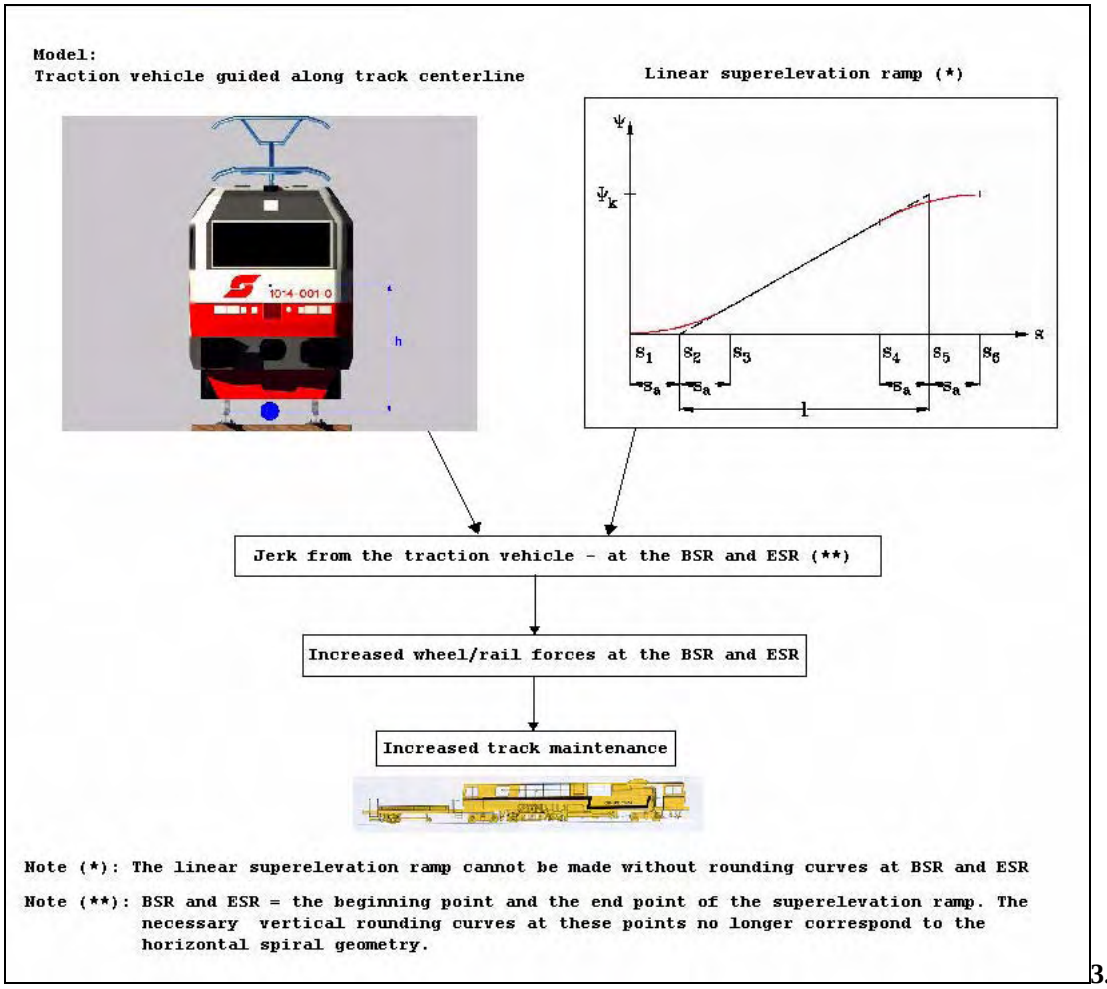
In certain cases the VSB spiral cannot be used because of its length. The Bloss curve is popular in Europe. It provides gradual transition of roll acceleration without providing the gradual transition for jerk that is characteristic of the VSB spiral. The Bloss curve brings major ride improvements in comparison with clothoid or parabolic spirals. Since the Bloss curve is relatively short, it is widely used for upgrades of existing track that often aim at operational speed increases as shown in Figure 3.2-6.

The upper picture shows the shift of the track centerline in the direction opposite to the direction of the curve because the wheels of the vehicle that rotates around its gravity center on the superelevation ramp swing outward as can be observed in the vehicle's crossection shown in Figure 3-2.3.

[2] This phenomenon associated with traditional spirals was independently realized and documented by Donges in 1968, by Louis T. Klauder, Jr., in 1972, and by Dr. Hasslinger in Austria in 1980 who succeeded in installation of experimental sections with new generation of vehicle-stability-based (VSB) spiral placed in the vehicle's center of gravity in 1982. Three curves of a mainline double track and one curve of a secondary double track line were selected for the test. The new spirals were provided only in one track of the double track line while the other track remained equipped with the original clothoid spirals and served as a reference. During the period from 1982 to 2001, the reference track had to be tamped three times to restore track geometry while the geometry of the track equipped with the VSB spirals remained within allowable tolerances without tamping.

[3] Two main suppliers of proprietary software based on VSB compliant mathematical functions are present at the market, Herbert von Hesslinger, Austria, and Louis T. Klauder Jr. PhD, USA.

Figure 3.2-1: The Problem with a Traditional Spiral According to Hasslinger's Transition Curves between the Tangent Track and a Circular Curve of Constant Radius



3.2 Enhanced Standard Operational Concept

Figure 3.2-2: Sudden Lateral Acceleration Kinks on a Traditional Spiral

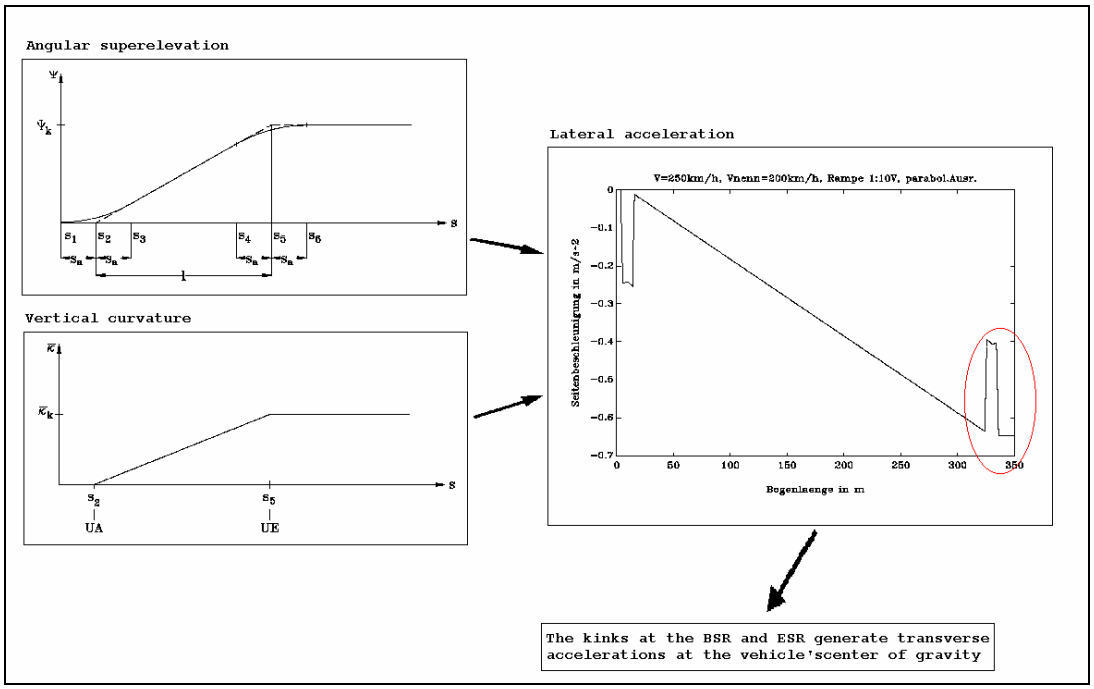


Figure 3.2-3: Movement of Car's Center of Gravity on a Conventional Spiral from CG1 to CG2 that Causes the Lateral Acceleration Jilt and Lateral Jerk

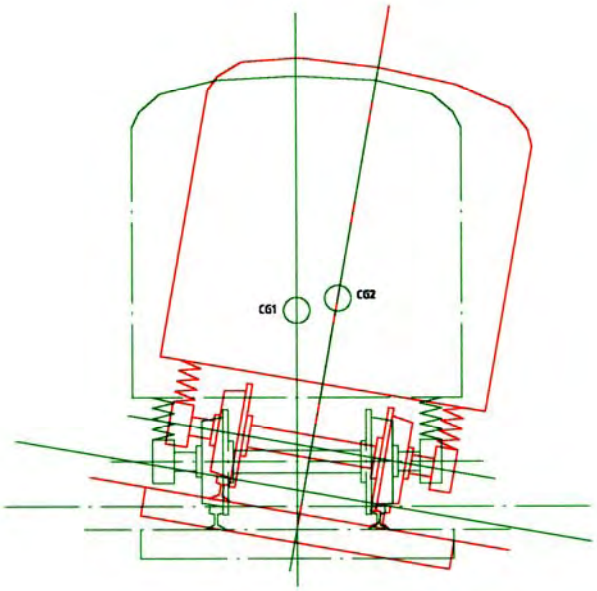
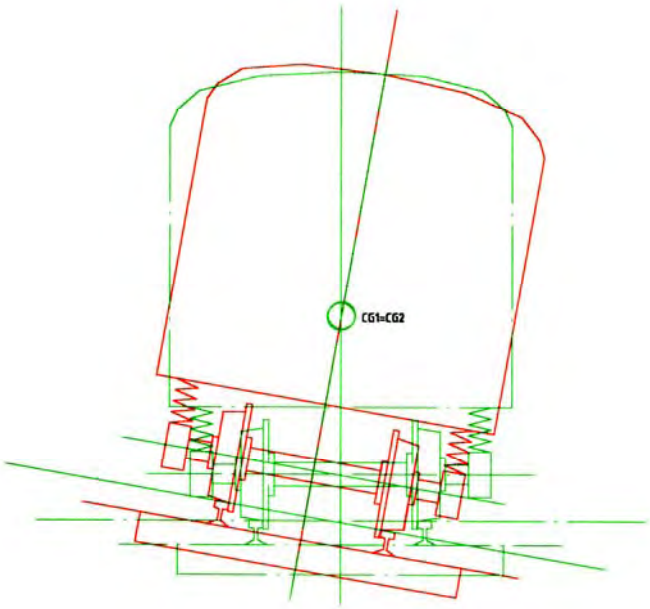


Figure 3.2-4: *Top*: Complete elimination of all car's center of gravity movements by new VSB spiral geometry and a Swiss-style lowering of inner rail on a curve
Bottom: Elimination of the car's sideway movement (roll) while allowing a vertical movement due to the standard outer rail's rising on a curve



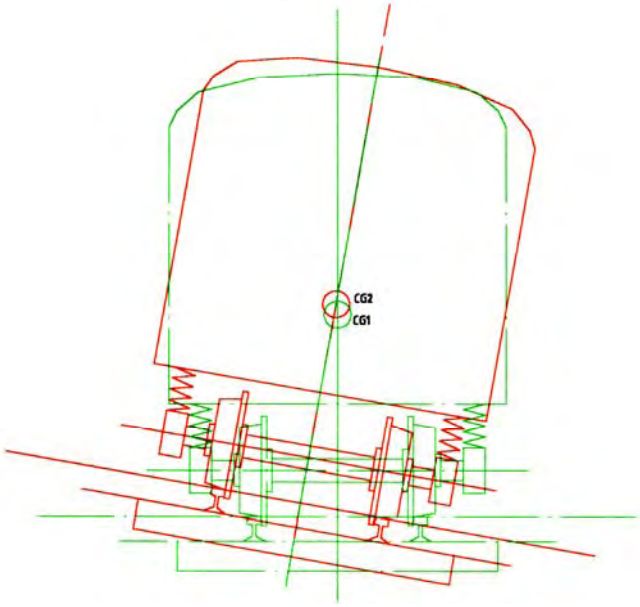
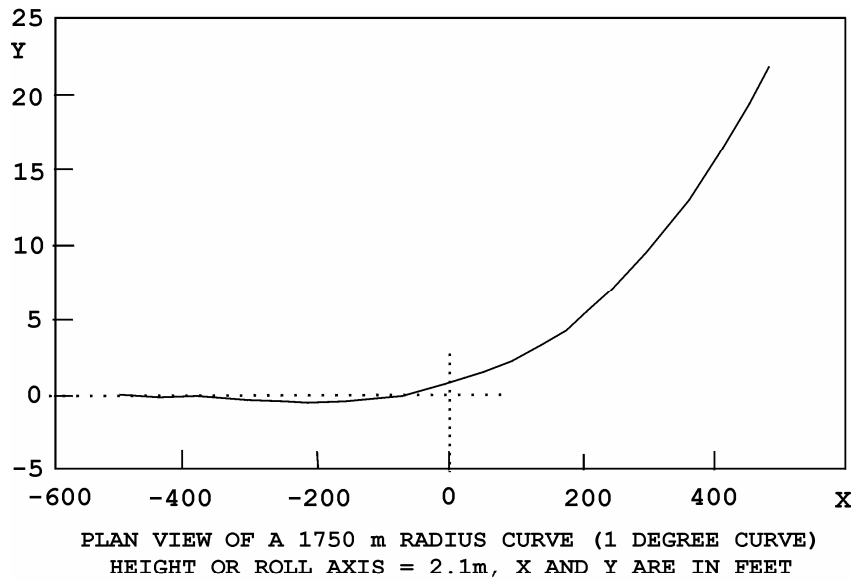
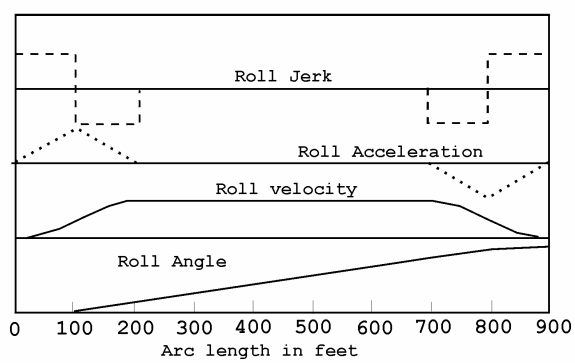


Figure 3.2-5: Example of VSB spiral geometry according to Louis T. Klauder

The upper picture shows the shift of the track centerline in the direction opposite to the direction of the curve because the wheels of the vehicle that rotates around its gravity center on the superelevation ramp swing outward as can be observed in the vehicle's crossection shown in Figure 3.2-3.





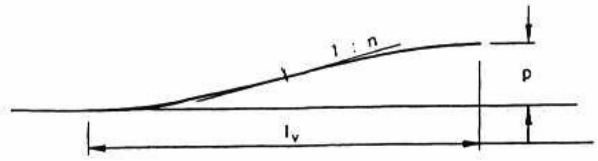
4.0 Gauges and Clearances

4.1 Shuttle Operational Concept

The conventional operational concept would allow the interchangeability between Israel Railways rolling stock and that of the operator of the West Bank-Gaza railway. This provides considerable opportunities to exchange (borrow) equipment and to share maintenance facilities and personnel. An alternative operating approach would be to adopt a shuttle concept similar to the one utilized by the Channel Tunnel. In this case, cars, buses and trucks would embark on the train at the origin of the trip and disembark at the end of the trip. Vehicle drivers would use ramps and drive directly onto and off the shuttle cars with little delay in time. Consequently, the rolling stock used is non-traditional and is relatively expensive. Its interchangeability with Israel or Egyptian Railways equipment would be limited even though conventional rolling stock could operate on the Palestinian line; the Palestinian shuttles could not be used on their lines. This might require buying two types of rolling stock one for shuttle operations and the other for conventional operations.

Figure 3.2-6: Non-linear Superelevation Ramp and Simple spiral According to Bloss

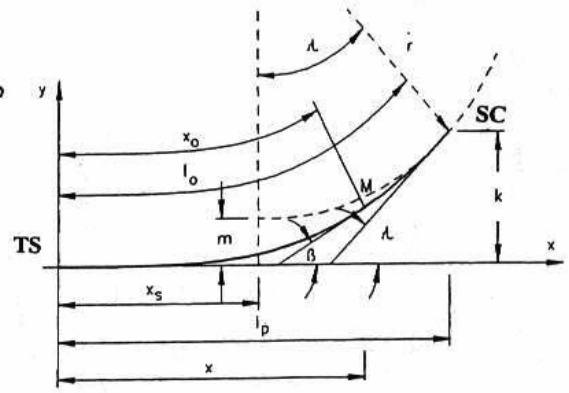
$$p(x) = p \cdot \left[3 \cdot \left(\frac{x}{l_v} \right)^2 - 2 \cdot \left(\frac{x}{l_v} \right)^3 \right].$$



$$1 : n = \frac{3 \cdot p}{2\,000 \cdot l_v}$$

Relative slope of rails related to warp

$$p'(x) = 6 \cdot p \cdot \left(\frac{x}{l_v^2} - \frac{x^2}{l_v^3} \right).$$



General function of the spiral **x** and **y** coordinates of a general point	$y = \frac{x^4}{4 \cdot l_p^2 \cdot r} - \frac{x^3}{10 \cdot l_p^3 \cdot r}$
Tangent angle λ at the end point	$\mathrm{tg}\,\lambda = \frac{l_p}{2 \cdot r}$
Ordinate of the end point **k**	$k = 0{,}15 \cdot \frac{l_p^2}{r}$
Circular curve to tangent distance **m**	$m = k - r \cdot (1 - \cos\lambda)$
Ordinate of the center of the curve **x**	$x_s = l_p - r \cdot \sin\lambda$
Spiral length in the spiral centerline **l**	$l_o = l_p + \frac{l_p^3}{43{,}8 \cdot r^2}$
Length of a part of the spiral $\mathbf{x_o}$ measured in the track centerline	$x_o = x + \frac{1}{2 \cdot r^2} \left(\frac{x^7}{7 \cdot l_p^4} - \frac{x^8}{8 \cdot l_p^5} + \frac{x^9}{36 \cdot l_p^6} \right)$
Tangent angle β at a general point	$\mathrm{tg}\,\beta = \frac{x^3}{l_p^2 \cdot r} - \frac{x^4}{2 \cdot l_p^3 \cdot r}$

The track gauges and clearances will be considerably larger than the standard clearances utilized by Israel Railways. The distance between tracks of a double track line will be 5.00 m, the height of the clearance profile 7.20 m, and the width of a double track clearance profile 10.00 m, subject to further modifications.

The space provided for movement of trains will be more than adequate for rolling stock used by the Israel Railways. However, the power cable of catenaries will be located at a higher elevation above the track than what corresponds to the standards of Israel Railways. Electrical locomotives of future interchange option will be provided with a dual pantograph height. International trains, if any, will be hauled by diesel locomotives until neighboring countries adopt electrification programs so that the difference in the location of the catenary cable will not be an issue for a long time.

4.2 Enhanced Standard Operational Concept

The track gauges and clearances will comply with the standards utilized by Israeli Railways.

5.0 Gradients

While fast trains of the passenger transportation aspect of the line could easily operate on gradients up to four percent, the economy of freight operations of the proposed mixed traffic line lead to gradients well below two percent.

In anticipation of large volumes of freight in the future, the maximum gradient of 1.5 percent and the preferred 1.3 percent gradient consistent with the standards of Israeli Railways have been established. These gradients correspond to the gradients that were actually achieved by alignment design within two corridors of the given topographic area without any extraordinary structural measures such as long tunnels and high bridges.

6.0 Axle Loads

The axle loads of freight trains have an increasing tendency worldwide. The axle loads reaching 300 kN appear on new European railway projects. The axle loads in the USA, Canada and Mexico have already reached almost 400 kN. It is recommended to use 300 kN for the shuttle operational scenario. The minimum of 250 kN may be acceptable for freight operations of the standard option if the actually found foundation conditions are poor.

7.0 Grade Separation

The track of the connector will be fully grade-separated by underpasses or overpasses wherever roads, highways, and railways are crossed for the following reasons:

- The design speed is above the practical limits normally used for level crossings.
- There is no railway level crossing technology in existence that guarantees a zero occurrence of an accident; and
- Any collision between a train and a foreign vehicle may trigger an international incident.

8.0 Separation between Highway and Railway Traffic of Combined Road/Rail Alternative

Wherever railway parallels a highway, road vehicles have to be physically prevented from entering the railway track by one of the following means in addition to the standard highway barrier installed along the edge of the highway:

- Vertical wall of sufficient impact resistance to prevent trucks from crushing through it and obstructing the railway track in a case of major accident. Its height should be sufficient to prevent a container loosen by an accident from sliding over the wall on the track.

  The wall should be preferably a retaining wall and the track elevation sufficiently higher than the elevation of the adjacent roadway.

- The railway is placed on an embankment whose slope is 1:1.5 or steeper, and the top of the rail is at least 3m higher than the elevation of the roadway.

- The railway should be located at least 15 m away from the shoulder of the highway on a level terrain where the elevations of the railway track and highway are less than 3 m.

These requirements are derived from practices of American railways CTX and Santa Fe, as well as rapid transit systems in Washington DC, New York and Chicago. Specific references are being sought.

9.0 Track Structure

9.1 Ballasted Track Placed on Soils

Standard ballasted track is suitable for all track installed at grade, on embankments and in cuts. The minimum thickness of subballast layer, also called blanket layer or construction layer, should be at least 1m deep if rock exists at the bottom of the excavation.

A blanket layer of suitable strength and depth is needed for static strength of the railway. Lime, cement or bituminous stabilizations are acceptable to achieve desired properties. The elasticity modulus of the track subgrade should not exceed 120 MPa. A reduced elasticity modulus with good elastic recovery of underlying materials is preferable to a subgrade that is excessively hard and stiff.

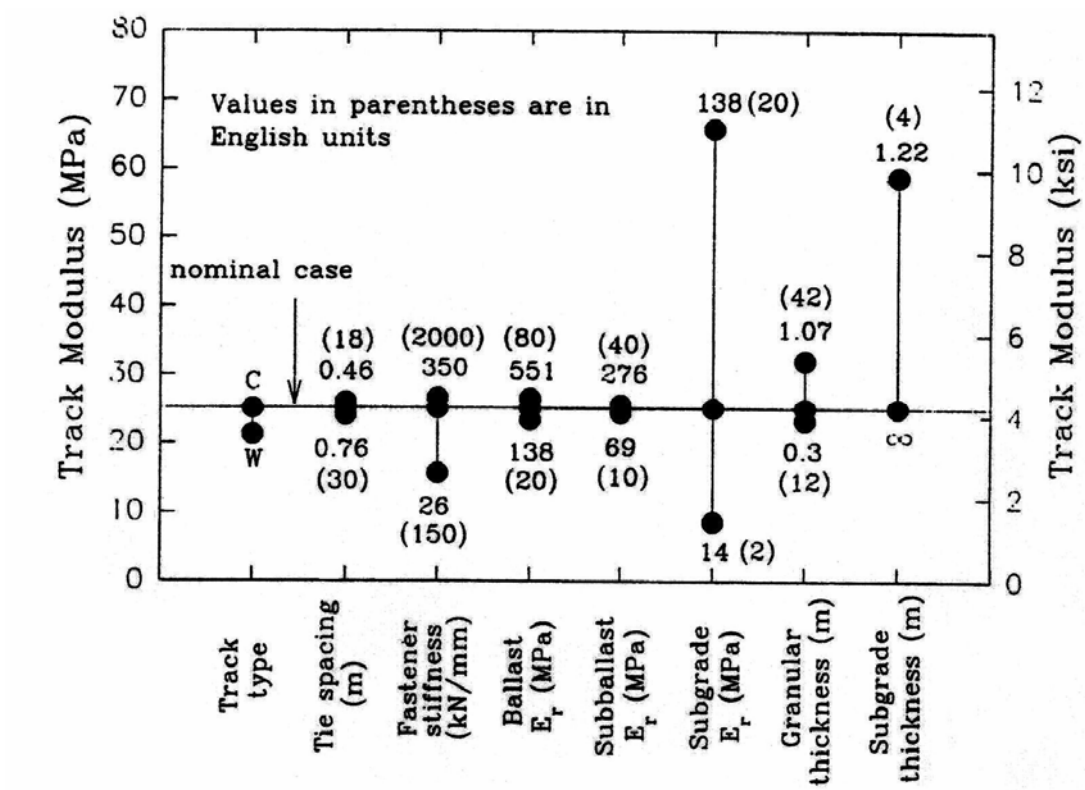
A major difference exists between static only design and dynamic design of railway subgrade. The dynamic approach leads to the elasticity modulus 40 to 60 MPa and leads to reduced maintenance rates providing that the elastic recovery is excellent and the permanent component of vertical deflection is very low.

In the cases of low strength soils present under the track, stresses in the rail progressively increase. The track/train interaction system displays stochastic behavior and dynamic peaks are amplified at certain frequencies. The strength of a weak stratum and its depth has much greater effect on the behavior of track than what is assumed by the Timoshenko's theory of elasticity. An enlarged suballast layer and/or layers placed on the week soil increase the bearing capacity at the interface with ballast. However, they accomplish surprisingly little within the overall loading scenario of the track. The adopted design theory should take into considerations time-dependent variables such as natural frequencies of participating soils, and address the dynamic track/train interaction scenarii for the entire operational speed range. The **Figure 3.2-7** shows the effect of individual track components on the elasticity of the track dominated by a soft subsoil layer and its depth.

The **Figure 3.2-7** also documents how little elasticity is added to the track by ballast in contrary to the popular belief and in contrary to design approaches that place ballast on directly on firm foundations such as tunnel inverts or bridge decks.

Should the depth of inadequate soils under the track become too costly for replacement or soil improvement options, the track should be built on an elevated structure, on a submerged concrete box (Holland), or the low preferred frequency of unsuitable soils responsible for resonance effects in the area of soft soils should be modified. For instance, the necessary increase of preferred frequency of soils was achieved by dry cement piles placed at 2 m distances in Sweden.

Figure 3.2-7: Effects of Track Components on Track Modulus



Source: *Track Modulus-its Meaning and Factors Influencing It* by Ernest T. Selig and Ding Qing Li, TRB Paper No. 94 0630, January 1994

Geotechnical conditions constitute a major alignment design factor. Unsuitable areas should be avoided where possible. Agro Geotechnical overview of the entire interest area is desirable. Appropriate geotechnical exploration during the design of the railway is necessary. The reliability and economy of the exploration can be enhanced by the utilization of remote sensing methods of geophysics.

The traditional drilling approach based on actually drilled borings at spaced at prescribed equal distances is less reliable, slower, and much less economical than the combination of small number of calibration borings with data obtained by suitable combination of geophysical methods. In such a case only one boring is needed per each quasi-homogenous zone of uniform geological properties. The quasi-homogenous zones or blocks are determined at the beginning of the exploratory project.

A use of only one geophysical method is inadequate.

9.2 Ballastless Track in Tunnels

Since the maintenance of ballasted track placed directly on very rigid concrete invert is intensive, a properly designed ballastless track will provide better results.

Ballastless track forms exist in a number of variations that range from poor imitations of ballasted track to the best-performing railway track in existence. The situation on the ballastless track market is misleading because disastrous ballastless track alternatives are advertised next to successful ones without any clear distinction. The best indicator of a good choice is the dampening value that should be in excess of 1.2 based on the "Three Decibel Method" specified for Eurotunnel track. The dampening test should be performed in addition to other routinely performed tests of ballastless track froms.[4]

9.3 Track on Elevated Structures

Since the bridge slab is very stiff, the same that was said about the tunnel track applies to elevated structures. The maintenance intensity of a ballasted track placed on elevated structures is high. Costly ballast mats have been tried worldwide with mixed success. They often curl and interfere with tamping operations.

Ballastless track with the independent booted blocks functioning as dampers has been successfully installed on several railways and rapid transit systems worldwide. However, its advantage over the ballasted track is not as dramatic as in the case of tunnel for the following reasons:

- The temperature changes generate complex loading conditions when the bridge spans and continuously welded rail expand differently. Stresses in participating trackwork and structural members can become quite high. In the case of ballasted track, the track expands and contracts independently of bridge spans so that the stress increases due to the temperature changes are much lower.

- The potential distortion of the track by unequal settlement of bridge piers is easier to correct on a ballasted track than on a track directly attached to the concrete slab of an elevated structure.

For this reason, a novel railway tie that includes independent booted blocks is being developed to add the desired dampening ability to the ballasted track of elevated structures.

9.4 Trackwork Components

9.4.1 Rail

The U.I.C. 60 rail profile, or AREA 136 RE rail profile, is recommended for all trackwork. The rail should be installed at the 1:20 lateral inward incline. The rail should be shop-welded into 150 to 200 m long rails, transported to the site, and field-welded into a continuously welded rail (CWR). Expansion joints may be still necessary at certain locations.

[4] To date, only the family of ballasted track of Eurotunnel type spread to about twenty other locations worldwide has met the dampening requirement. Its life expectancy has been proven to be indeed many times higher than the life expectancies of virtually all other ballastless track forms present on the market including products of prominent manufacturers. This is because this track type is based on a rail support provided by a concrete block suspended between two elastomers so that the system works as a damper. The other ballastless track systems present at the market are still primarily based on the static design approach so that the controlling dynamic forces are essentially disregarded or inadequately addressed by empirical experience and formulas.

The complex theory of CWR has been finally completed after decades of testing. It facilitates virtual elimination of expansion joints in the vast majority of climatic conditions. A project-specific CWR design should be provided at the final design stage.

Rail Specification - Metallurgy: The recommended rail specification is as follow:

- Mainline Track and All Special Trackwork

  (1) Standard control-cooled manganese steel rails are permitted on curves which have a radius 600 m or greater. They have the following metallurgy:

Carbon C	0.60 to 0.85%
Manganese Mn	0.70 to 1.50%
Silicon Si	0.05 to 0.90%
Phosphorus P	< 0.04
Sulphur S	< 0.04

  (2) Rails made from high strength steel, micro-alloyed, alloyed or heat treated, shall be utilized on all rails placed on the curves of mainline track which have a radius smaller than 600 m, and the rail utilized within the crossovers. Metallurgy of high strength micro-alloy and alloy steel rail is specified as follows:

  a. Micro-alloy Chromium-Molybden-Vanad steel:

Carbon C	0.60 to 0.82 %
Manganese Mn	0.80 to 1.30 %
Silicon Si	0.30 to 0.90 %
Chromium Cr	0.80 to 1.30 %
Molybdenum Mb	0.01 to 0.20 %
Vanadium	0.04 to 0.06 %
Phosphorus P	< 0.020 %
Sulphur S	< 0.020 %
Aluminum Al	< 0.040 %
Hydrogen H2	< 2.5 ppm

  b. Traditional Alloy Chromium Manganese steel:

Carbon C	0.60 to 0.85 %
Manganese Mn	0.40 to 1.70 %
Silicon Si	0.25 to 1.20 %
Chromium Cr	0.40 to 1.20 %
Molybdenum Mb	0.10 to 0.25 % or Vanadium 0.07 to 0.20
Phosphorus P	< 0.040 %
Sulphur S	< 0.040 %

- Secondary Trackage

  The rail steel permitted on secondary trackage with the curve radius greater than 300 m can be of standard control cooled metallurgy. All other rail shall be of high strength as specified above.

- Frogs and Switch Rails

  Austenitic manganese steel with the 11 to 15 % manganese content shall be used on frogs and preferably switch tongues as well. The U.I.C. Code 866, Technical Specifications for the Supply of Cast Manganese Steel Crossings for Switch and Crossing Work, shall apply. 50 Joule DVMF Impact Value shall be consistently maintained in the special trackwork. Fine pearletizing and/or other specialized forms of heat treatment are permitted on switch rails only providing that the minimum DVMF Impact value of 50 Joule DVMF value is consistently maintained.

Rail Specification - Mechanical Properties: The recommended mechanical properties of the rail are as follow:

- Hardness

  (1) The hardness of rail steel shall not be less than 310 BHN (Brinell Hardness Number) except for the lower strength rail which is permitted on secondary trackage. The minimum hardness of the lower strength rail is 285 BHN.

  (2) Maximum hardness is 388 BHN. This value may be exceeded only when fully fine pearlitic structure is maintained. U.I.C. Code 721 R, Recommendations for the use of Hard Quality and Extra Hard Quality Rails, shall be followed.

- Tensile Strength

  The tensile strength of all types of rail utilized on the rapid transit system shall not be less than 850 N/mm2. Typical tensile strength in excess of 1,000 N/mm2 is expected but not required from the alloy rail specified for the mainline track, special trackwork and curves.

- DVMF Impact value

  The DVMF impact value shall not be less than 30 Joule in the plain track areas and 50 J on critical components of special trackwork such as frogs, points and switch rails. Also, the rail shall be tested for impact toughness according to the U.I.C. Code 860, H = 0.15 G.

- Unconventional properties

  The rail shall be tested for the following unconventional properties according to U.I.C. 900A:

  Rupture toughness
  Low cycle fatigue - coefficient of cyclic strengthening
  High cycle fatigue - fatigue limit according to Woehler's curve

Tolerances: The acceptance of deviations of the supplied rail from the specified rail profile shall be based on the AREA Manual, Chapter 4, Part 2, Art.5.

9.4.2 Ties

Standard Line Ties: Concrete ties monoblock type spaced at 600 mm center to center are recommended. The domestic design, furnishing and handling of concrete ties should be reviewed and modified for increased axle loads. The ties should be equipped with ductile fastener shoulders to receive elastic rail clips. Steel tie plates are avoidable by adequately designed elastomeric rail pads.

Special Ties: Special ties may be equipped with cast-in special steel plates for installation of turnouts. However, threaded inserts to receive threaded connections of special trackwork to the ties may become an unnecessary intensifier of track maintenance. Threadless elastic clips inserted into shoulders cast in the concrete or welded on the special plates should be used and threaded anchors holding plates in the concrete avoided as well.

9.4.3 Fasteners

The fasteners should be of elastic design and entirely threadless. Threaded connections are prone to loosening by dynamic activities describable by the second harmonic function, or tend to rust and freeze, so that labor-intensive re-tightening or loosening of bolts is necessary. This exercise is completely avoidable by utilization of widely available threadless trackwork components. Even when the domestic climate is generally dry and does not lead to progressive corrosion of clip bolts, threadless fastener alternatives offer major maintenance savings.

The static toe load of the fastener should be 11 kN +/- 2 kN. The minimum static preload deflection of the clip should be 10 mm +/-.

Electrical insulators placed between the elastic clip and the flange of the rail are usually used to facilitate incremental lateral adjustment of the rail position +/- 10 mm or more using asymmetrical insulators. Electrical insulators functioning also as mechanical components of the fastening system should have adequate mechanical strength and resistance to abrasion.

The rail should be supported by an elastomeric rail pad supplied together with the fastener by the same supplier. The elastic response of the rail pad should not depend on the change of its external shape. Its internal deflection abilities should be provided by closing microcellular voids, or by deformation of interior openings, studs or cavities.

The fastener should be tested for endurance in a dynamic loading environment of wide frequency range, and impact attenuation test should be performed in addition to the standard fastener testing.

9.4.4 Ballast

Ballast is the weakest component of the track structure. The selection of appropriate rock is essential. In addition to the static strength of ballast, proper attention should be given to its toughness and endurance in the dynamic loading environment of the railway track.

Annex 3-3

GEOLOGICAL AND GEOMORPHOLOGICAL CHARACTERISTICS
PRELIMINARY DRAFT

The analysis continued with an examination of geological and geomorphological features. A general geological description of the area follows. A general geological map with a description of the main soil/rock characteristics is attached as Figure 3.3-1 at the end of the annex.

The geology of the region is based on the tectonic structure of the Judea Mountains, which are a non-symmetrical anticline. Most of the rocks that build the anticline are sedimentary rocks, which have a massive to well-bedded structure. The anticline is a folded structure with a steep slope at the eastern side and a relatively moderate slope at the western side. The direction of the anticline axis is north-north-east to south-south-west, which results in a steep bedding inclination at the western slopes and a moderate bedding inclination at the southern slopes. The ancient rock units (of the Cenomanian and Turonian Ages) are exposed along the anticline slopes and on the top of the anticline axis. These rock units are buried at the western area (Shfela) beneath younger rock units (Eocene and Neogene Age). The main tectonic process of folding was terminated before the Eocene Age and therefore the chalk and chalky limestone units are not folded and faulted, and the region is characterized by a low seismic activity. These units were later eroded due to the regression of the sea in the Neogene Age, which resulted in deep channels and river streams which at the present time are filled with younger deposits. At the Quaternary Age, most of the sediments are from terrestrial origin and the soil profile is influenced by climate changes. Sand dunes and loess are created in arid areas and clayey to silty soil in areas of humid climate.

The connecting road will cross three main geomorphological regions:

1. The Coastal Plain – a relatively flat area, 20 km in width with elevations of +50 m above sea level (a.s.l) close to the Gaza Strip and up to +170 m a.s.l at the border with the Shfela region. The average inclination is 0.6%.

2. The Shfela Region – A hilly region, 20 km in width with rounded hills up to +450 m a.s.l. The average inclination is 1.5%.

3. The Southern and Western Slopes of the Hebron Mountains – A mountainous region, 10 km in width with a peak elevation of +1002m at Hebron. The western slopes are relatively steep slopes with an average inclination of 5.5%. The southwestern slopes are moderate, average inclination is 2.7%, due to the tectonic structure of the Hebron Ridge.

The division of rock units is in respect to the geomorphology. The distribution of the rock units is presented in the attached 1:200,000 scale geological map Figure 3.3-1. The letter symbols in the map, which describe the soil/rock units, are marked in brackets. In summary:

- The Coastal Plain – consists of brown fine grained clayey soils (q), loess (q), silty to red sandy soil (qh) and sand dunes (qs), crossed by elongated north-south ridges built of calcareous sandstone (qk), which has the local name Kurkar.

- The Shfela – consists of light brown silty to clayey soils (q), with local outcrops of conglomerate and gravel (ngc) along the valleys. Weak to moderately strong Chalk to Chalky Limestone (emr and ea), marl and marly chalk (eu) appear along the hills and well bedded limestone (ol and mm). This region consists of hundreds to thousands of man-made ancient caves and underground cavities that may cross the road alignment.

- The slopes of the Hebron Mountain – consists of variable rock units from fat marl (pa), soft chalk (ma and sc), chert (ca), hard strong dolomite (c3), to limestone (t and c2).

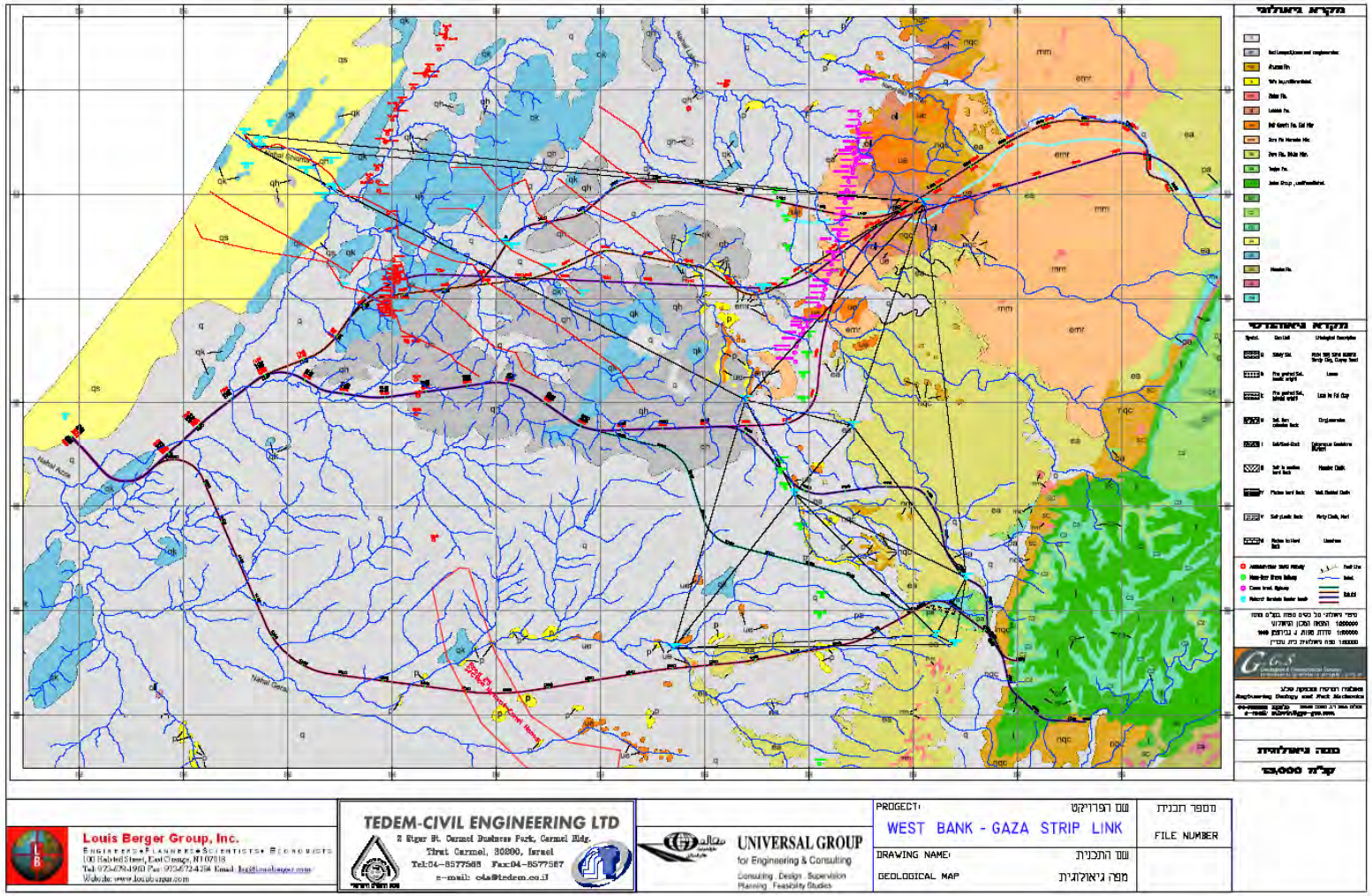
In conclusion, the geology of the region is defined by the topographic inclination and the direction of rock bedding planes. The soil/rock units are be defined according to their geotechnical characteristics and in respect to the geomorphological regions:

- The coastal plain – issues are compressive strength, shear strength, swelling and settlements potential, Elastic modulus, USCS and AASHTO classifications of different soils and the influence of the moisture content on the physical and mechanical characteristics of soil, especially on loess.

- The Shfela - issues are compressive strength, shear strength, swelling potential of marls, Elastic modulus, rippability of rock according to seismic wave velocity, geomechanical classifications of rocks for tunnel sections, instability of slopes, and the influence of the drainage system and hydrogeology of the region. A special issue is the influence of man-made cavities along the road.

- The slopes of the Hebron Mountains – issues are compressive strength, shear strength, swelling potential of marls, Elastic modulus, rippability of rock according to seismic wave velocity, geomechanical classifications of rocks for tunnel sections, instability of slopes, and the influence of the drainage system and hydrogeology of the region. A special issue is the influence of karst phenomena on the mechanical properties of the rock mass.

Map 3.4: Geologic Map



ANNEX 3-4

PRELIMINARY HYDROLOGICAL ANALYSIS

1.0 General

This survey presents the preliminary hydrological assessment of major river channels that each alignment alternative crosses, with their drainage basin sizes and the probability of peak discharges for these major crossings. In addition, a general explanation is provided for hydrological zones that exist along each road alignment. The general discharge-drainage basin area tables are given for each of the alignments and for the major crossings.

This hydrological assessment does not address the small drainage basins dissected by the various alternatives. These small basins will be analyzed later under the general planning scheme of the chosen alternative.

The major drainage area sizes are based on the "Rivers of Israel and their Drainage Basins" publication issued by the Ministry of Agriculture, Department of Soil Conservation.

2.0 Hydrological Zones

The area for the different alternatives is divided into three major zones in terms of the topography and of the six major soil types.

2.1 Topographical Zones

All the road alignments traverse the country from West to East. They pass from the Negev plains through the Shfela (lowlands), to the hilly areas of Lakhish-Lahav, and eventually into the mountainous area of Mt. Hebron.

From a hydrological perspective, the steeper the drainage basin the higher is the flow velocity, Lag time decreases and less water penetrates into the ground – factors influencing the magnitude of the peak discharges.

Therefore, the area can be divided into six different hydrological units:

Old " Patrol Road"		**Planned Road 6 Alignment**
Northern Negev/Southern Shfela soil types K	Lakhish-Amatzia chalk hills soil type B	Mt. Hebron Mountainous - steep soil types A and B
Northern Negev soil type N	Lahav-Sansana Hills soil types M and N	Southern Mt. Hebron soil types M and B

The boundary between the mountainous terrain and the moderate chalk hills passes the Old Patrol Road (Shekef-Lahav Road). The border between the moderate hills, the Northern Negev plains and the Southern Shfela generally crosses the planned Road 6 alignment. Between the loessial soil of the northern and southern parts, the border passes near the settlements of Nir Moshe, Ruhama and all the way to Nahal Adoraim in the hilly terrain.

2.2 Soil Groups

In general, the division between the different soil groups is the north-south and east west directions:

The North-Eastern Zone (Mt. Hebron): The area is characterized by A and B soils. Terra-Rosas and Rendzinas, where the former originates from hard limestone rock, are characterized by deep Karstic fractures. These soils are highly permeable and transport most of the rainwater during low and moderate intensity rainstorms (despite the soils' steepness).

The North-Central Zone (the chalk hills of the Lakhish-Amatzia area): The area is characterized especially by B type soils (Rendzina) that originate from chalk rock. These soils are less permeable than the A and B soils because the parent material chalk is an impermeable layer.

The North-Western Zone: The area is characterized by hilly plains and clay alluvial soils. The soil is primarily K type (brown-grumosol soils) that during low probability rainstorms is not sufficiently permeable and may cause peak discharges.

The South-Eastern Zone – Southern Mt. Hebron: The area is characterized by B and M soils (Rendzinas and brown-loessial soils). The soil is exposed due to decrease in rainfall amounts and intense grazing, consequently increasing the runoff amounts.

The Southern Central Zone: The area is characterized by M soils (light-brown loessial soils and brown lithosols). The steep gradient of the hilly terrain combined with these soils produce high amounts of runoff.

The South-Western zone: The area is characterized by plains with loessial soils (N, N2 and small amounts of S and M).

3.0 Major Streams

The major streams of the Northern Negev and Southern Shfela flow through the project zone. From a north-south direction the various alternatives cross the following streams:

- Nahal Guvrin
- Nahal Lakhish
- The tributaries of Nahal Shikma (Adoraim, Kelach, Shikma and Hanun)
- The northern tributaries of Nahal Besor (Hagadi, Sharsheret, Grar and Phachar)

These ephemeral streams are dry during the summer months, and may discharge very high quantities of water, especially during the autumn and spring months. The floods are produced due to the streams' drainage outlet from the steep Mt. Hebron and their passage through quickly crusted soils in addition to their large drainage areas.

4.0 Basin Discharges

General data relating to discharge probabilities by basin and also to the different soil types is presented in Figures 3.4-1 through 3. These graphs are intended to illustrate possible scenarios reflecting probable discharges in the project area.

The calculation was performed according to the graphic-analytical technique. The developers of the model undertook a probabilistic analysis of 170 gauging stations around the country. The country was divided into 11 hydrological zones according to soil types and geomorphic units, and a probabilistic calculation of discharges for the different drainage basins was developed.

As stated above, the graphs are only for general evaluation of the hydrologic regime and a more precise calculation is needed once the planning alternative will be chosen. The new calculation will be based on the drainage basins' area, their gradients, the land cover (such as vegetation), measured hydrologic data of nearby streams, the cross-sectional character of the active channel, channel regulation and other variables that affect the design discharges.

Figure 3.4-1: The Probabilistic Discharges for Drainage Basins in the Mountainous Area (for Mountain Soils)

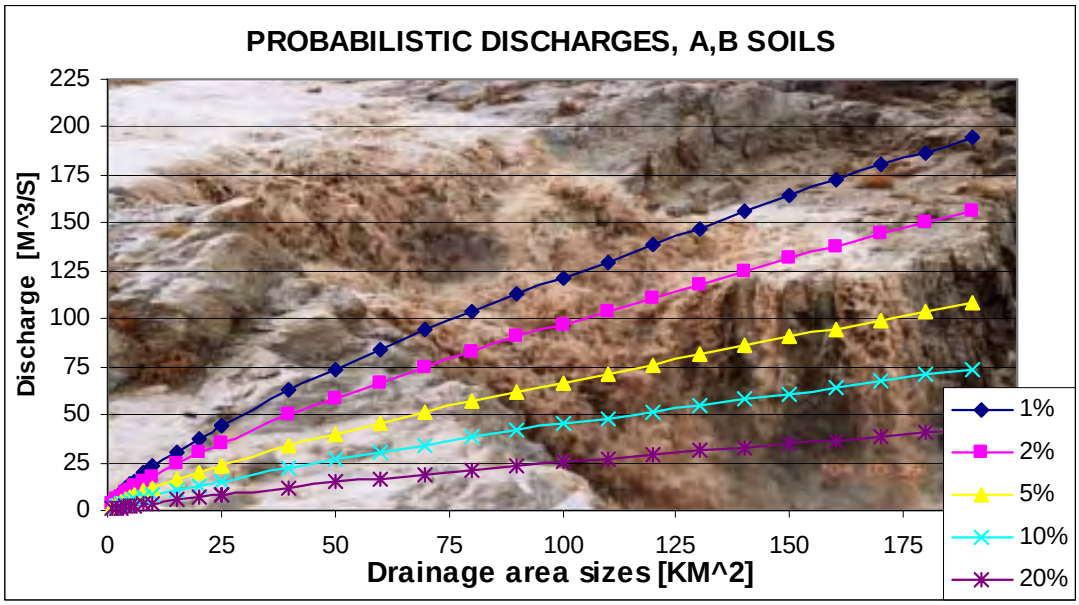


Figure 3.4-2: The Probabilistic Discharges for Drainage Basins in the Alluvial Soils of the Southern Shfela

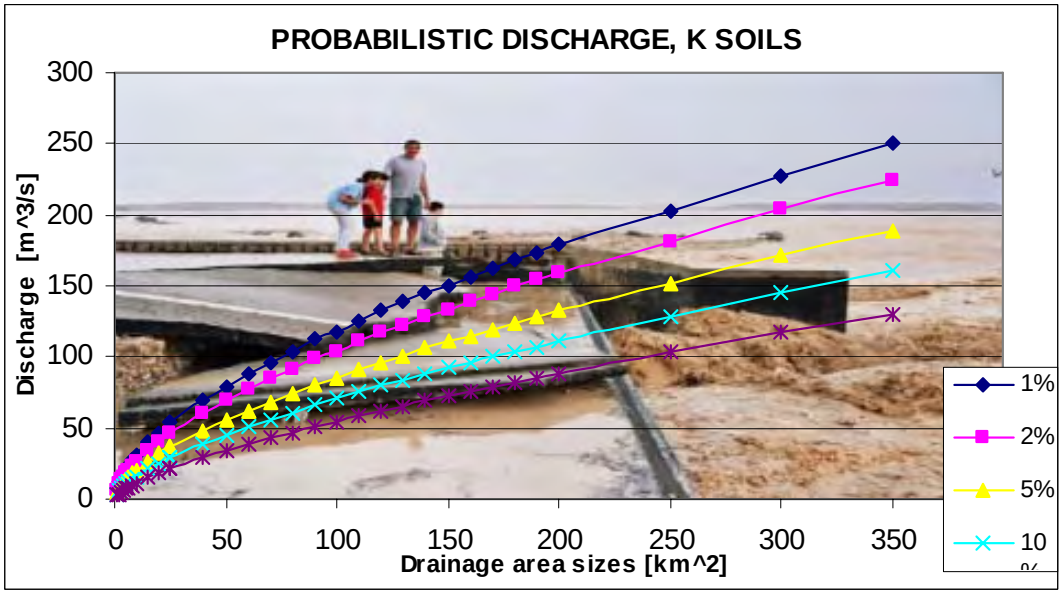
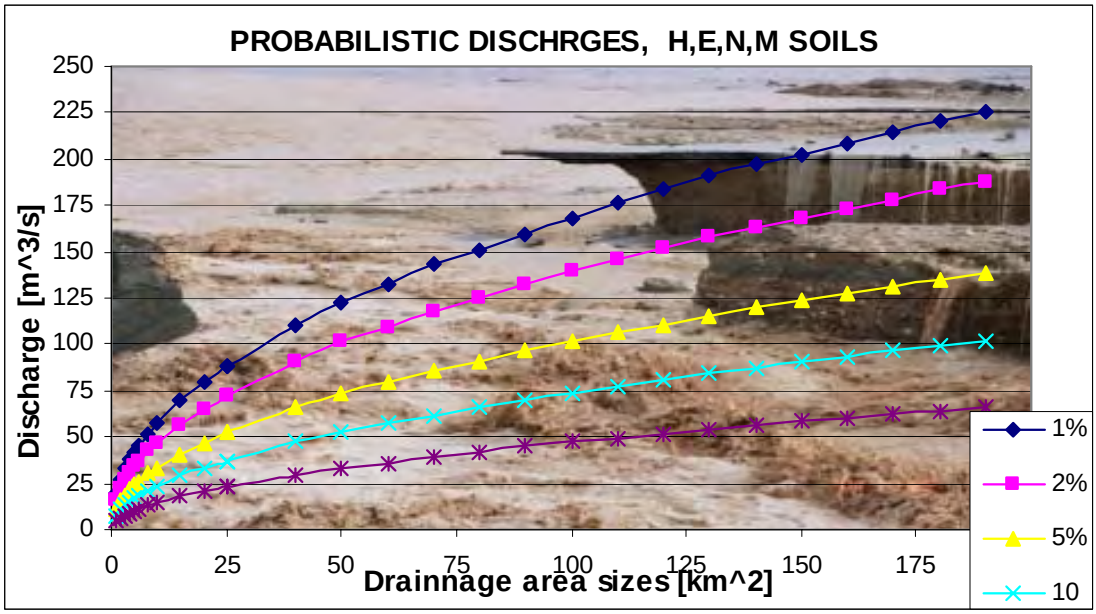


Figure 3.4-3: The Probabilistic Discharges for Drainage Basins in the North Negev (Loessial soils)



5.0 Calculated Discharges of Major Streams

The design discharges for the major streams crossing the planned area (given for the various alternatives) are presented in Tables 3.4 – 1 to 6. The adjoining map shows the localities where the design discharges were calculated. The discharges shown in the tables are preliminary only and for general assessment and are not intended for the final planning procedure. Some general remarks regarding the calculation of discharge flows are:

- Channel crossings that repeat in two different alignments are only mentioned once in the preceding alternative (see map).
- The small channels that cross the different alignments will be dealt with separately after one of the alternatives has been selected.
- For calculation purposes, in additions to bridges and water culverts detailed in the main crossings, it is recommended to add an additional culvert sized 2x2 for every 1 kilometer of road.

5.1 Alignment 1

Some consideration in the design of the road/rail link along this alignment are:

- In the section parallel to the railroad tracks, there are many channels crossing.
- Nahal Kosem and Nahal Nir-Am Shems are drain the urban area of the city of Sderot.
- Near Bet Govrin, attention should be given to Nahal Guvrin adjacent to the road (the discharges for the stream in case there will be a crossing that appears in 1.14A).
- In the upper reaches of Nahal Govrin, attention should be given to the location of the road in relation to the channel.

Table 3.4-1: Probabilistic Discharges for the Major Stream Crossings for Alignment 1

section num'	stream name	drainage area [km^2]	main soil group	Probabilistic discharges					
				20% 1:5 years	10% 1:10 years	5% 1:20 years	4% 1:25 years	2% 1:50 years	1% 1:100 years
1.1	HANUN	90	H,E,M,N	44.8	70.1	96.5	105.1	132.3	159.8
1.2	TIAH, MEKOROT	6	K	8.1	11.6	15.2	16.3	19.9	23.4
1.3	KOSEM	5	K	7.1	10.4	13.7	14.7	18.0	21.3
1.4	NIR-AM, UP	4	K	6.1	9.0	11.8	12.8	15.6	18.5
1.5	HOGA	64.2	K	40.5	53.0	64.8	68.6	80.0	91.2
1.6	SHIKMA	375	K	136.8	168.6	198.2	207.4	235.1	262.0
1.7	BAROR	38	K	28.1	37.7	47.0	50.0	59.0	68.0
1.8	HELETS	16.2	K	15.8	21.9	27.9	29.8	35.7	41.6
1.9	BAROR, UP	16	K	15.6	21.7	27.6	29.5	35.4	41.3
1.10	BAROR, UP	14	K	14.4	20.1	25.6	27.4	32.9	38.3
1.11	SHALVA	12.4	K	13.3	18.5	23.7	25.3	30.4	35.5
1.12	NOAM	24.8	K	21.2	28.8	36.3	38.7	46.1	53.4
1.13	LAHISH	117	A,B	28.6	50.6	74.9	83.0	109.1	136.1
1.14A	GOVRIN	100	A,B	25.3	44.9	66.5	73.8	97.0	121.0
1.15A	GOVRIN	50.4	A,B	14.8	26.7	39.9	44.4	58.7	73.6

5.2 Alignment 2

North of Mount Hesi, attention should be given to the road's location in relation to Nahal Shikma. It is recommended to transfer the road to the south of Mount Hesi and to avoid unnecessary channel crossings.

Table 3.4-2: Probabilistic Discharges for the Major Stream Crossings for Alignment 2.

section num'	stream name	drainage area [km^2]	main soil group	Probabilistic discharges					
				20% 1:5 years	10% 1:10 years	5% 1:20 years	4% 1:25 years	2% 1:50 years	1% 1:100 years
2.1	HOGA	64.2	K	40.5	53.0	64.8	68.6	80.0	91.2
2.2	SHIKMA	375	K	136.8	168.6	198.2	207.4	235.1	262.0
2.3	SHIKMA	390	K	139.8	172.3	202.4	211.8	240.1	267.5
2.4	SHIKMA	337	K	126.5	156.5	184.3	192.9	219.0	244.2
2.5	ADORAYM	226.4	H,E,M,N	72.1	110.7	150.5	163.5	204.4	245.7
2.6	MAAHAZ	6.4	K	8.4	12.1	15.8	17.0	20.7	24.4
2.7	SHALVA	6	A,B	2.8	5.3	8.2	9.2	12.3	15.7
2.8	NOAM	14	A,B	5.4	10.1	15.4	17.2	23.0	29.1

5.3 Alignment 3

Table 3.4-3: Probabilistic Discharges for the Major Stream Crossings for Alignment 3

section num'	stream name	drainage area [km^2]	main soil group	Probabilistic discharges					
				20% 1:5 years	10% 1:10 years	5% 1:20 years	4% 1:25 years	2% 1:50 years	1% 1:100 years
3.1	MIFLASIM	18.3	H,E,M,N	19.7	31.9	44.8	49.1	62.5	76.3
3.2	HOGA	10	H,E,M,N	14.3	23.5	33.3	36.6	46.8	57.4
3.3	HED	8.5	H,E,M,N	13.3	21.9	31.1	34.1	43.7	53.6
3.4	-	4	H,E,M,N	9.0	15.0	21.5	23.6	30.4	37.4
3.5	SHIKMA	51	H,E,M,N	33.6	53.3	74.0	80.8	102.2	124.1
3.6	-	12.7	H,E,M,N	16.1	26.5	37.4	41.1	52.6	64.4
3.7	ADORAYM	201	A,B	44.3	77.1	113.0	125.0	163.3	202.9
3.8	NOAM	14	A,B	5.4	10.1	15.4	17.2	23.0	29.1

5.4 Alignment 4

Table 3.4-4: Probabilistic Discharges for the Major Stream Crossing for Alignment 4

section num'	stream name	drainage area [km^2]	main soil group	Probabilistic discharges					
				20% 1:5 years	10% 1:10 years	5% 1:20 years	4% 1:25 years	2% 1:50 years	1% 1:100 years
4.1	-	3.5	H,E,M,N	8.4	14.0	20.1	22.1	28.5	35.1
4.2	SHIKMA	39	H,E,M,N	29.3	46.7	64.9	70.9	89.8	109.0
4.3	-	3	H,E,M,N	7.7	13.0	18.6	20.5	26.4	32.5

5.5 IMG Alternative (Earlier Version of Alignment 2)

In the area South of Kibbutz Brur-Ha'il, attention should be given to the alignment location in relation to Nahal Shikma. In addition, attention should be given to its location in relation to Nahal Marsha.

Table 3.4–5: Probabilistic Discharges for the Major Stream Crossing for IMG Alternative (1)

section num'	stream name	drainage area [km^2]	main soil group	Probabilistic discharges					
				20% 1:5 years	10% 1:10 years	5% 1:20 years	4% 1:25 years	2% 1:50 years	1% 1:100 years
I.0	KOSEM	5	K	7.1	10.4	13.7	14.7	18.0	21.3
I.1	NIR-AM	9.5	K	11.1	15.6	20.2	21.6	26.1	30.6
I.2	HOGA	64.2	K	40.5	53.0	64.8	68.6	80.0	91.2
I.3	SHIKMA	375	K	136.8	168.6	198.2	207.4	235.1	262.0
I.4	SHIKMA	355	K	131.4	162.3	190.9	199.8	226.7	252.7
I.5	HAZAV	4	K	6.1	9.0	11.8	12.8	15.6	18.5
I.6	SHIKMA	107	H,E,M,N	48.9	76.3	104.9	114.3	143.7	173.6
I.7	ADORAYM	222	H,E,M,N	71.4	109.7	149.1	162.0	202.5	243.4
I.8	SHALVA	5	A,B	2.4	4.6	7.1	8.0	10.8	13.7
I.9	NOAM	14	A,B	5.4	10.1	15.4	17.2	23.0	29.1
I.10	LAHISH	115	A,B	28.2	49.9	73.9	82.0	107.7	134.4
I.10A	LAHISH	73	A,B	19.6	35.4	52.8	58.7	77.6	97.2
I.11	MARESHA	42	A,B	12.7	23.2	35.0	39.0	51.9	65.3
I.12	GOVRIN	80	A,B	21.1	37.9	56.6	62.9	83.1	104.1
I.13	EL-AVHARA	23	A,B	8.0	14.7	22.2	24.8	33.0	41.5
I.14	E-SABI	7	A,B	3.1	5.9	9.2	10.3	13.9	17.6

5.6 Alignment 6

It is recommended that this alignment by pass the "Beeri Badlands" Reserve from the south in order to avoid the crossings a number of many channels.

Table 3.4-6: Probabilistic Discharges for the Major Stream Crossings for Alternative 6

section num'	stream name	drainage area [km^2]	main soil group	Probabilistic discharges					
				20% 1:5 years	10% 1:10 years	5% 1:20 years	4% 1:25 years	2% 1:50 years	1% 1:100 years
6.1	SHUVA	23.8	H,E,M,N	22.5	36.4	51.0	55.8	71.1	86.6
6.2	BOHU	18	H,E,M,N	19.6	31.7	44.5	48.7	62.0	75.7
6.3	-	15	H,E,M,N	17.8	28.9	40.7	44.5	56.8	69.2
6.4	SHARSHERET	17	H,E,M,N	19.0	30.8	43.2	47.3	60.3	73.6
6.5	GRAR	244	H,E,M,N	75.8	116.1	157.7	171.3	214.0	257.2
6.6	PEHER	54	H,E,M,N	34.6	54.8	76.1	83.1	105.1	127.5
6.7	GRAR, UP	12	H,E,M,N	15.7	25.7	36.4	40.0	51.2	62.7
6.8	-	4	H,E,M,N	9.0	15.0	21.5	23.6	30.4	37.4
6.9	-	6	H,E,M,N	11.2	18.5	26.2	28.8	36.9	45.2

In Table 3.4-7, a summary of the preliminary sizing of the culverts and bridges are indicated.

Figure 3.4-4 shows the location of the proposed principle drainage structures.

Figure 3.4-4: Hydrological Map of the Alternative Alignments

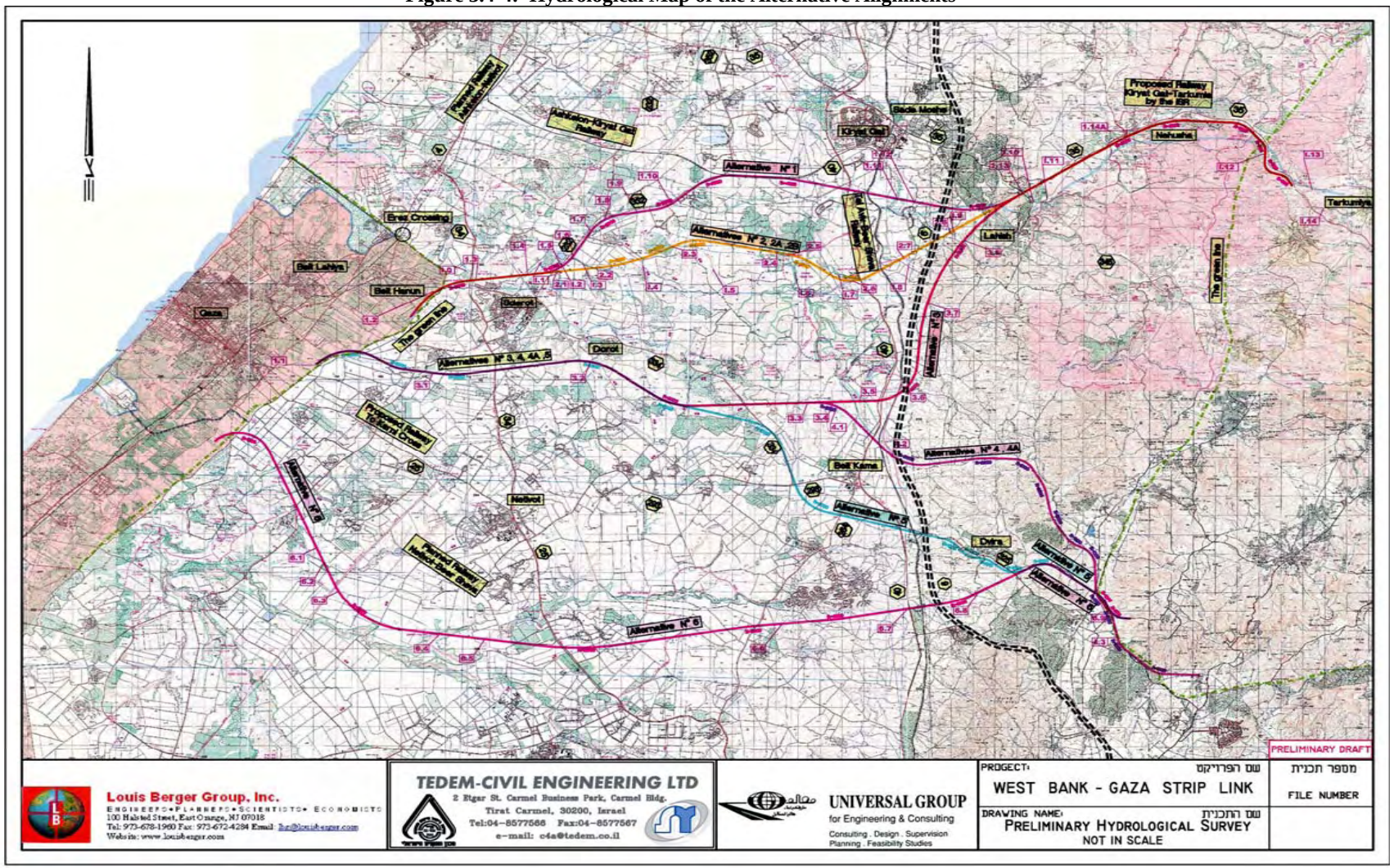


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Table 3.4-7: Bridges and Culvert Sizes for the Major Stream Crossings for Alignments 1 through 6

	section num'	stream name	drainage area [km^2]	discharge [m^3/s]		culvert size m	upstream w.s elevation [m]	
				2% [1:50 years]	1% [1:100 years]		1%	2%
1	1.1	HANUN	90.0	132.3	159.8	×	bridge	bridge
2	1.2	TIAH, MEKOROT	6.0	19.9	23.4	2*2.5×2.5	2.05	2.22
3	1.3	KOSEM	5.0	18.0	21.3	2*2×2.5	2.16	2.40
4	1.4	NIR-AM, UP	4.0	15.6	18.5	2*2×2.5	2.00	2.19
5	1.5	HOGA	64.2	80.0	91.2	×	bridge	bridge
6	1.6	SHIKMA	375.0	235.1	262.0	×	bridge	bridge
7	1.7	BAROR	38.0	59.0	68.0	3*3×3	2.78	3.08
8	1.8	HELETS	16.2	35.7	41.6	3*2.5×2.5	2.25	2.46
9	1.9	BAROR, UP	16.0	35.4	41.3	3*2.5×2.5	2.22	2.46
10	1.10	BAROR, UP	14.0	32.9	38.3	3*2.5×2.5	2.14	2.35
11	1.11	SHALVA	12.4	30.4	35.5	3*2.5×2.5	2.07	2.22
12	1.12	NOAM	24.8	46.1	53.4	3*3×3	2.35	2.58
13	1.13	LAHISH	117.0	109.1	136.1	×	bridge	bridge
14	1.14A	GOVRIN	100.0	97.0	121.0	×	bridge	bridge
15	1.15A	GOVRIN	50.4	58.7	73.6	×	bridge	bridge
16	2.1	HOGA	64.2	80.0	91.2	×	bridge	bridge
17	2.2	SHIKMA	375.0	235.1	262.0	×	bridge	bridge
18	2.3	SHIKMA	390.0	240.1	267.5	×	bridge	bridge
19	2.4	SHIKMA	337.0	219.0	244.2	×	bridge	bridge
20	2.5	ADORAYM	226.4	204.4	245.7	×	bridge	bridge
21	2.6	MAAHAZ	6.4	20.7	24.4	2*2.5×2.5	2.07	2.29
22	2.7	SHALVA	6.0	12.3	15.7	2*2×2	1.68	2.00
23	2.8	NOAM	14.0	23.0	29.1	2*2.5×2.5	2.19	2.57
24	I.0	KOSEM	5.0	18.0	21.3	2*2.5×2.5	1.87	2.12
25	I.1	NIR-AM	9.5	26.1	30.6	2*2.5×2.5	2.38	2.67
26	I.2	HOGA	64.2	80.0	91.2	×	bridge	bridge
27	I.3	SHIKMA	375.0	235.1	262.0	×	bridge	bridge
28	I.4	SHIKMA	355.0	226.7	252.7	×	bridge	bridge
29	I.5	HAZAV	4.0	15.6	18.5	2*2×2.5	2.00	2.19
30	I.6	SHIKMA	107.0	143.7	173.6	×	bridge	bridge
31	I.7	ADORAYM	222.0	202.5	243.4	×	bridge	bridge
32	I.8	SHALVA	5.0	10.8	13.7	2*2×2	1.53	1.79
33	I.9	NOAM	14.0	23.0	29.1	2*2.5×2.5	2.19	2.57
34	I.10	LAHISH	115.0	107.7	134.4	×	bridge	bridge
35	I.10A	LAHISH	73.0	77.6	97.2	×	bridge	bridge
36	I.11	MARESHA	42.0	51.9	65.3	3*3×3	2.55	2.98
37	I.12	GOVRIN	80.0	83.1	104.1	×	bridge	bridge
38	I.13	EL-AVHARA	23.0	33.0	41.5	3*2.5×2.5	2.14	2.46
39	I.14	E-SABI	7.0	13.9	17.6	2*2×2.5	1.83	2.14

40	3.1	MIFLASIM	18.3	62.5	76.3	×	bridge	bridge
41	3.2	HOGA	10.0	46.8	57.4	3*3×3	2.38	2.73
42	3.3	HED	8.5	43.7	53.6	3*3×3	2.29	2.61
43	3.4	-	4.0	30.4	37.4	3*2.5×2.5	2.07	2.32
44	3.5	SHIKMA	51.0	102.2	124.1	×	bridge	bridge
45	3.6	-	12.7	52.6	64.4	3*3×3	2.55	2.95
46	3.7	ADORAYM	201.0	163.3	202.9	×	bridge	bridge
47	3.8	NOAM	14.0	23.0	29.1	3*2×2.5	1.96	2.25
48	4.1	-	3.5	28.5	35.1	3*2×2.5	2.25	2.57
49	4.2	SHIKMA	39.0	89.8	109.0	×	bridge	bridge
50	4.3	-	3.0	26.4	32.5	×	bridge	bridge
51	6.1	SHUVA	23.8	71.1	86.6	×	bridge	bridge
52	6.2	BOHU	18.0	62.0	75.7	×	bridge	bridge
53	6.3	-	15.0	56.8	69.2	×	bridge	bridge
54	6.4	SHARSHERET	17.0	60.3	73.6	×	bridge	bridge
55	6.5	GRAR	244.0	214.0	257.2	×	bridge	bridge
56	6.6	PEHER	54.0	105.1	127.5	×	bridge	bridge
57	6.7	GRAR, UP	12.0	51.2	62.7	3*3×3	2.52	2.88
58	6.8	-	4.0	30.4	37.4	3*2.5×2.5	2.07	2.32
59	6.9	-	6.0	36.9	45.2	2*3×3	2.67	3.05

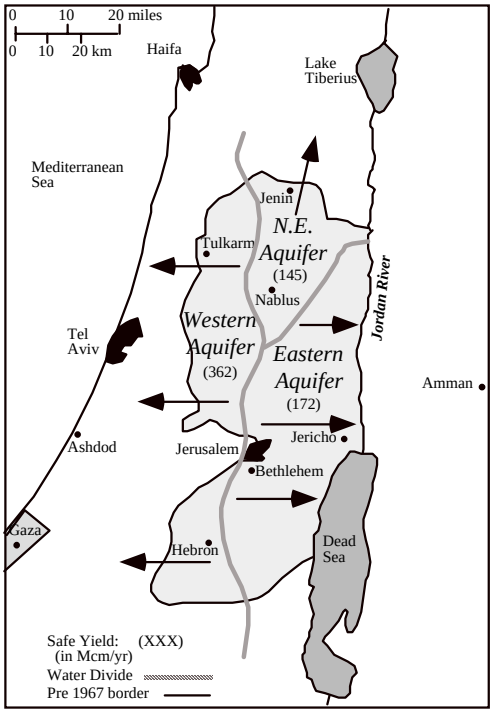
ANNEX 4-1
UTILITY TRANSMISSION REQUIREMENTS - WATER COMPONENT

1 Existing Water Resources and Allocation Thereof

1.1 General

The vast majority of water supply to the Palestinian Territories is derived from natural surface and underground sources. By their nature, these sources are, in the first instance, independent of political boundaries.

Various agreements exist for the allocation of water between Israel and the Palestinian Territories, most notably, the Oslo Agreement[1] and various current agreements between Mekoroth, the Israeli water supply organization, and the Palestinian Water Authority (PWA). The Oslo Agreement provides an interim arrangement for the division of natural water resources between Israel and the Palestinian Territories, but this has not been fully implemented. It can not be automatically assumed that the Oslo Agreement will be fully implemented in the future; neither can it be assumed that it will even be the basis for future allocations. The majority of Palestinian potable water supply, particularly in the West Bank, is derived from sources currently controlled by Mekoroth. But while the magnitude of these supplies is based on various agreements which currently, on a day-to-day basis, are honored, these will not necessarily form the basis of future arrangements.



As a consequence of the aforementioned physical and administrative realities, an assessment of resources must, in the first instance, be broadly based.

The discussion of "allocation" hereunder, relates to the division between Palestinian and Israeli consumers. Further subdivision between potable and agricultural use is discussed later in this study.

1.2 West Bank

At the present time, groundwater and springs provide essentially all the water available for Palestinian use in the West Bank. The existing water resources are derived from three major groundwater aquifer systems, a series of springs that emanate from these aquifers, and, to a modest extent, surface runoff. The West Bank is a hilly area, with elevations varying from 400 m below sea level in the Jordan Valley to 1,000 m above sea level in the hills. The West Bank receives rainfall averaging about 600 mm per year, but this is not evenly distributed. Annual

[1] Israeli-Palestinian Agreement on the West Bank and the Gaza Strip ("Oslo II"), signed September 28, 1995, Annex III, Article 40

rainfall generally varies from less than 100 mm in the east and south to 700 mm in the north and west[2].

Groundwater Resources
Water is supplied to the West Bank area from a series of groundwater aquifers contained within three groundwater systems, Northeastern, Eastern, and Western Aquifers, typically referred to collectively as the Mountain Aquifer System. The aquifers contain many of the same formations; however, the aquifer boundaries are established as a result of flow patterns. The total renewable groundwater resources in the West Bank were estimated in 1993[3] to be between 590 and 690mcm/year as indicated below in Table A4.1.

Table A4.1: Estimated Safe Yield of the West Bank Aquifers

Aquifer	Estimates of safe yield (mcm/year)*
Northeastern	140-200
Eastern	100-130
Western	350-360
Total	590-690

* mcm = millions of cubic meters

Most of this potential is exploited either naturally (through natural springs) or artificially (through wells). It is generally accepted that the combined Palestinian and Israeli use of the groundwater resources of the West Bank is approaching the annual renewable recharge or even exceeding it. The PWA suggests that the groundwater table in some wells has dropped by as much as 25 meters in the past 10 years, which, if true, is indicative of serious over-exploitation.

Surface Water Resources – Wadis
Wadis in the West Bank are divided into two major groups; eastern wadis and western wadis. Eastern wadis flow from the central mountains towards the Jordan Valley, and contribute to the recharge of shallow aquifers and flows in the Jordan River. Western wadis flow from the central mountains in a westerly direction towards the Mediterranean Sea. Surface water flow in wadis is intermittent, resulting from rainfall events that occur during the wet season. The total runoff in the West Bank is estimated[4] at 64 mcm/year. A study on water and wastewater[5] shows that some 20 mcm/year could realistically be utilized from surface flood water by the construction of storage dams in major wadis.

Wadis are substantially unexploited, partly because the rainfall occurs during the period of the year when it is least needed for irrigation purposes. Use of wadis would require construction of relatively expensive dams and use of this water for potable purposes would also require provision of treatment facilities.

Surface Water Resources – The Jordan River System
The Jordan River flows from north to south from an elevation of 2,200 m above mean sea level at Mount Hermon to about 395 m below mean sea level at the Dead Sea. The Jordan River passes a straight distance of about 140 km, but with a river length of about 350 km due

[2] Ministry of Planning and International Cooperation (MOPIC) - 1997
[3] Comprehensive Planning Framework for Palestinian Water Resource Development – Camp Dresser & McKee (CDM) – July 1997
[4] Environmental Profile – ARIJ 1997
[5] Ministry of Planning and International Cooperation (MOPIC) - 1997

to its tortuous path. The catchment area of the Jordan River and Dead Sea basin is approximately 40,650 km^2, while the exploitable water quantity from the Jordan River system[6] is estimated at 1,300 mcm/year.

The October 26, 1994 Peace Treaty between Jordan and Israel discusses allocation of Jordan River abstraction rights between the two nations, while the Oslo Agreements between Israel and the Palestinian Territories carry no mention of the Jordan River. The clear implication is that there is no anticipation (on the parts of Israel and Jordan, at least,) of a future Palestinian nation having river abstraction rights.

1.3 Gaza

Groundwater Resources

Groundwater, which accounts for almost 98 percent of the current supply, is the most significant source of water in Gaza. The remaining supplies are purchased from Mekoroth. Surface water that might otherwise be available from Wadi Gaza is diverted in Israel before it can reach the Gaza Strip, while rainfall either recharges the groundwater or is collected in cisterns and used immediately. Other sources of groundwater replenishment include groundwater flow from the east, return flow from irrigation, infiltration from surface water runoff, pipe leakage, and untreated wastewater. 1997 estimates[7] of the recharge into the Gaza Aquifer from the various sources are summarized in Table A4.2 below.

Table A4.2: Groundwater Replenishment for the Gaza Aquifer System

Sources of return flow	Estimated quantity (mcm/year)	Percentage of total
Rainfall	46	41.2
Groundwater flow from the east	7	6.3
Surface water infiltration	2	1.6
Pipe leakage	13	11.6
Untreated wastewater	14	12.5
Irrigation	30	26.8
Total	112	100

The groundwater replenishment of 112 mcm/year can be subdivided into 55 cum/year of natural recharge plus 57 mcm/year of recharge from human sources.

All groundwater resources in Gaza are allocated for use by the Palestinian Territories.

Piped supply

A piped supply of potable water from Israel with a design capacity of 5 mcm per year is currently being commissioned. This is discussed in the Oslo Agreement as an “interim” arrangement.

[6] El-Musa – 1996

[7] Comprehensive Planning Framework for Palestinian Water Resource Development – Camp Dresser & McKee (CDM) – July 1997

1.4 Assumptions for the Future

The concept of a fixed dedicated transportation link between Gaza and the West Bank, presumes the future existence of two separate political entities (the Palestinian Territories and Israel) and broad (either temporary or permanent) agreement on issues of mutual interest.

As discussed later in the water section of this study, existing water resources being utilized by the Palestinian Territories are already insufficient to satisfy current requirements, and the situation will deteriorate in the future unless additional resources are identified. Increased efficiency in the use of water by means of reduced leakage could provide at least some short term respite.

Overlapping with the general situation of Palestinian water supply, is the fact that the Mountain Aquifer which supplies water to both the Palestinian Territories and Israel is already being fully exploited, or possibly even over-exploited. "Israel recognizes the Palestinian water rights in the West Bank."[8] However, while this implies that the Palestinian Territories can always be confident of being able to draw water from the Mountain Aquifer, this Israeli recognition in principle, does not imply that figures accepted for the interim arrangement will necessarily be used in a final agreement.

For purposes of this study, the following assumptions with regard to future availability of existing water resources are made:

1. The Oslo Agreement allocations which were established as an interim arrangement will be fully implemented as a long term arrangement and the unallocated yield from the Eastern Aquifer will be allocated to the Palestinian Territories. The Territories will therefore receive a gross allocation from the Mountain Aquifer of 146 (118+28) mcm/year of potable water plus 50 mcm/year of brackish water.

2. The Palestinian Territories will be free to construct dams on wadis within the West Bank and utilize collected water.

3. Gaza will continue to have unrestricted use of the Gaza aquifer with a natural recharge of 55 mcm/year plus recharge from human activities. Notwithstanding the fact that groundwater quality in Gaza is extremely poor and deteriorating further, it is assumed that if abstraction is, in the future, limited to the rate of recharge, the water will remain usable.

4. Existing piped supplies from Israel to the West Bank and Gaza will be discontinued.

[8] Oslo Agreement II, Annex III, Article 40, Principle 1

2 Current Palestinian Utilization of Water Resources

2.1 West Bank

Gross potable supply in the year 2002[9] was approximately 62.8 mcm, which equates to a unit consumption rate of about 86 l/c/d, while the net per capita consumption was estimated at only 51 l/c/d. The difference between the gross supply rate and the net consumption rate is attributed to various types of losses, the greatest being leakage. Such a loss rate of around 40% is unacceptably high, but nevertheless, is not unexpected in an environment in which there are logistical and administrative difficulties and inadequate funds for proper maintenance. Detailed figures relating to the year 2002 are presented hereunder in table A4.3.

Table A4.3: West Bank Municipal and Industrial Water Consumption in 2002

Area	Population ('000)*	Percentage population served	Supply (mcm)		Per capita** consumption (l/c/d)	
			Gross	Net	Gross	Net
North	904	69	24.4	14.6	75	33
Central & south	1,104	83	38.4	23.0	97	57
Total	2,008	76	62.8	37.7	86	51

* Population figures used in the above table are those used by PWA and are slightly different to those used for projection purposes elsewhere in this report.
** It should be noted that the per capita figures in the above table relate to the total population. If they are presented in terms of consumption by members of the population actually served, the figures of 86 and 51 l/c/d become 113 and 68 l/c/d respectively.

Annual water usage for agricultural purposes is harder to estimate, as a significant proportion of boreholes are un-metered. Two alternatives are 89.3 mcm (1991)[10] and 85 mcm per year (1998)[11]. Significantly, both of these figures are much higher than the figure for Municipal and Industrial (M&I) water consumption.

[9] Various PWA reports, 2000-2003
[10] The Department of Agriculture in the West Bank (data published by the Rural Research Center, An-Najah National University)
[11] MOPIC Regional Plan – December 1998

2.2 Gaza

M&I data for Gaza, from the same source as that for West Bank, is presented below in Table A4.4.

Table A4.4: Gaza Municipal and Industrial Consumption in 2002

Population ('000)*	Percentage population served	Supply (mcm)		Per capita consumption (l/c/d)	
		Gross	Net	Gross	Net
1,250	98	62.7	40.1	138	88

* Observations on the West Bank data apply equally to Gaza data

Gaza agricultural usage is estimated at 83 mcm (1991)[12] which, as in the West Bank, is much greater than M&I consumption.

3 Population Projections

Various scenarios for future population have been studied and are discussed elsewhere in this report. They are used herein for the assessment of future water demand without further comment.

Table A4.5: Population Projections ('000)

Scenario	Year	2005	2010	2015	2020	2025	2030
High growth	West Bank	2,265	2,558	2,854	3,184	3,553	3,964
	Gaza Strip	1,350	1,579	1,815	2,087	2,399	2,758
	Total	3,615	4,137	4,669	5,271	5,952	6,722
Medium growth	West Bank	2,228	2,472	2,703	2,956	3,233	3,535
	Gaza	1,332	1,525	1,709	1,915	2,147	2,406
	Total	3,560	3,997	4,412	4,871	5,380	5,941
Low growth	West Bank	2,193	2,389	2,562	2,746	2,944	3,156
	Gaza	1,314	1,473	1,609	1,758	1,921	2,098
	Total	3,507	3,862	4,171	4,504	4,865	5,254

[12] The Department of Agriculture in the West Bank (data published by the Rural Research Center, An-Najah National University)

4 Water Demand Projections

4.1 Municipal and Industrial (M&I)

Domestic

In 1997, Consultants to PWA[13] recommended the adoption of World Health Organization standards[14] for domestic water supply. These standards recommend targets for minimum and average rates of supply to domestic consumers in small communities of 100 l/c/d and 150 l/c/d respectively. At that time, the PWA Consultants recommended a 10 year horizon to achieve the lower supply rate and a 20 year horizon to achieve the higher.

These targets remain realistic today, except that events over recent years have been such that little effective progress has been made to date in achieving them. Consequently, for purposes of this study, 2005 is taken as the base year from which improvements will be implemented.

Miscellaneous (public, livestock, commercial and industrial)

Separate data on existing public, livestock, commercial and industrial water consumption does not appear to be available. The 1997 Consultants made projections for these various demands starting at a total of 30 l/c/d when the target domestic supply of 100 l/c/d is achieved, rising to 39 l/c/d when the target of 150 l/c/d is achieved. These figures are reasonable and will be adopted for purposes of this study.

System Losses

As indicated in earlier sections of this study, system losses are currently of the order of 40% in the West Bank and 36% in Gaza. These figures are unacceptably high, and their reduction must be a fundamental component of the overall program to improve water supply. Projections of supply requirements should therefore assume a phased reduction in losses from current levels to something more realistic. For purposes of this study, it is assumed that losses will be reduced at a steady pace to 20% of gross supply within twenty years.

On the basis of the foregoing, projected per capita potable water demand will be as indicated in Table A4.6.

Table A4.6: Projected per Capita M&I Water Demand

Year	Net Demand (l/c/d)			Losses		Gross demand (l/c/d)
	Domestic	Misc.	Total	% of supply	l/c/d	
2005*	68		68	40	45	113
2010	68	26	94	35	51	145
2015	100	30	130	30	56	186
2020	123	34	157	25	52	209
2025	150	39	189	20	47	236
2030	150	39	189	20	47	236

* figures for the year 2005 are assumed to be identical to those recorded for 2002

[13] Comprehensive Planning Framework for Palestinian Water Resource Development – Camp Dresser & McKee (CDM) – July 1997

[14] WHO Guidelines on Technologies for Water Supply Systems in Small Communities – 1993

Applying these demand rates to the population projections discussed earlier in this report, provides the gross potable water supply requirements over the next twenty five years as summarized in Table A4.7.

Table A4.7: Projected Gross M&I Water Demand

Table A4.7.1 – High Growth Scenario

Year	Gross demand (l/c/d)	Population ('000)			Gross demand (mcm/year)		
		W. Bank	Gaza	Total	W. Bank	Gaza	Total
2005	113	2,265	1,350	3,615	93.4	55.7	149.1
2010	145	2,558	1,579	4,137	135.4	83.6	219.0
2015	186	2,854	1,815	4,669	193.8	123.2	317.0
2020	209	3,184	2,087	5,271	242.9	159.2	402.1
2025	236	3,553	2,399	5,952	306.0	206.7	512.7
2030	236	3,964	2,758	6,722	341.5	237.6	579.1

Table A4.7.2 – Medium Growth Scenario

Year	Gross demand (l/c/d)	Population ('000)			Gross demand (mcm/year)		
		W. Bank	Gaza	Total	W. Bank	Gaza	Total
2005	113	2,228	1,332	3,560	91.9	54.9	146.8
2010	145	2,472	1,525	3,997	130.8	80.7	211.5
2015	186	2,703	1,709	4,412	183.5	116.0	299.5
2020	209	2,956	1,915	4,871	225.5	146.1	371.6
2025	236	3,233	2,147	5,380	278.5	184.9	463.4
2030	236	3,535	2,406	5,941	304.5	207.2	511.7

Table A4.7.3– Low Growth Scenario

Year	Gross demand (l/c/d)	Population ('000)			Gross demand (mcm/year)		
		W. Bank	Gaza	Total	W. Bank	Gaza	Total
2005	113	2,193	1,314	3,507	90.5	54.2	144.7
2010	145	2,389	1,473	3,862	126.4	78.0	204.4
2015	186	2,562	1,609	4,171	173.9	109.2	283.1
2020	209	2,746	1,758	4,504	209.5	134.1	343.6
2025	236	2,944	1,921	4,865	253.6	165.4	419.0
2030	236	3,156	2,098	5,254	271.9	180.7	452.6

4.2 Agricultural

As discussed above, the current usage of potable water for agricultural purposes is far in excess of that for M&I purposes, and this; in an environment of acute water scarcity. The significance of agriculture and its place in the future economy of the Palestinian Territories was acknowledged in 1997 in the rationale for development of water resources as follows[15]:

> It is unlikely that future development in the agricultural sector will be able to provide sufficient employment and economic opportunity to support the growing Palestinian population at an economic level which matches the aspirations and capabilities of the Palestinian people. It is assumed therefore, that the economic future of the West Bank and Gaza will be largely based upon the development of light industry and regional commerce, and that the assumed future demand for, and value of, water will reflect these characteristics of the Palestinian economy.

Based on this broad philosophy, the 1997 study went on to establish key principles for the assessment of how future agricultural demands should be satisfied. These included:

- the employment of lower-quality water (such as treated wastewater, flood water, wadi runoff or brackish water) for irrigation wherever realistic;
- no increase of fresh water supply to the agricultural sector beyond current levels;
- a minimum supply of fresh water should be maintained to cater for select high-value sensitive crops, for blending and for periodic soil flushing;
- use of flood water and wadi run-off will lead to a corresponding reduction in use of fresh water; and
- the rate of increase in the area of irrigated land will be limited to what can be sustained by the above principles.

These broad principles are as appropriate today as they were in 1997.

The 1997 study concluded that use of potable water for irrigation would gradually be replaced by use of brackish water; surface water collected in wadis and treated sewage effluent. As a result of these changes, use of potable water for irrigation purposes would remain at the same level until 2000 and decline thereafter. For the West Bank, the study anticipated consumption of potable water for irrigation purposes declining at a rate of approximately 0.5 mcm per year until 2020 and at an accelerated rate of about 1.0 mcm per year thereafter. For Gaza, it anticipated a more rapidly declining rate of about 2.5 mcm per year.

The scenario of “freezing” the rate of usage of potable water for irrigation at current rates and assuming a reduction in the future remains appropriate today.

Estimated use of water for irrigation purposes in 1991[16] was 89.3 mcm in the West Bank and 83 mcm in Gaza, while corresponding with 1997 figures, according to the CDM 1997 study

[15] Comprehensive Planning Framework for Palestinian Water Resource Development – Camp Dresser & McKee (CDM)– July 1997
[16] Land survey conducted by the Department of Agriculture in the West Bank and published by the Rural Research Center, An-Najah National University.

were 80.6 mcm and 88.7mcm respectively. There do not appear to be more recent statistics, so the 1997 figures, applied to the year 2000 will be adopted, as recommended by CDM.

Events over recent years have been such that much of the economic development of the Palestinian Territories has been stalled and anticipated reductions in usage of potable water for irrigation purposes have not been achieved. However, there is a very high level of enthusiasm on the part of the international donor community for investment in infrastructure and it can be assumed that when the most pressing political issues have been resolved, improvements in infrastructure will be rapid in the short term. Consequently, while the short term improvements anticipated by CDM in 1997 are not materializing, the medium and longer term expectations remain valid. Thus for purposes of this study, the CDM projections will be adopted.

Projected bulk potable water requirements for irrigation are summarized in Table A4.8 hereunder.

Table A4.8: Potable Water Demand for Irrigation (mcm per year)

Year	West Bank	Gaza	Total
2000	80.6	88.7	169.3
2005	78.1	76.2	154.3
2010	75.6	63.7	139.3
2015	73.1	51.2	124.3
2020	70.6	38.7	109.3
2025	65.6	26.2	91.8
2030	60.6	13.7	74.3

4.3 Total Potable Water Demand

Combining domestic and agricultural demand projections, results in composite figures as summarized in Table A4.9 hereunder.

TableA4.9: Total Potable Water Demand

Table A4.9.1 – High Growth Scenario

Year	M&I demand (mcm/year)			Irrigation demand (mcm/year)			Total demand (mcm/year)		
	W. Bank	Gaza	Total	W. Bank	Gaza	Total	W. Bank	Gaza	Total
2005	93.4	55.7	149.1	78.1	76.2	154.3	171.5	131.9	303.4
2010	135.4	83.6	219.0	75.6	63.7	139.3	211.0	147.3	358.3
2015	193.8	123.2	317.0	73.1	51.2	124.3	266.9	174.4	441.3
2020	242.9	159.2	402.1	70.6	38.7	109.3	313.5	197.9	511.4
2025	306.0	206.7	512.7	65.6	26.2	91.8	371.6	232.9	604.5
2030	341.4	237.6	579.0	60.6	13.7	74.3	402.0	251.3	653.3

Table A4.9.2 – Medium Growth Scenario

Year	M&I demand (mcm/year)			Irrigation demand (mcm/year)			Total demand (mcm/year)		
	W. Bank	Gaza	Total	W. Bank	Gaza	Total	W. Bank	Gaza	Total
2005	91.9	54.9	146.8	78.1	76.2	154.3	170.0	131.1	301.1
2010	130.8	80.7	211.5	75.6	63.7	139.3	206.4	144.4	350.8
2015	183.5	116.0	299.5	73.1	51.2	124.3	256.6	167.2	423.8
2020	225.5	146.1	371.6	70.6	38.7	109.3	296.1	184.8	480.9
2025	278.5	184.9	463.4	65.6	26.2	91.8	344.1	211.1	555.2
2030	304.5	207.2	511.7	60.6	13.7	74.3	365.1	220.9	586.0

Table A4.9.3 – Low Growth Scenario

Year	M&I demand (mcm/year)			Irrigation demand (mcm/year)			Total demand (mcm/year)		
	W. Bank	Gaza	Total	W. Bank	Gaza	Total	W. Bank	Gaza	Total
2005	90.5	54.2	144.6	78.1	76.2	154.3	168.6	130.4	298.9
2010	126.4	78.0	204.4	75.6	63.7	139.3	202.0	141.7	343.7
2015	173.9	109.2	283.2	73.1	51.2	124.3	247.0	160.4	407.5
2020	209.5	134.1	343.6	70.6	38.7	109.3	280.1	172.8	452.9
2025	253.6	165.4	419.0	65.6	26.2	91.8	319.2	191.6	510.8
2030	271.9	180.7	452.6	60.6	13.7	74.3	332.5	194.4	526.9

5 Requirements for Augmented Water Supply

Having established the gross water supply demand for the West Bank and Gaza under various population development scenarios, the requirements for additional potable water supply can be determined. These are summarized hereunder in Table A.4.10.

Table A4.10: Additional Potable Water Requirements

Table A4.10.1 – High Growth Scenario

Year	Total demand (mcm/year)			Available supply (mcm/year)			Shortfall in supply (mcm/year)		
	W. Bank	Gaza	Total	W. Bank	Gaza	Total	W. Bank	Gaza	Total
2005	171.5	131.9	303.4	146.0	112.0	258.0	25.5	19.9	45.4
2010	211.0	147.3	358.3	146.0	112.0	258.0	65.0	35.3	100.3
2015	266.9	174.4	441.3	146.0	112.0	258.0	120.9	62.4	183.3
2020	313.5	197.9	511.4	146.0	112.0	258.0	167.5	85.9	253.4
2025	371.6	232.9	604.5	146.0	112.0	258.0	225.6	120.9	346.5
2030	402.0	251.3	653.3	146.0	112.0	258.0	256.0	139.3	395.3

Table A4.10.2 – Medium Growth Scenario

Year	Total demand (mcm/year)			Available supply (mcm/year)			Shortfall in supply (mcm/year)		
	W. Bank	Gaza	Total	W. Bank	Gaza	Total	W. Bank	Gaza	Total
2005	170.0	131.1	301.1	146.0	112.0	258.0	24.0	19.1	43.1
2010	206.4	144.4	350.8	146.0	112.0	258.0	60.4	32.4	92.8
2015	256.6	167.2	423.8	146.0	112.0	258.0	110.6	55.2	165.8
2020	296.1	184.8	480.9	146.0	112.0	258.0	150.1	72.8	222.9
2025	344.1	211.1	555.2	146.0	112.0	258.0	198.1	99.1	297.2
2030	365.1	220.9	586.0	146.0	112.0	258.0	219.1	108.9	328.0

Table A4.11 – Water Supply Shortfall Scenarios

Year	Potable water supply shortfall (mcm/year)								
	High growth scenario			Medium growth scenario			Low growth scenario		
	W. Bank	Gaza	Total	W. Bank	Gaza	Total	W. Bank	Gaza	Total
2005	25.5	19.9	45.4	24.0	19.1	43.1	22.6	18.4	40.9
2010	65.0	35.3	100.3	60.4	32.4	92.8	56.0	29.7	85.7
2015	120.9	62.4	183.3	110.6	55.2	165.8	101.0	48.4	149.5
2020	167.5	85.9	253.4	150.1	72.8	222.9	134.1	60.8	194.9
2025	225.6	120.9	346.5	198.1	99.1	297.2	173.2	79.6	252.8
2030	256.0	139.3	395.3	219.1	108.9	328.0	186.5	82.4	268.9

6 Conceptual Options for Augmented Water Supply

6.1 Groundwater, Surface Water and Treated Sewage Effluent

Additional groundwater, surface water and treated sewage effluent alternatives are effectively unavailable for M&I use for reasons noted hereunder.

Groundwater

It has already been assumed for purposes of this study that the interim allocation of groundwater between the Palestinian Territories and Israel, agreed under the Oslo Agreement will translate into a permanent arrangement using the same proportional distribution. If this assumption is accepted, then there is no potential to increase the availability of potable groundwater to the Palestinian Territories beyond the levels already assumed. If, on the other hand, the Palestinian Territories receive a greater allocation in the future, this will lead to a corresponding reduction in the quantities of water required from other sources. The decision on final sizing of any pipeline between Gaza and the West Bank should be preceded by a more rigorous study of the anticipated long term division of Mountain Aquifer water between the Palestinian Territories and Israel.

As discussed earlier, there is 50 mcm/year of brackish water available from the Mountain Aquifer, which has not been allocated under the Oslo Agreement. Conceivably this could be desalinated and made available for M&I uses. However, the 1997 calculations on future reduction in use of potable water for irrigation, presupposed increased use of other sources, including brackish groundwater, for irrigation purposes. Thus treatment of brackish water for M&I use would not lead to a net reduction in the need for the importation of potable water to the West Bank.

There is no potential for improved availability of groundwater in Gaza. On the contrary, the resource is already being over-exploited.

Surface Water and Treated Sewage Effluent

The situation with regard to surface water and treated sewage effluent is identical to that for brackish groundwater. Any allocation for M&I use would not lead to a net reduction in the need for the importation of potable water.

6.2 Desalination

The need for desalination of seawater to satisfy the future potable water needs of the region has already been recognized. Israel has constructed a plant at Ashqelon, close to the northern border of Gaza and at least three additional plants are envisaged in the future. USAID are considering funding the construction of a plant in Gaza, with a short term capacity of 22 mcm/year, with potential for expansion to 55 mcm/year in the future.

In practical terms, there is effectively no limit to how much raw water can be desalinated in Gaza to satisfy the needs of the Palestinian people, both in Gaza and in the West Bank. It must however be acknowledged that costs will be much higher than the costs associated with use of natural groundwater.

6.3 Bulk Importation

Over recent years, there has been much discussion on the possibility of importing water to help satisfy the future needs of Israel. The most common arrangements being considered; have been either a piped supply or tanker supply from Turkey. While no firm arrangements have been made, the potential for importing water remains.

The concept of importing water into Gaza for local use or for onward transmission to the West Bank is as feasible as for importation to Israel.

6.4 Scenarios for Water Transfer between Gaza and the West Bank

As already noted, there is a shortage of potable water in both the West Bank and Gaza. This shortage is currently more acute in Gaza than the West Bank, but even if a connecting pipeline were to exist today, it would be unrealistic to consider transfer to Gaza of anything more than a very modest quantity, and that only on a short term basis. In the longer term, in the absence of any potential to increase the availability of potable water from within the West Bank, there is no realistic likelihood of transferring large quantities of water to Gaza on a regular basis.

Thus, any pipeline to be constructed between Gaza and the West Bank should be sized and designed to cater primarily for the needs of the West Bank rather than the needs of Gaza. Control arrangements could of course be designed to allow for the possibility of transfer of limited quantities of water in the opposite direction in case of an emergency such as a major failure of desalination facilities.

6.5 Summary

Without a change to existing allocation agreements, there is no potential for improved availability of groundwater, and other local supply options are not available.

Desalination of Mediterranean seawater in Gaza or importation of water via Gaza are the only realistic options for the augmentation of supply to the West Bank and Gaza. From the perspective of the feasibility of a pipeline connecting the two areas, the relative merits of these two options are not important and they can consequently be viewed together.

7 Options for the Immediate Future

The foregoing sections of this study have focused on the current demand for water, how these demands should be assumed to increase in the future and an assessment of how these demands can be met in conceptual terms.

The broad conclusion is that there is already a shortage of water in both the West Bank and Gaza and neither one can realistically be expected to supplement the needs of the other under current bulk supply arrangements. The only realistic way of overcoming this supply shortfall is to increase the availability of water at the coast (either in Gaza or Israel) and make arrangements for transfer to the West Bank.