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Volume II – Appendices

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Appendices

APPENDIX 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/railway facility is chosen. Note that for combined road/railway alternatives, the geometrics are even further constrained. Also note further that we have chosen railway design values which exceed present Israeli RR guidelines.

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 (i.e. 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/railway 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]

4.1 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 railway alignment, it is necessary to also review briefly the rail speed standards. Presently, the Israeli Railways have a maximum design speed of 160 km/h. 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/h. Even though only passenger trains could reach this limit, the railway quality necessary to accommodate 200 km/h 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 railway speed has been set at 200 km/h for all terrain sections except those in the last 12 km 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/h.

4.2 Rolling/Mountainous Terrain

All referenced standards indicate that an appropriate design is 100 km/hr. The railway desk study indicates that the sharpest radius without considerable cuts is 500m, which in the case of rail design equates to 110 km/h. Within a combined road/railway right-of-way corridor, the road 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/h.

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%. 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 combined road/rail 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/h 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/h design speed. In this terrain, it may be that the road alignment could deviate substantially from the required railway 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 meet 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 railway, 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 3.0m 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 ensure 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 2m has been adopted for Alternative A1 (see typical sections in Volume 3). 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 about 6m.

Another possibility is to place the railway component of a combined road/railwayl 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 10m. For the sunken alignment, the clear zone is defined as the distance to the retaining walls, and has also been set at 10m. This typical section is less desirable than others from a safety aspect.

7.7. Combined Road/Railway 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. However, in this conceptual design no interchanges are permitted on the route through Israel. Therefore it is proposed to locate the railway in the median and switch to a side location within Gaza and the West Bank.

7.8 Typical Sections

For typical sections, see Volume 3, 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 this conceptual study proposes links 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

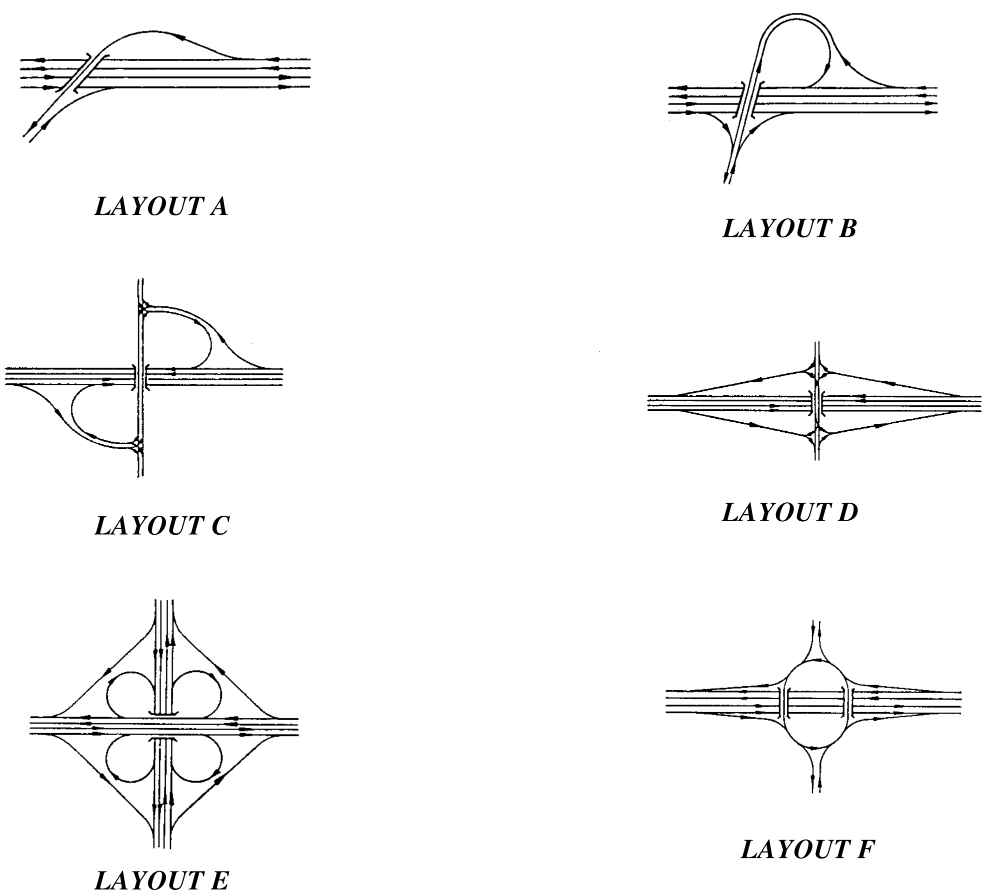


Figure 3.1-1: Interchange Configurations

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 study was performed at each proposed highway grade separation to determine whether the project road should be carried over or under the crossroad. The decision were 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 fewer disturbances 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.

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 4.5m 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 2 to3m below the surrounding ground level. By placing excavated material as embankments on each side of the road, the road will appear to be sunken by 3.5 to 4.5m.

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 about 4.5m.

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. 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 5m.

The study team addressed the issue of the spoil earthworks resulting from a depressed freeway section. For instance, for Alternative A2 (see typical sections in Volume 3), a road only sunken section, the width between retaining walls would be approximately 50m. At a depth of 5m and a length of approximately 40 km, 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 10m. 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 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 2.3m at the subgrade, with partial height retaining walls, giving embankments of 3.2m. 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)

Consideration was given to locating sections of the alignment 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.

Short 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 for water, telecommunications, and gas utilities to one side of the right-of-way would add about 8m to the right-of-way width. The addition of an underground utility corridor in the median would add about 4m to the right-of-way width.

The study also included investigation of an electric power transmission in the corridor. An above ground high voltage power transmission line would add about 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 the typical crss-section drawings of Volume 3.

10.0 Typical Sections

Typical sections for these various alternatives studied of road and combined road/railway, and for at-grade, cut/fill and sunken alternatives, and are given in Volume 3. They are summarized as follows:

Alternative A: Road only Alignments

- Typical shallow and high fill sections - First Stage
- Typical cut section in rock and in soil - First Stage
- Typical sunken sections with side spoil embankments, either without retaining walls or (to reduce right-of-way width) with retaining walls – First Stage
- Typical sunken sections with side spoil embankments – Future Stage
- Typical fill and cut sections – Future Stage

- Typical fill sections with optional utilities corridors and access zones outside the road prism – First Stage
- Typical fill sections with optional utilities corridor (for water, telecommunications & gas) inside central median of the divided road, and optional utility corridor (for electricity) and access zones outside the road prism – First Stage

Alternative C: Combined Road/Railway Alignments

- Typical shallow and fill sections – First Stage
- Typical cut section in rock and in soil - First Stage
- Typical fill and cut sections – Future Stage
- Typical fill sections with optional utilities corridors and access zones outside the road/railway prism – First Stage

For the **At-surface and Sunken Road Only** options, cross-sections were developed based on acquisition of sufficient right-of-way and on execution of requisite earthworks, drainage and other construction provisions to permit future construction of a 2 x 3-lane divided highway. However, the adopted cross-section conceives that a minimum 2 x 2-lane divided highway will initially be built – which is referred to as '**First Stage**'. The future possible expansion to a 2 x 3-lane highway is referred to as '**Future Stage**'. It is envisaged that the outer 2 lanes each side of an 8.1 m wide highway median reservation will be constructed in the First Stage. Then, in a Future Stage, 2 inner lanes could easily and economically be added with a resultant median width of 2 m.

For the **At-surface Combined Railway/Road** option, the '**First Stage**' represents initial construction of a 2 x 2-lane road, with a 2-track diesel railway located in the central median of the road. In this First Stage the 2 inner road lanes each side of the railway would be built. '**Future Stage**' expansion is represented by the addition of an outer road lane to each of the 2 carriageways.

ANNEX 3-2

RAILWAY DESIGN STANDARDS

1. Design Speed

The desirable maximum design speed for the West Bank-Gaza Transport Link is 200 km/h for passenger trains. 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 200 km/h design speed may be seldom used in the initial years or decades after of operations, the following advantages support an adoption of this 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 reduce travel times and result in time savings for passengers and freight. The relaxed environment of contemporary fast trains offers a more comfort ride and greater passenger satisfaction.

- Safety

  Many safety-related features of the contemporary fast train, which is the safest mode of transportation, 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 that are 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 $160 \text{ km/h} < V < 200 \text{ km/h}$
$K = 6.5$ for $120 \text{ km/h} < V < 160 \text{ km/h}$
$K = 7.1$ for $V = 120 \text{ km/h}$

Case A

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 2000m is 120mm. Since the speed of standard freight train will be reduced and limited by other factors, the actual superelevation provided in the track may be further reduced.

Case B

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 curve of 2000m radius 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, <u>Progressive track alignment design</u> and in the Annex A, <u>Supplementary information for track</u>

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 curve provided between the tangent track and the track on a curve of constant radius is the traditional parabolic and clothoid designs. 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 between the center gravity and 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 methods causes the center of gravity of a vehicle entering the curve to be 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] as shown graphically in 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]

[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.

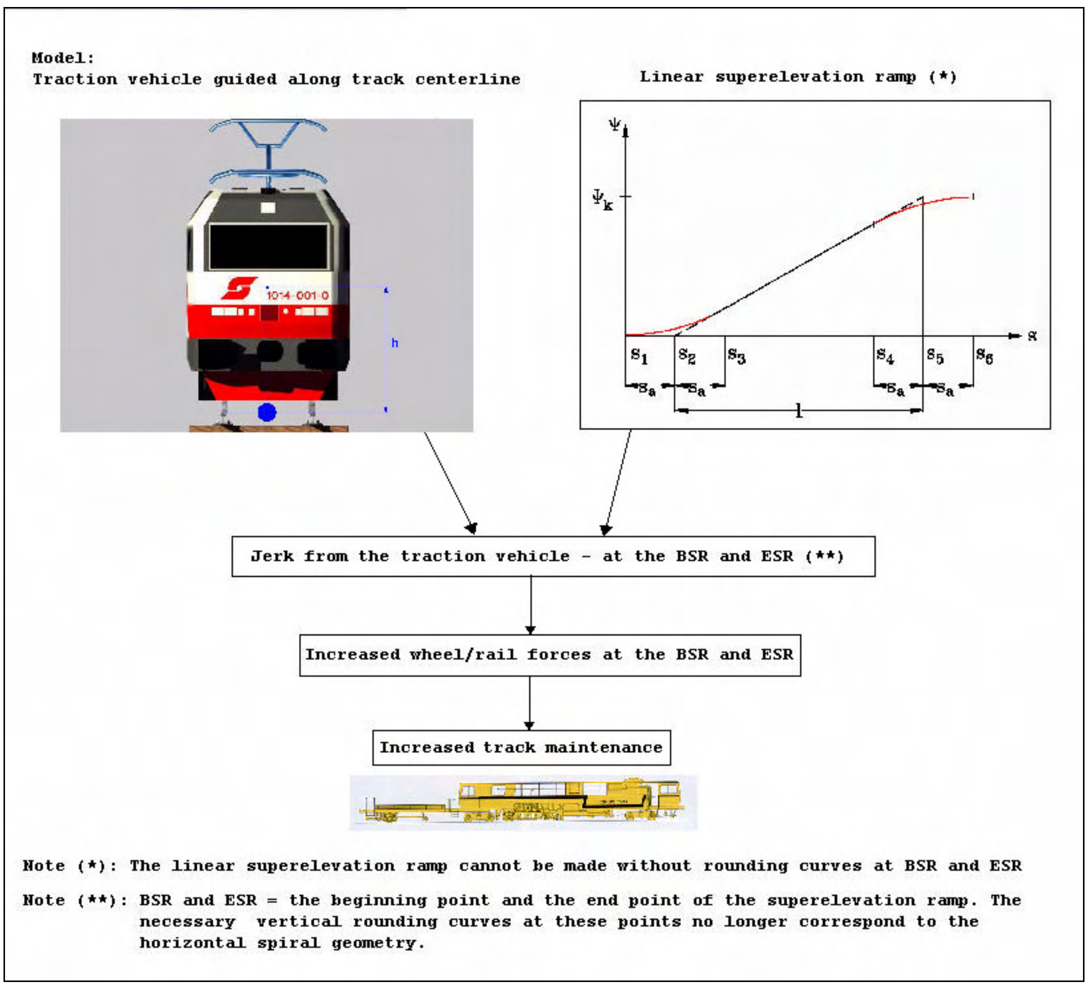
[3] Two main suppliers of proprietary software based on VSB compliant mathematical functions are present at the market, Herbert von Hesslinger, Austria, and Louis T. Klauder Jr. PhD, USA.

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 cross section shown in Figure 3-2.3.

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



Enhanced Standard Operational Concept

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

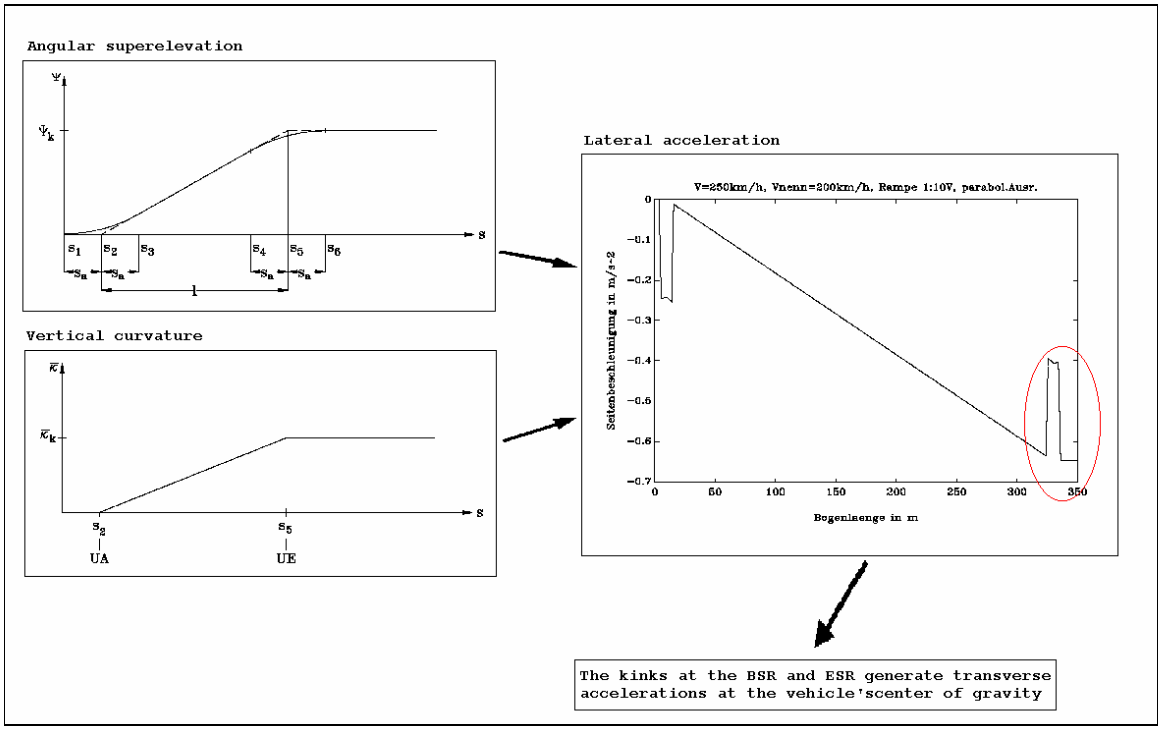


Figure 3.2-3: Movement of Car's Center of Gravity on a Conventional Spiral from CG1 to CG2 that Causes the Lateral Acceleration Jilt and Lateral Jerk

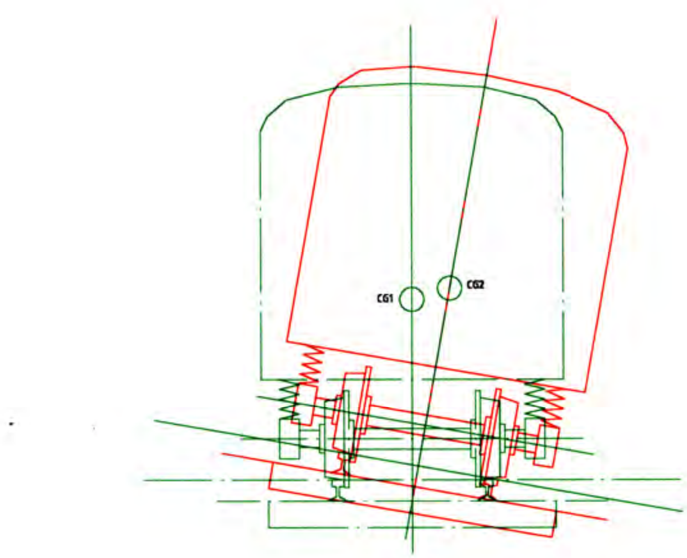
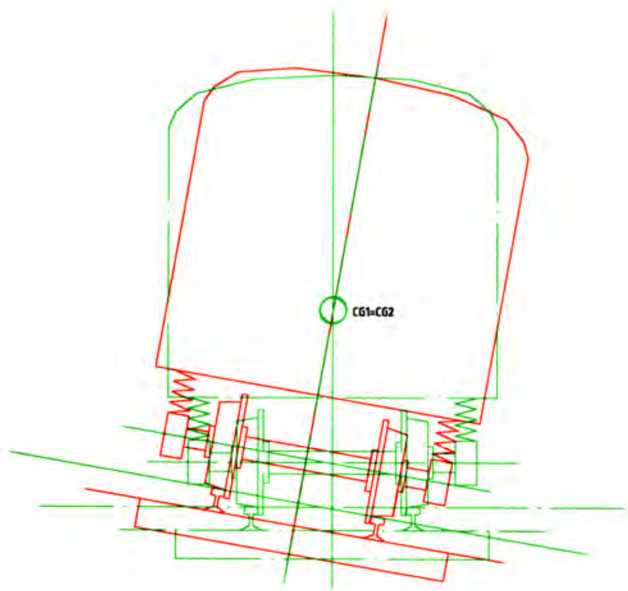
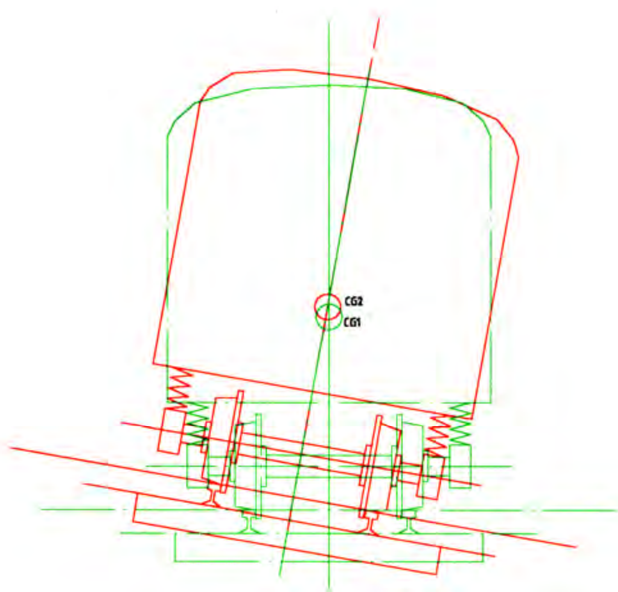


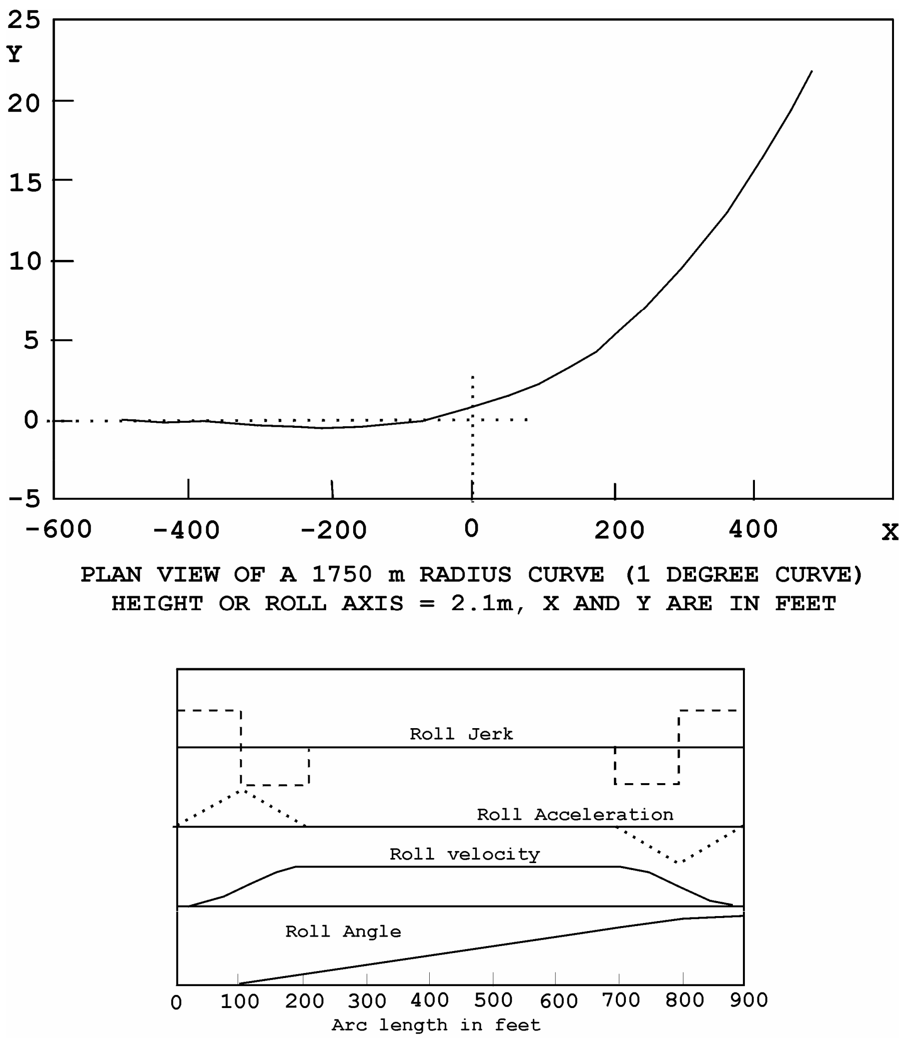
Figure 3.2-4: Center of Gravity Movements





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 figure 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 (or in the longer term with the Egyptian Railways) 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.

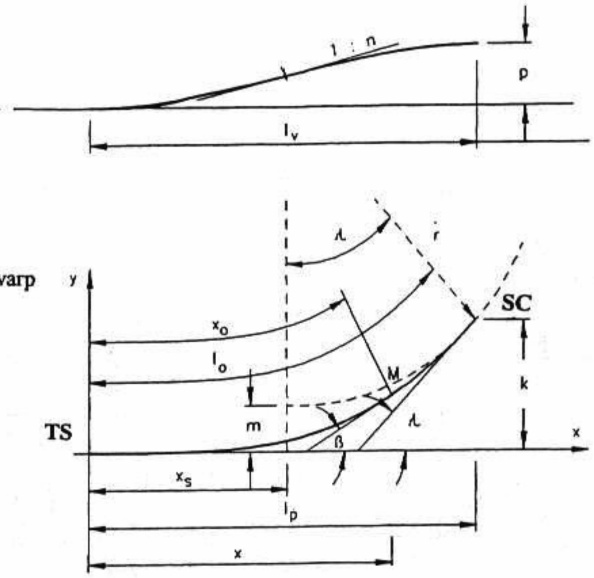
Figure 3.2-6: Non-linear Superelevation Ramp and Simple spiral According to Bloss

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

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

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	$y = \frac{x^4}{4 \cdot l_p^2 \cdot r} - \frac{x^5}{10 \cdot l_p^3 \cdot r}$
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 **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 that need to be 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 suitable means in addition to the standard highway barrier installed along the edge of the highway. A vertical wall of sufficient impact resistance is required to prevent trucks from crushing through it and obstructing the railway track in a case of major accident.

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.

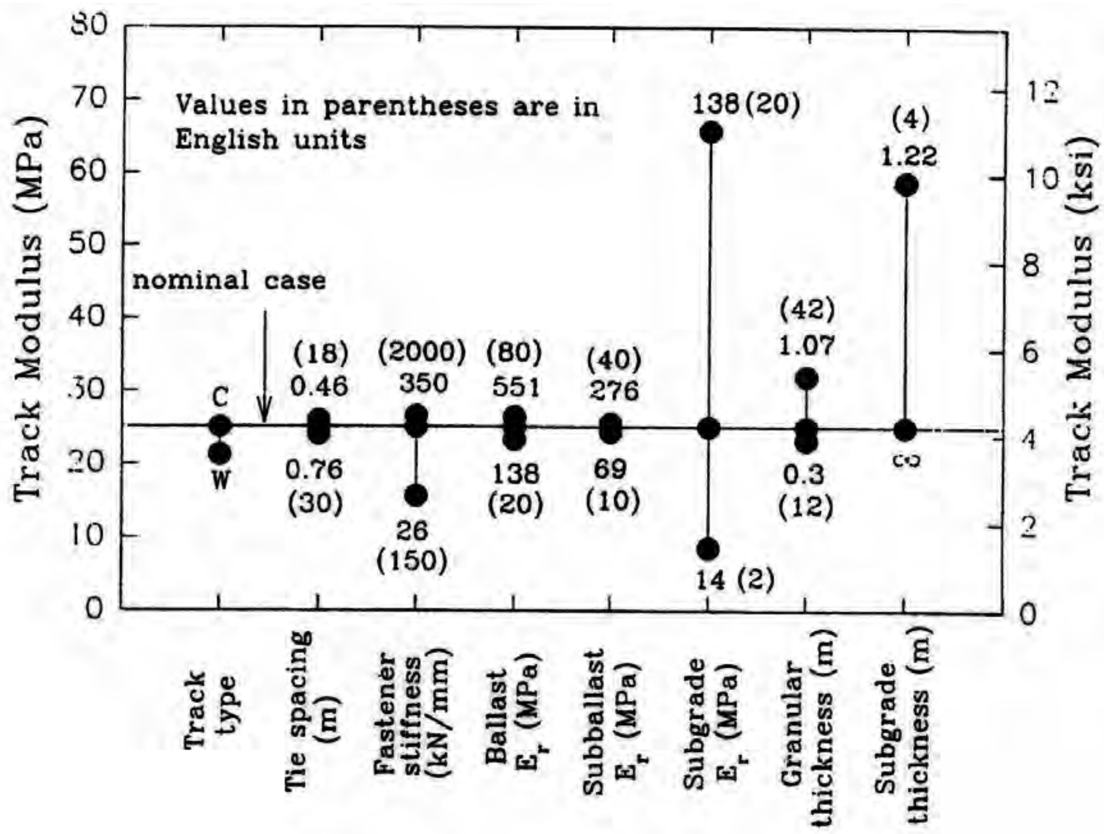
A major difference exists between static only design and dynamic design of railway subgrade. The dynamic approach leads to the elasticity modulus 40 to 60 MPa and leads to reduced maintenance rates providing that the elastic recovery is excellent and the permanent component of vertical deflection is 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 and thickness of a weak stratum have much greater effect on the behavior of track than what is assumed by the Timoshenko's theory of elasticity. An enlarged sub-ballast 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.

[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.

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.

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.

10. Terminals

Terminals of the Gaza-West Bank Connector constitute two major railway facilities located at each end of the line. The terminals are designed to support a wide range of services that are associated with the distinct transportation task of connecting the two geographically separate parts of Palestine. The layout of the terminals directly influences the operational performance of the entire system. For this reason, they should be designed as efficiently as possible using the latest available technology.

10.1 Essential Functions of a Railway Terminal

10.1.1 Passenger Terminal Functions

The basic functions of a passenger terminal are summarized as:

a. Loading and unloading of passengers;
b. Ensuring the safe flow of passengers through the station building and to and from the platforms;
c. Providing entry and egress control;
d. Providing various passenger services;
e. Accommodating special needs of traveling public;
f. Supporting inter-modal passenger transfer.

10.1.2 Freight Terminal Functions

The basic functions of freight terminal are to:

a. Ensure the efficient inter-modal transfer , loading, unloading, and temporary storage of freight;
b. Receive, process, assembly and dispatch trains;
c. Provide entry and egress facilities and control access to and from and within the freight terminal area; and
d. Oversee freight flow management.

10.1.3 Operational Management of the Mainline and Terminal Facilities - Required

These facilities will be mainly localized at the Gaza Terminus because of the availability of level land.

Track control center: This facility controls the operations of the terminal and the switching of the tracks.

Traction power supply and control: These facilities are need for electric power locomotives and electric multiple units (EMU). For diesel operations these facilities are not required. A large substation will be required at the Gaza facilities. A second one will be needed and could be located at the West Bank Terminus.

Maintenance of rolling stock: These facilities are workshops to inspect and maintain the rolling stock.

Infrastructure maintenance center, component storage and staging areas: These facilities are to assemble materials and equipment, to maintain equipment and to store material and equipment prior to undertaking a major maintenance activity. The maintenance activities covers the following infrastructure:

a. Way, track and structures;
b. Train control;
c. Communications;
d. Power supply;

10.2 Principal Aspects of Track Configuration:

In order to maximize the effectiveness of terminal operations and land use, the following provisions should be adopted:

10.2.1 Continuous Traffic Flow through the Yard

Operations in the depot shall be streamlined and devoid of unnecessary shunting and reversal movements. The reversal movements are permitted only as an interim operational feature which will be eliminated in the future. At that time, the yard's configuration will facilitate continuous forward movement from the point of entry to the point of departure. This is will be achieved by the following means:

a. Linear arrangement of yard with linear egress

The yard arranged in this manner is entered at one end and exited at the other end of the assigned land lot. The train enters or bypasses the car wash, then enters the track group, enters or bypasses service group with the shop building and enters or bypasses departure group. Then the train exits at the end of the yard and enters the manline for revenue operations.

While this arrangement is the best option, conditions for its implementation may not be feasible due to limited availability of land.

b. U-turn arrangement of the yard with a loop

The conditions for linear arrangement of yard with linear egress seldom exist so that a loop at the end of the yard lot is provided to facilitate continuous flow of trains through the yard. One or two properly designed loop tracks will satisfy contemporary service requirements. However, violation of requirements stated in the Article 14 may reduce the benefits from the continuous flow of cars through the yard.

The yard of Line 1, Phase 2 provides sufficient space for utilization of a continuous flow with a loop should the linear arrangement of yard with linear egress cannot be provided.

10.2.2 Alternative Egress

Even when linear egress capable of accommodating full flow of trains of the linear arrangement of yard is not provided, a restricted and/or emergency egress is desirable.

It should be provided wherever possible so that special trackwork malfunction or an accident at a critical location within the yard would not impact operations of the line.

10.2.3 Reversal of Trains

Trains should not operate on the main line exclusively in the same position. This happens when the driver merely walks from one end of the train to the other at terminals while the train is never turned around. Each train should be turned around by going around the loop in the yard after an established number of runs. This practice will eliminate asymmetrical wear on wheelsets so that wheel maintenance will be considerably reduced.

10.2.4 Design Speed in the Yards

The yard should be designed for 40 km/h maximum design speed even when the actual operational speed is lower. This provision will eliminate adoptions of marginal trackwork arrangements that would lead to excessive rail wear even when they may be still safe operationally.

10.2.5 Concentration Services in One Location

Except for car wash and hot wheel detectors, all rolling stock maintenance functions should be performed in one large shop building located as close to the perimeter of the depot's area as possible. Integration of all functions into one building will enhance productivity while the location of the shop near the perimeter of the land lot will lead to a loop of largest possible radius.

Integration of services in one location has the following advantages:

a. Separate shops, sheds and installation inspection equipment stands require separate track accesses, often with its own branching and arrival tracks. This results in increased space requirements in the yard while the advantage of continuous traffic flow is usually lost.

It is more efficient to branching into a large number of tracks at one location than branch into a smaller number of tracks at two or more locations in the yard.

b. The proximity of inspection and repair service areas offer increased flexibility in allocating manpower, resources and in the accessibility of spare parts storage in the performance of various classes of scheduled maintenance and incidental repairs.

c. Construction of a single large building is more economical than construction of two or more buildings of smaller size.

10.2.6 Car Wash

An indoor car wash building of a minimum length equal to at least two transit rail car lengths should be located at the approach area of the yard pass first crossovers. However, the Shenzhen metro follows a standard that provides a generous space inside the car wash as well as in the adjacent wash track. This standard exceeds minimum requirements. It should be followed.

Each train should have an option either to travel through the car wash or by-pass it. The car wash should be equipped with wastewater treatment plant or be attached to a yard facility designed to process large quantities of water that contain car wash chemicals. Every storage track should be accessible from the car wash through suitable branching of the trackwork.

10.3 Track Geometry Within the Yard

10.3.1 Spacing between Parallel Train-Storage Tracks

The tracks provided for storage of trains should be spaced at staggered distances of 4 and 6 meters to allow access of service carts needed during internal cleaning of stored vehicles.

In the case of electrification of the railway, an essential aspect of the tunnel options, the number of catenary posts in the yard storage areas should be minimized by suspending catenaries from horizontal members spanning across the tracks. The necessary posts should be placed within the shorter distance between the tracks which should be increased accordingly so that it will become 4m plus the diameter of the pole. The catenary poles should not be placed within the area where track centerlines are spaced at the 6m distance to preserve the access to trains by servicing vehicles.

The same principles apply to lighting poles. However, a small number of large lighting towers placed outside the parallel track groups is preferred over an alternative increased number of smaller lights placed between tracks.

In the areas intended for joint development over the track area, the spacing of the track centerlines should be increased by 1m to provide ample space for future building columns.

10.3.2 Horizontal Curves

The radii of horizontal curves in the yards should be as large as possible.

Minimum radii of horizontal curves: The minimum radius of curvatures in the curves and turnouts of the yard is preferably 190m and exceptionally 140m. While rolling stock manufacturers often indicate lower minimum radii that are considerably smaller than the 140m minimum radius., The operation of equipment on curves with very small radii should be avoided since these conditions disproportionately increase maintenance costs and probability of derailments. These special cases include seldom-traveled tracks, tracks for incomplete trains and individual cars, as well as tracks utilized exclusively by specialized track maintenance equipment.

The stated minimum radii are considerably larger than the radii considered adequate by previous generations of terminal builders. In comparison with their predecessors, contemporary passenger cars are larger offer spacious interior, and their suspensions are stiffer due to acoustic concerns at the expense of their turning abilities on sharp curves. Self-steering trucks would considerably improve performance of trains on curves, permit lower radii, and reduce side rail wear, an effect achieved by GM locomotives in railroad industry. However, adherence to rigid truck frames and axle-mounted motors persists in the field of otherwise advanced vehicle design. The simplicity of maintenance and lower cost of basic rolling stock is usually stated as the reason for this preference over more advanced and complex vehicle suspensions which were developed decades ago and have not find sufficient market.

The minimum straight distances between curves of the same directions: The straight distance should be 10m in the case of 140m radius and 6m in the case of 190m radius

The minimum straight distances between curves of opposite directions: The minimum straight distances between curves of opposite directions are given in Table 3.2-1. Radii are marked as r_1 and r_2 . The upper numbers in the heading row and the upper numbers in the first column of the Table 3.2-1 show the radii in tens of meters.

10.3.3 Geometry and Selection of Turnouts

Horizontal branch radii: The stated 140m absolute minimum and 190m preferred minimum horizontal branching radii have been established according to branch radii of standard unilateral turnouts. Namely 1:6, 1:7 and 1:7.5 turnouts with branch curvatures of 140m (for 1:6 turnout) and 190m radius (for 1:7 and 1:7.5 turnouts). These turnouts should be of tangential design to eliminate short tangents in their branch paths as manufactured by special trackwork producers in continental Europe.

Tangential configuration of turnouts: The branch curve within a tangential turnout occupies the entire length of the turnout so that its radius can be much larger than the radius of a branch curve located within a typical conventional turnout of the same length. The beginning of the branch curve is thus identical with the front joint of the turnout, and the end of the branch curve is identical with the end joint of the tangential turnout. The type of self-standing tangential turnout that has a straight section pass the end of the deviation curve of its branch should not be used within a sequence.

Since the curve of recommended tangential turnouts passes through the frog, the frog must have its branch path curved. Turnouts of this kind are therefore termed "low speed tangential turnouts with curved frogs" (LSTT-CF).

Curves created by sequentially placed unilateral tangential turnouts: The branching paths of sequentially placed tangential turnouts can create a common curve. The tangential turnouts placed almost directly next to each other's branch paths on the same curve improve the quality of ride and save space. A short curved simple track should be added between the turnouts in such manner that the next turnout starts pass the area of long ties of the previous turnout.

Use of non-tangential turnouts in the yards: There is a strong tendency to use sequences of conventional non-tangential or even old generations' turnouts in yards because they belong to the category of secondary trackage traveled by trains without passengers. The resulting track layouts of yards are quite space demanding for the following reason:

Table 3.2-1: Minimum Tangent Lengths between Circular Curves of Opposite Direction for Speeds not to Exceed 40km/h

r_2 / r_1	150	170	180	190	200	220	230	250	280	300	325	350	400	450	500	600	700
150	11 m																
170																	
180																	
190				10 m													
200																	
220																	
230							6 m										
250																	
280																	
300										4 m	Tracks carrying trains with passengers						
325										0	Yard track						
350																	
400																	
450																	
500																	
600																	
700																	

The branch curve of a typical conventional turnout starts at a certain distance from the front joint of the turnout and ends before its frog. There is a straight section between the front joint of the turnout and the beginning of the deviation curve of the consecutive turnout in a sequence. Also, there is a straight section from the frog to the end of the preceding turnout. The sum of both straight distances is less than the minimum tangent permitted between two separate turnout curves of the same direction. A straight track segment must be added between branch paths' of such turnouts to avoid running instabilities and derailments.

Self-standing individual turnouts, that are not a part of a sequence, branching or a crossover, can be of non-tangential design, or of tangential design with a straight branch section pass the frog, provided that the branching radius is sufficiently large.

Turnout with 300m branch radius, usually designated as 1:9-300: The turnout with 300m branch radius is preferred in the following situations:

- Mainline is extended into the yard
- Heavily traveled entry turnouts of the yard and entry crossover

In the yard, wherever small deviation angles are needed to accomplish efficient yard layout.

Preference for limited number of turnout types: The number of turnout types in the yard should be as low as possible to reduce the inventory of spare parts and to simplify maintenance. Almost every yard can be designed using only two types of unilateral turnouts, 1:7-190 (left and right), and 1:9-300 (left and right). Double crossovers should be used only in the locations where crossovers composed of simple unilateral turnouts cannot be used. Proper design of special trackwork will eliminate a need for using complex and maintenance-intensive special trackwork such as three-way turnouts.

The most frequently used yard turnout is the one with 190m branch radius. The straight distance needed between curves of the same direction is six meters, and between curves of the opposite direction ten meters.

Curved ladder track: The LSTT-CF turnouts can be placed on the same branch curve almost directly next to each other to form a curved ladder track. An intermediate curved section, one to two meters long, is added between turnouts in such a manner that the next turnout starts pass the location of long ties of the previous turnout. This property of LSTT-CF turnouts is a powerful space-saving feature that enhances quality and safety of operations inside the yard. Utilization of LSTT-CS turnouts reduces the number of directional changes that the train must overcome in the yard. This number determines the probability of derailments, along with the radii of curves.

The curved ladder track placed on a single basic curve is a major space saving feature. It leads to far better solutions than similar branching accomplished by non-tangential turnouts. However, its basic curve must be lubricated at all times because large number of passing trains will otherwise cause accelerated side wear of the railhead. In the conditions of Szenzchen's yard of Line 1, Phase 2, where the available land is not restricted, utilization of a straight ladder track would be more appropriate even when the length of the yard's trackage would increase. The curved ladder track can be used in the trackage of other yards where the land allocation is not so generous.

10.3.4 Vertical Geometry

It is preferred that the entire crossover is placed within the same plane and outside of vertical curves that accomplish gradient changes.

In difficult conditions, where gradient change curves are exceptionally placed in the intermediate tracks between turnouts, the turnouts and the track crossing can be placed at their own horizontal or inclined planes. However, the vertical gradient change curves within the intermediate tracks of the crossover can be only convex, not concave.

Under very severe circumstances, a convex vertical curve can be exceptionally permitted to reach into the turnout, however, not into the switch point rail and/or frog areas.

Turnouts shall not be placed within concave vertical curves under any circumstances.

10.4 Manufacturers of Low Speed Tangential Turnouts with Curved Frogs

The manufacturers of LSTT-CF turnouts include major manufacturers such as BWG in Germany, Cogifer in France, Voest Alpine in Austria, and D+T in Czech Republic. European-made turnout rails are combined with American components in the USA. Tangential turnouts are not available in United Kingdom.

10.5 Road Access, Unloading Ramp for Road Vehicles, and Parking Areas

Road access should be provided to all facilities of the yard, such as the shop building, car wash, hot wheel detector and revenue collection facility. Also, an access road should exist on at least one side of any track group, branching area, and loop track. Odd shaped and unused areas resulting from track branching layouts should be used for parking unless they are occupied by outdoor storage. Crossing of yard tracks is permitted immediately next to the main shop building and over the loop. Crossing storage tracks should not be permitted.

A ramp for unloading road vehicles should be established along one side of the main shop building adjacent to an open paved area that is adequate for turning road trucks.

10.6 Fire Road

A fire road shall be provided around the perimeter of the main shop building. Also, the access roads provided along the track groups shall be designated as fire roads. All roads shall be kept unobstructed at all times to facilitate speedy access should fire starts in any of yard's facilities or in a train.

10.7 Test Track

A test track of full yard length should be provided to test repaired vehicles.

10.8 Yard to Mainline Connection

The connection of the main yard planned for Line 1, Phase 2, should be accomplished by turnouts placed in the mainline track. The mainline tracks should be built at two different elevations with the track located closer to the yard being at the lower level. The yard track connecting the other mainline track will be at a higher elevation. This track will pass above the low track towards the yard so that the mainline track and the yard feeder track will not cross at the same level. Such inconvenient crossing would be necessary if both mainline tracks were built at the same level.

The proximity of station to the place of yard tracks' connection leads to platforms of mainline track provided at two different levels. This solution was used at the deviation stations of Orange Line and Blue Line, as well as the Yellow Line and Blue Line on the metro system of Washington Metropolitan Area Transit Authority (WMATA).

The operational arrangement at the connection of the yard lead tracks to the mainline at one or at the both ends of the yard should be reconsidered. It should provide the least amount of interference with revenue operations of the mainline, to avoid reverse movements in the mainline, and to eliminate crossing mainline tracks wherever possible. The train storage at the yard entrance between mainline tracks may be substituted for by rapid access option in the yard.

10.9 Implementation phasing and future expansion of the Yard

A depot that will support gradually increasing traffic should be designed for the final operational maximum that will be reached at the completion of the entire rapid transit system. However, the implementation of the yard should be phased according to the actual need at each particular stage of the project. The design should be made in such a manner that no demolitions are necessary in the time of expansion.

10.10 Loop

Depending on the operational intensity of the yard, one or two loop tracks should be built. Each loop track should be superelevated by 125 to 175mm. Since the tracks within the turnouts are not superelavated, transitional superelevation ramps at the ends of the loop are necessary. The high rail of the loop track, as well as the outer rail of curved ladder tracks must be lubricated at all times to control lateral wear of the rail head. The transverse rail incline must be 1:20 or steeper to enhance the effect of wheels' conicity during curving.

The loop should have a radius of at least 140m. Smaller radii curves are used frequently; however, the sharper the curve, the more intense is the lateral wear on the rail head. The trucks of rapid transit trains passing through loops of radii smaller than 100m are known to lock in curving position and derail inward at the end of the loop.

APPENDIX 3-3

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 steep Shfela soil types K	Lakhish-Amatzia chalk hills soil type B	Mt. Hebron Mountainous - 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 3.3-1: The Probabilistic Discharges for Drainage Basins in the Mountainous Area (for Mountain Soils)

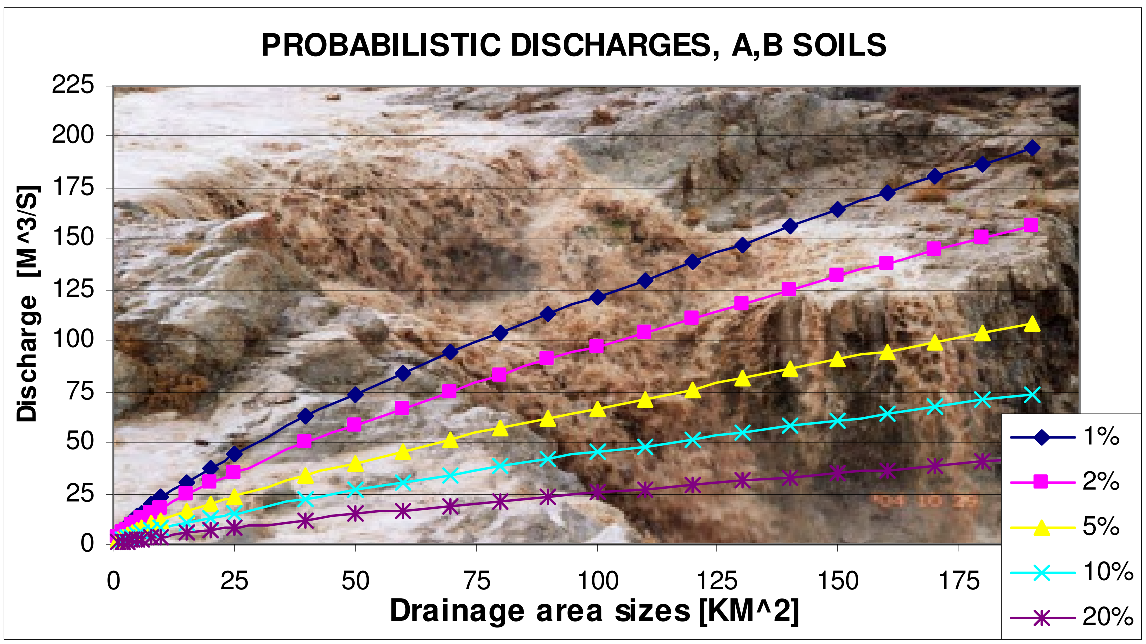


Figure 3.3-2: The Probabilistic Discharges for Drainage Basins in the Alluvial Soils of the Southern Shfela

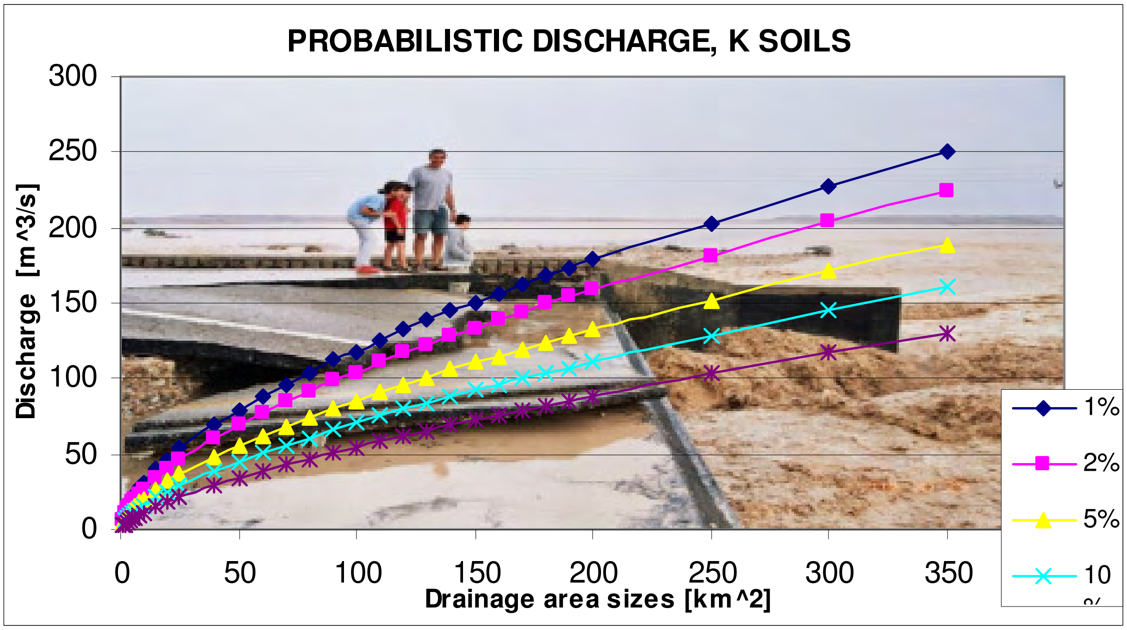
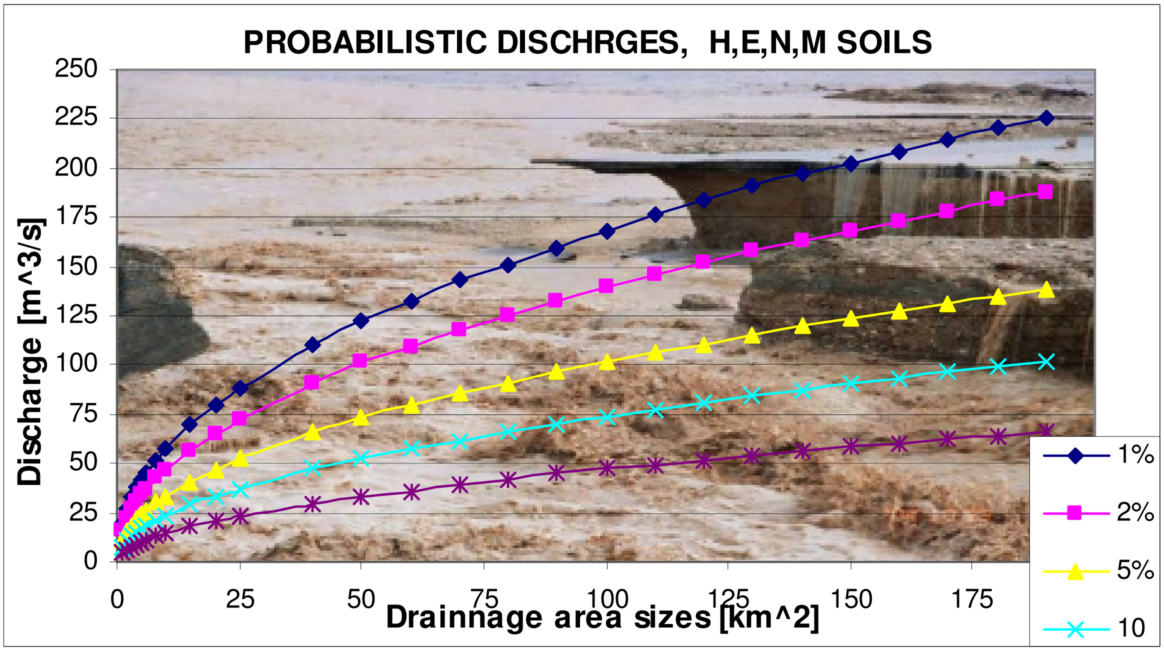


Figure 3.3-3: The Probabilistic Discharges for Drainage Basins in the North Negev (Loessial soils)



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 3.3-1: 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 3.3-2: 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 3.3-3: 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 3.3-4: 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 3.3–5: 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.

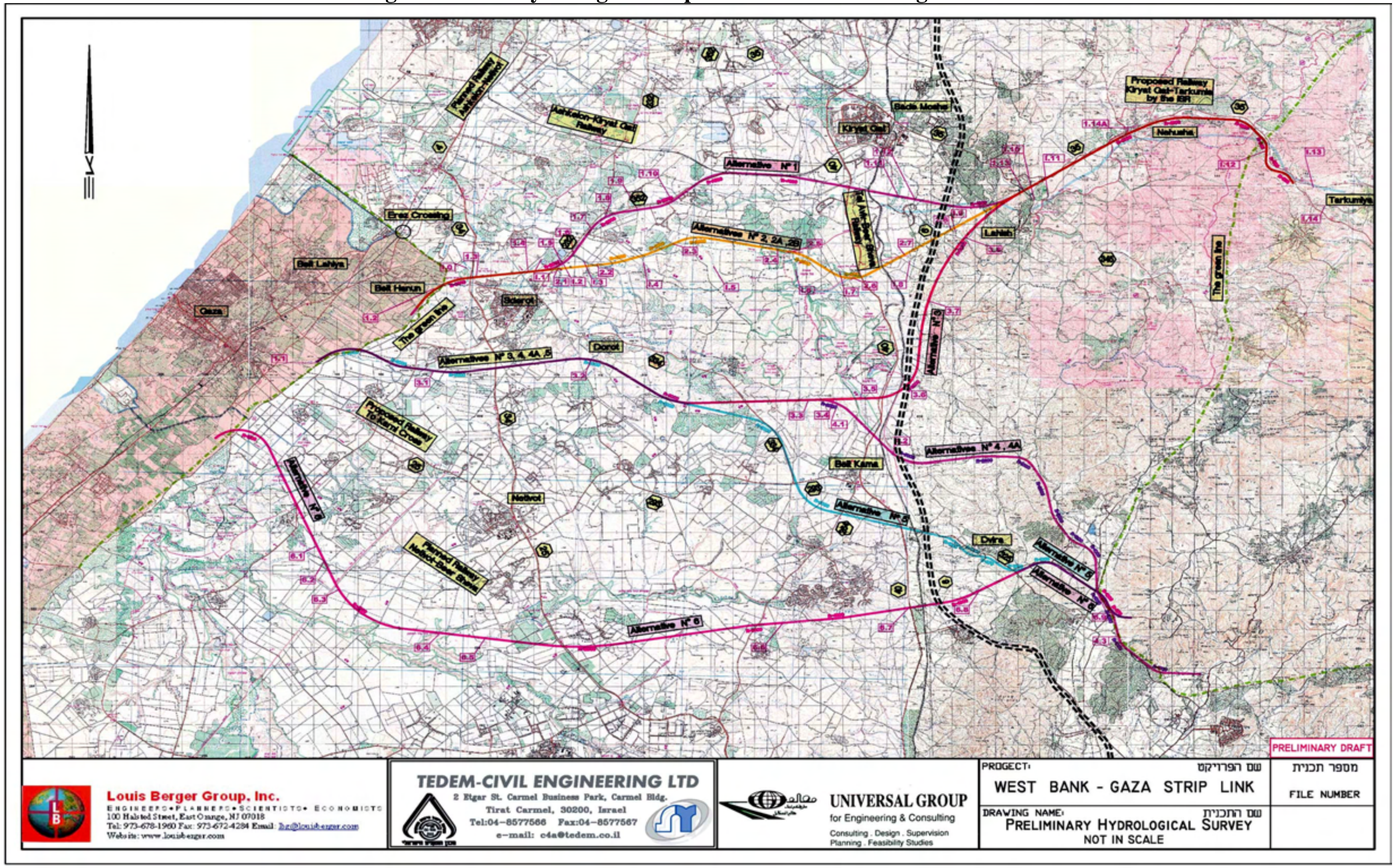
Table 3.3-6: Probabilistic Discharges for the Major Stream Crossings for Alternative 6

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 3.3 -4: Hydrological Map of the Alternative Alignments



22/12/2005 15:32:54, user37, ISO A2 - 420 x 594 mm. (landscape),
1:1

Table 3.3-7: 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

APPENDIX 3-4

GEOLOGICAL AND GEOTECHNICAL REPORT

1. Data Review

The geological analysis of the West Bank to Gaza Strip Transport Link included collecting available geological data from maps and other geotechnical reports from adjacent projects. The following references were examined:

1. Cross Israel Highway sections 19 and 20 – Site investigation report done by Technion – building and infrastructure testing laboratories with guidance of Professor Ilan Ishai.
2. Naan–Beer Sheva Railway -Site investigation report done by Isotop Ltd. with guidance of Professor Ilan Ishai. (Designed by Deker Ltd.).
3. Naan–Beer Sheva Railway – Preliminary geotechnical report done by Geolog Ltd.
4. Ashkelon-Beer Sheva Railway -Site investigation report done by Isotop with guidance of Professor Ilan Ishai. (Designed by Ynon Ltd.).
5. Ashkelon-Beer Sheva Railway -Preliminary geotechnical report done by Yuvalim Ltd.
6. Road no. 25 -Preliminary geotechnical report done byYuvalim Ltd.
7. Engineering geology of numerous Chalk rocks in Israel. Doctorate thesis, Hayati, G., 1975.
8. Stability of underground openings in jointed chalk rock – A case study from bell shaped caverns, Beit-Govrin National Park. Tsesarsky, Michael and Hatzor Y., 1999.

Additional data have been collected in the field from outcrops of soil and rock units that are exposed along the various routes and by impression from soil/rock condition in several projects that are being constructed, among them:

- The new border road along Gaza area at the western area.
- The road along the separation fence at the eastern area.

The data is summarized in a textual report and in the following drawings:

- Drawing 2872-GEO-001A – Geological and Geotechnical map, scale 1:50,000. (7 files GGS-2872-421 to 427 divided to 30 sheets of A3).
- Drawing 2872-GEO-441 – Geological longitudinal profile Alt. No. 1 (Divided to 3 sheets of A3).
- Drawing 2872-GEO-442 – Geological longitudinal profile Alt. No. 2 (Divided to 3 sheets of A3).
- Drawing 2872-GEO-443 – Geological longitudinal profile Alt. No. 3 (Divided to 4 sheets of A3).
- Drawing 2872-GEO-444 – Geological longitudinal profile Alt. No. 4 (Divided to 3 sheets of A3).
- Drawing 2872-GEO-445 – Geological longitudinal profile Alt. No. 5 (Divided to 3 sheets of A3). Drawing 2872-GEO-446 – Geological longitudinal profile Alt. No. 6 (Divided to 3 sheets of A3).

2. Geology

2.1 General Description

The geology of the region is based on the tectonic structure of Judea Mountains and on the sedimentary sequence along the Shfela area and the coastal plain. The Judea Mountains are a non-symmetrical anticline. Most of the rocks that form the anticline are sedimentary rocks, which has massive to well bedded structure. The anticline is a folded structure with a steep slope at the eastern side and relatively moderate slope at the western side. The direction of the anticline axis is north-north-east to south-south-west, which results steep bedding inclination at the western slopes and moderate bedding inclination at the southern slopes. The ancient rock units (Cenomanian and Turonian age) 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 therefore the chalk and chalky limestone units are not folded and faulted. The region is characterized by a low seismic activity. These units were eroded later due to the regression of the sea during the Neogene age, which resulted in deep channels and river streams which at the present time are filled with younger deposits. During the Quaternary age most of the sediments were from terrestrial origin and the soil profile is influenced by climate changes; sand dunes and loess were created in arid eras and clayey to silty soil in eras of humid climate.

2.2 Geological Formations

The geological formations are presented in Figure 1 according to the geological sequence. The following is a short description of each formation and its lithology.

1. Kefar Shaul Fm. – non-continuous formation. Its thickness 15-20m, contains marly to chalky lime stone.
2. Weradim Fm. – Thickness of 50-150m. Well bedded to massive, hard gray dolomite.
3. Bi’na Fm. -Thickness of 100m. Well-bedded white yellowish, hard limestone.
4. Mount Scopus Group – can be divided to 4 formations:
   a. Menuha Fm. - Thickness of 70m. Medium hard to soft chalk.
   b. Mishash Fm. -Thickness of 10-15m. Massive or brecciated chert.
      - Ghareb Fm. -Thickness of 40m. Weathered marly chalk.
      - Taqiya Fm. -Thickness of 0-50m. Mainly shales and marl.
5. Zor’a Fm. -can be divided into 2 members:
   a. Adulam Mem. – Max thickness of 150m. White, well bedded chalk to limey chalk with chert horizons and chert nodules.
   b. Maresha Mem. -Max thickness of 100m. Unconformably overlies the Adulam member. The contact between the two is not easily recognized. Consists of white massive chalk. It is well exposed in several bell shaped caverns.
6. Ziqlag Fm. – Thickness of 10 m. Recognized in the field as relicts of well bedded limestone.
7. Beit-Nir Fm. -Thickness of 0-30 m. Conglomerates containing limestone and chert pebbles, cemented by cliché (Nari).
8. Alluvium – contains recent deposits of young conglomerate along valley streams, and soils. East of Gerar stream the alluvium consists of fine particles, which are deposited by wind (aeolian process) and therefore soils are classified as Loess.

References is made to Figure 1, Geological Map of the Alternative Alignments.

2.3 Geomorphology

The connecting road will cross three main geomorphological regions:

1. The coastal plain – A relatively flat area, 20 km width, with elevations of +50 m above sea level (asl) close to the Gaza strip and up to +170 m asl at the border with the Shfela region. The average inclination is 0.6%.

2. The Shfela region – A hilly region, 20 km width with rounded hills up to +450 m. asl. The average inclination is 1.5%.

3. The southern and western slopes of the Hebron mountains – A mountainous region, 10 km width with a peak elevation of +1002 m 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.

2.4 Rock Units

The division of rock units is related to the geomorphology. The distribution of the rock units are presented in the attached 1:50,000 scale geological map. The letters on the map, which described the soil/rock units, are contained in brackets below.

1. The coastal plain consists 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. It is estimated that soil south of Hanun and Shikma streams are from aeolian and alluvial origin (loess – geo-unit Ib, Id) and the soil north of these streams is mainly from alluvial origin (geo-units Ia, Ic and Id).

2. The Shfela consists of light brown silty to clayey soils (q), with local outcrops of conglomerate and gravel (ngc) along the valleys. Weak to moderate hard Chalk to Chalky Limestone (emr and ea), marl and marly chalk (eu) and well bedded limestone (ol and mm) occur along the hills. This region contains hundreds to thousand of man made ancient caves and underground cavities that may cross the road alignment.

3. The slopes of Hebron Mountain consist of variable rock units from fat (highly plastic) marl (pa), soft chalk (ma and sc), chert (ca), hard strong dolomite (c3), limestone (t and c2). The sedimentary rock is well bedded with bedding inclined up to 25° toward the north-west.

3. Description of the Alternative Alignments

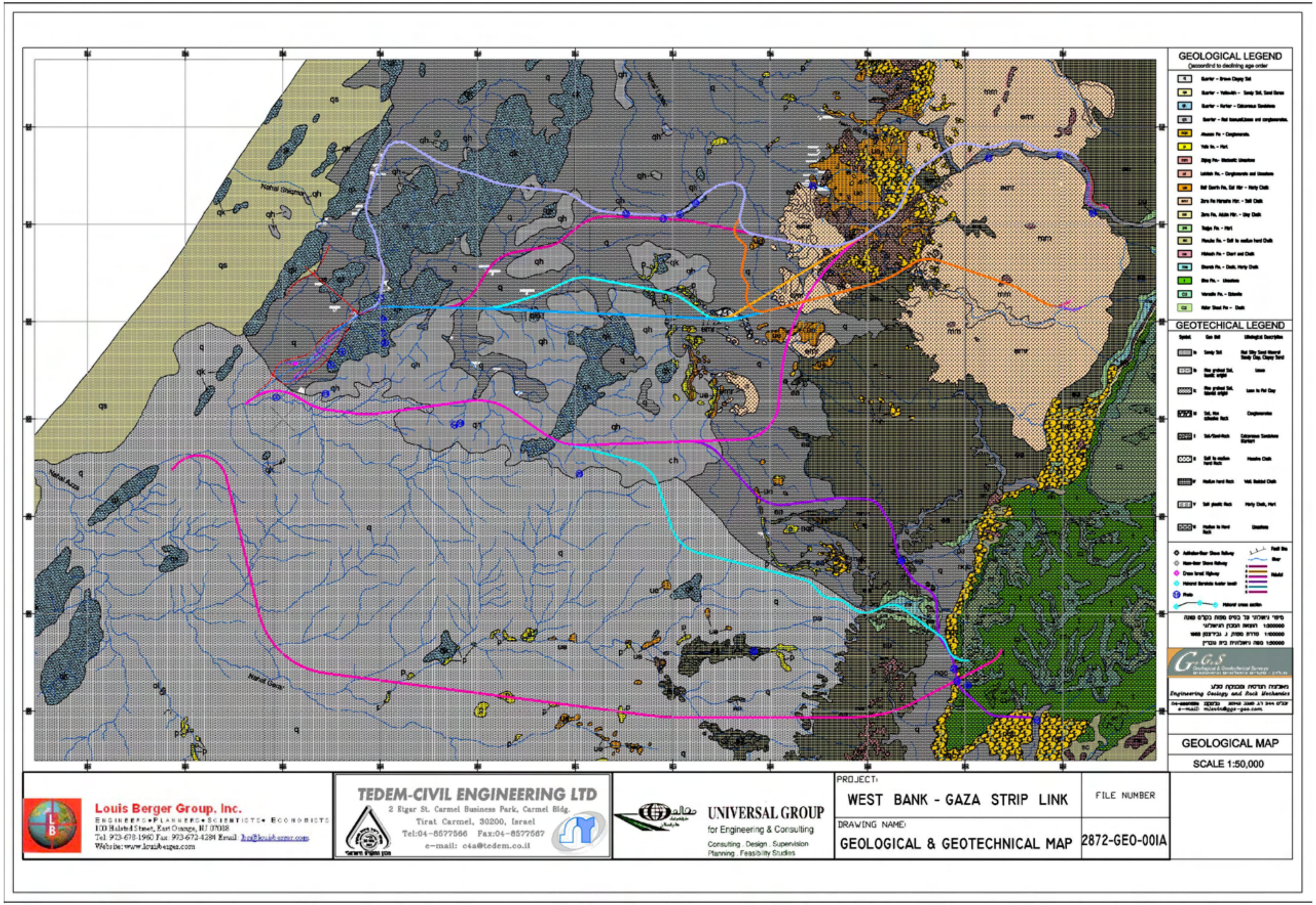
This section presents a general description of the geological units and the differentiations between the alternative routes. Representative pictures of the soil units are presented in Appendix A. Detailed division of the geotechnical units is presented in Tables 1 to 6. The six different alternatives are divided into three main routes.

1. Northern Corridor – Alignment 1 and 2 cross the coastal plain along the Kurkar ridges (Calcareous Sandstone) and sand dunes up to section 1230 (see pictures 1 to 8). Alignment 1, which is the more northern, passes through sandy clays up to section 1310 and silty to lean clay, which covers layers of Kurkar from section 1310 up to section 1400 (see

pictures 9-12 along Ashkelon-Beer-Sheva railway). Alternative 2 passes closer to Shikma stream and it is assumed that the soil profile is similar to Alignment 1, although it may contains lenses of conglomerate, gravel, marl and lean clay up to section 2400. From section 1400 and 2400 up to 1520 and 2520 both Alignment 1 and 2 cross a hilly zone characterized by marl, marly chalk and massive soft chalk, which may be interrupted by lenses of conglomerate and gravel. Alternatives 1 and 2 are on the same alignment from section 1520 and pass along the southern banks of Beit-Govrin stream in a massive to well bedded chalky rock, which is covered by lean (low plasticity) to fat clay (pictures 17-20). The depth of clay is relative to the distance from the streamline. Alignment 2s is a sunken version of Alignment 2 with average depth of 10-15m below the ground surface. Alignment 7 is the tunneling version of Alignment 2 (section 2180 to 2360 only) with an average depth of 30m to 50m below the ground surface. Alignment 7 and 8 are tunneling alignments. Alignment 7 follows Alignment 2 up to section 7360 where the total excavation is 21.3 km of cut & cover tunnel. Alignment 8 is designed as a bored tunnel with total length of 37.2km and a short section of cut & cover (0.35km). Alternative 7 matches Alignment 8 at section 7360. The maximum depth of the tunnel is 105m below the ground surface at section 8525.

2. Central Corridor – Alignment 3, 4 and 5 are on the same alignment up to section 3280 (4280, 5280 respectively). The route is on the coastal plain up to section 3200 (4200 and 5200 respectively) along a relatively flat cultivated area (picture 13). From section 3200 and up to 3360 (4360 and 5340 respectively) the alternatives pass through dissected hilly area dissected by small streams (pictures 14-16). The soil profile in this section contains silty clay (loess) and lean to fat clay lying on top of Kurkar layers (calcareous sandstone). Alternatives 3 and 4 are on the same alignment from section 3280 to 3450 (4280 to 4350 respectively). Alternative 3 from section 3360 is curved northward and up to section 3430 passes through clayey soil, which covers Kurkar. From section 3430 and up to 3500 Alternative 3 passes through a hilly area with marl and marly chalk, covered by lean to fat clay. Alternative 3 is unified with alternative 1 from section 3500. Alternative 4, from section 4370 to section 4440 is located in a relatively flat cultivated area with lean clay (loess) to fat clay which reaches a depth of 7m to 10m, covering chalky rock. From section 4440 to section 4520 the alternative passes through medium hard, well bedded chalk to limey chalk (Pictures 21, 22). From section 4520 to 4540 the road is within Yabal valley, which is the border between Lahav hills and the western slopes of the Hebron Mountains. From section 4540 a tunnel section with length of 4km is designed to pass through conglomerate, chalk, and limestone sequence up to section 4575. From section 4575 to 4605 the alternative passes through conglomerate and gravel overlying limestone and dolomite (Pictures 23-26).

3. Southern Corridor – Alignment 6 is crosses the coastal plain up to section 6300 through silty clay and clayey sand loess overlying calcareous sandstone (Kurkar). From section 6300 to 6500 the upper strata contain lean to fat clay with some outcrops of marly chalk overlying well-bedded chalk. From section 6460 to section 6520 the route is in a hilly area of well bedded chalk where a tunnel section of 1200m is designed. From section 6520 to 6545 the alternative crosses a wide valley with lean to fat clay overlying chalk and marl. From section 6545 to 6575 the western slopes of the Judea Mountains consist of Limestone and Dolomite (Pictures 25, 26).


GEOLOGICAL LEGEND
GEOTECHICAL LEGEND
GEOLOGICAL MAP
SCALE 1:50,000
Louis Berger Group, Inc.
TEDEM-CIVIL ENGINEERING LTD
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WEST BANK - GAZA STRIP LINK
DRAWING NAME:
GEOLOGICAL & GEOTECHNICAL MAP
FILE NUMBER
2872-GEO-001A

4. Geotechnical Classification

The geotechnical classification is based on data from site investigations in nearby projects. The geo-units are divided to 6 main units.

1. Unit I is classified according to Unified Soil Classification System (USCS) and it is subdivided to 4 sub-units Ia, Ib, Ic and Id.

   Ia – Red silty Sand (Hamra), Sandy Clay and Clayey Sand (CL, SC).
   Ib – Silty Clay (Loess) (CL).
   Ic – Lean to fat Clay (CL-CH).
   Id – Conglomerate (GP, GC).

   The loess (Ib) is an Aeolian deposit (sedimentation by the wind) and therefore is internal structure is sensitive to water content.

2. Unit II is classified according to the Unified Soil Classification System (USCS) as SP-SM, but can be classified as a weak rock (Kurkar) when the carbonate content has values greater than 20%.

3. Unit III is a soft to medium hard chalk, which is classified as rock, but when it is remolded it is classified according to USCS classification as CL. The geotechnical properties of this rock vary according to the orientation relative to bedding plane (Tsesarsky and Hatzor, 1999). The unconfined uniaxial strength wc = 1.4-3.9MPa perpendicular to bedding plane and wc = 4.9-11.2MPa parallel to bedding plane.

4. Unit IV is a medium hard well-bedded chalky rock. The range of unconfined uniaxial strength is wc = 10-40MPa (Hayati, 1975).

5. Unit V is a soft plastic rock, very sensitive to water content and therefore is classified also by USCS as MH-CH or ML.

6. Unit VI is a medium to very hard rock, which is exposed only in the eastern part of alternatives 4, 5 and 6. The range of unconfined uniaxial strength is wc = 60-150MPa.

The summary of geotechnical properties of the geo-units is described in Table 1, which is based on average values from site investigations in nearby areas.

Table 1: Classification of Geological Units

Geo-unit	Description	S.P.T	V.T		Sieve Analysis				Dry Density	Water Content	Atterberg Limit			Unconf. Compres sion	USCS	AASHTO
		N1 value	undisturbed	remolded	#200	#40	#10	#4	kg/m3		L.L	P.L	P.I.	Strength		
		N/('v)^0.5	kPa	kPa	%					%	%	%	%	[MPa]		
Ia	Red Silty Sand (Hamra), Sandy Clay, Clayey Sand	18 (42)			22 (25)	84 (25)	92 (25)	96 (25)		6 (11)	30 (6), N.P. (15)	16 (6)	13 (6)		CL	A-2-4, A-2-6 A-6
Ib	Silty Clay Loess		480 (2)	131 (2)	67 (4)	88 (4)	95 (4)	100 (4)	1800 (3)	11 (3)	35 (3)	19 (3)	16 (3)		CL	A-6, A-7-6
Ic	Lean to Fat Clay	32 (30)	460 (35)	126 (35)	91 (42)	96 (38)	97 (32)	97 (16)	1700 (16)	20 (40)	55 (51)	21 (51)	34 (51)		CL (19) CH (34)	
Id	Conglomerate				40 (30)	48 (3)	58 (3)	58 (3)			48 (2)	25 (2)	24 (2)		GC	A-7-6 (3)
III	Soft to medium hard rock -massive Chalk	>50							110-1300 (dry)		35 (3)	27 (3)	8 (3)	1.5-4 (perpendicular) 5-11 (parallel)	SP (32) 23	
IV	Medium hard rock -well bedded Chalk													10-40		
V	Soft plastic rock -Marl, Marly Chalk	36 (15) >50 (17)			84 (2)			91 (2)		31 (10)	62 (41)	30 (41)	33 (41)	<1	MH-CH	
VI	Medium to very hard rock -Limestone, Dolomite													60-150		

Numbers in brackets are number of samples that were analyzed Based on geotechnical data from site investigations Cross Israel Highway section 19 and 20 Naan-Beer-Sheva Railway Ashkelon-Beer Sheva Railway
Tsesarsky and Hatzor, 1999 Hayati, G. 1975

Table 2: Division of the Alignments According to Geotechnical Units

Alignments No.	1,2,3,4,5,6,	1,2,3,4,5,6,	1,2,3,4,5,6,	1,2,3,4,5,	1,2,	1,2,	1	1	1, 2, 3	1, 2, 3
Chainage	0-1028 2000-2028 3000-3028 4000-4028 5000-5028 6000-6028	1028-1040 2028-2040 3028-3040 4028-4040 5028-5040 6028-6040	1040-1050 2040-2050 3040-3050 4040-4050 5040-5050 6040-6050	1050-1120 2050-2120 3050-3120 4050-4120 5050-5120 Alt 6 in Table 6	1120-1160 2120-2160 *Alt 3,4,5 in Table 4* *Alt 6 in Table 6*	1160-1220 2160-2220 *Alt 3,4,5 in Table 4* *Alt 6 in Table 6*	1220-1420 *Alt 2 in Table 3* *Alt 3,4,5 in Table 4* *Alt 6 in Table 6*	1420-1455 *Alt 2 in Table 3* *Alt 3,4,5 in Table 4* *Alt 6 in Table 6*	1455-1505 2450-2500 3455-3545 *Alt 4,5 in Table 5* *Alt 6 in Table 6*	1505-1620 2500-2620 3545-3660 *Alt 4,5 in Table 5* *Alt 6 in Table 6*
Geo Unit	Ia, Ib, Ic	II	Ia, Ib, Ic	Ia, Ib, Ic	Ia, Ib, Ic	II	0-10.0: Ic 10.0-13.0: II	III, V	Id, V	Ia, Ic, Id, III
General Description	Lean to fat Clay. Sandy Clay Clayey Sand	Kurkar, Calcareous Sandstone	Lean to fat Clay. Sandy Clay Clayey Sand	Lean to fat Clay. Sandy Clay Clayey Sand	Lean to fat Clay. Sandy Clay Clayey Sand	Kurkar, Calcareous Sandstone	Lean to fat Clay overlying Sand and Kurkar	Marl, Chalk, Marly Chalk	Conglomerate, Marly Chalk	Sandy Clays, Lean to fat Clays. Chalk
USCS	CH, CL, SC, SM	*SM, SP	CH, CL, SC, SM	CH, CL, SC, SM	CH, CL, SC, SM	*SM, SP	CH, CL, SC, SM, SP		GP, GC	CL, CH, GC
AASHTO	A-7-6, A-6 A-2-4, A-3	A-2-4, A-3	A-7-6, A-6 A-2-4, A-3	A-7-6, A-6 A-2-4, A-3	A-7-6, A-6 A-2-4, A-3	A-2-4, A-3	A-7-6, A-6 A-2-4, A-3	Rock	A-7-6, A-6	A-7-6, A-6 Rock
Geotechnical Report Typical Boreholes	Ynon-K61 Ynon-K106	Ynon-K123	Ynon-K61 Ynon-K106	Ynon-K61 Ynon-K106	Ynon-K61 Ynon-K106	Ynon-K123	Deker-5 Deker-6	Road6-K395 Road6-K410		
Remarks										Along Beit Govrin stream

The stability of the Kurkar structure is influenced by the carbonate content, which varies from 10% to 40%.
SP-SM is related to Kurkar containing 10%-20% of carbonate content. Above 30% of carbonate content the Kurkar is considered as rock

Table 3: Division of Alignment 2 According to Geotechnical Units

Alignment No.	2	2	2	2				
Chainage	2220-2260	2260-2360	2360-2410	2410-2450	*Alt 2 in Table 2*	*Alt 2 in Table 2*	*Alt 2 in Table 2*	*Alt 2 in Table 2*
Geo Unit	Ia, Ic	Upper: Ic Lower: II	Ia, Ic, V	III				
General Description	Lean to fat Clay. Sandy Clay Clayey Sand	Lean to fat Clay overlying Sand and Kurkar	Lean to fat Clay. Sandy Clay Clayey Sand. Marly Chalk	Chalk, Lean Clay overlying Chalk				
USCS		CH, CL, SC, SM, SP						
AASHTO	A-7-6, A-6	A-7-6, A-6 A-2-4, A-3	A-7-6, A-6	See table 1				
Geotechnical Report Typical Boreholes								
Remarks		Along the Shikma stream	Depth of Ground water 7.8m Level +142.4					

Table 4: Division of Alignments 3, 4 and 5 According to Geotechnical Units

Alignment No.	3, 4,5	3, 4, 5	3,4,5	3, 4, 5	3	3	3	3	3
Chainage	3150-3200 4150-4200 5150-5200	3200-3275 4275-4280 5275-5280	3275-3280 4275-4280 5275-5280	3280-3365 4280-4365 5280-5340	3365-3435 *Alt 4 in Table 5* *Alt 5 in Table 5*	3435-3445 *Alt 4 in Table 5* *Alt 5 in Table 5*	3445-3455 *Alt 4 in Table 5* *Alt 5 in Table 5*	3455-3475 *Alt 4 in Table 5* *Alt 5 in Table 5*	3475-3500 *Alt 4 in Table 5* *Alt 5 in Table 5*
Geo Unit	Ib	Ia	II	Ia	Ic III, V	III, V	Ic, III	III	
General Description	Loess and Sandy Clays overlying Sand, Kurkar and Conglomerate	Red Silty Sand (Hamra), Sandy Clay, Clayey Sand	Calcareous Sandstone (Kurkar)	Red Silty Sand (Hamra), Sandy Clay, Clayey Sand	Lean to fat Clay overlying Marl and Marly Chalk	Sandy to Clayey with gravel Conglomerate	Lean to fat Clay overlying Chalk	Chalk	
USCS					MH (for marl)	CL, SC, GP			
AASHTO	A-6, A-7-6	A-6	A-6	A-6					
Geotechnical Report Typical Boreholes	Del-P1,	Road25			Deker-K10				
Remarks									

Table 5: Division of Alignment 4 and 5 According to Geotechnical Units

Alignment No.	4	4	4	4	4	5	5	5	
Chainage	4365-4440	4440-4500	4500-4540	4540-4580	4580-4605	5345-5470	5470-5510	5510-5535	5535-5540
Geo Unit	Ia, IV, V	IV	III, V	Ic, Id, III, VI	Ic, Id, VI	Ia, IV, V	IV, V	Ic, Id	VI
General Description	Lean to fat Clay overlying Chalk and Marly Chalk	Well bedded chalk, limey chalk	Marl and soft Chalk	Clay, Conglomerate, Chalk and Limestone	Conglomerate, Limestone, Dolomite	Lean to fat Clay overlying Chalk and Marly Chalk	Well bedded chalk and Marl		Limestone
USCS									
AASHTO	A-6, A-7-6	See table 1							
Geotechnical Report Typical Boreholes	Deker-P12, P13 Deker-K13								
Remarks				Tunnel section 4000 m					

Table 6: Division of Alignment 6 According to Geotechnical Units

Alignment No.	**6**	**6**	**6**	**6**	**6**	**6**
Chainage	6050-6240	6240-6310	6310-6460	6460-6520	6520-6545	6545-6575
Geo Unit	Ia, Ib	Ib	Ib, III, V	IV	Ic	VI
General Description	Loess and Sandy Clays overlying Sand, Kurkar and Conglomerate	Loess overlying Sand, Kurkar and Conglomerate	Loess overlying Chalk. Marly Chalk	Well bedded Chalk.	Lean to fat clay overlying chalk, marl and conglomerate	Limestone, Dolomite
USCS	CL, SC	CL	CL		CL, CH, GP	
AASHTO	A-6, A-7-6 A-2-4, A-2-6	A-6 A	A-6	Medium hard rock	A-6, A-7-6	Hard Rock
Geotechnical Report Typical Boreholes	Del-P1,	Road25 – test pits				
Remarks	Drainage Area of Gerar Stream			Tunnel section 1200 m		

Table 7: Division of Alignment 7 and 8 (Tunnels) According to Geotechnical Units

Alternative No.	7, 8	7, 8	7	8	8	7,8	7,8	7,8
Chainage	7180-7225 8180-8225	7225-7250 8225-8250	7250-7380	8225-8340	8340-8370	7380-7410 8370-8405	7410-7470 8405-8470	7450-7570 8470-8560
Geo Unit	II	Ia, II	Ic	Ia, II	Ic	IV	III, IV	III, IV
General Description	Calcareous sand stone (Kurkar), and sandy soil.	Silty Clay and few zones with calcareous sandstone	Lean to fat Clay Conglomerate along streams	Silty Clay and few zones with calcareous sandstone	Lean to fat clay overlying chalk, marl and conglomerate	Clay cover Limestone interbedded with Chalk and Marl	Mostly medium hard well bedded Limey Chalk and some soft chalk	Mostly soft chalk and some zones of medium hard well bedded Chalk and limestone
USCS	Strength and stability of unit is according to level of cementation and carbonate content	CL	CL, CH GP along streams	CL, SC GP along streams	CL, CH, GP	ROCK		
AASHTO	A-2-4, A-3	A-6 A	A-6, A-7-6	Medium hard rock	A-6, A-7-6	Medium Hard Rock with clay pockets	Soft to Medium Hard Rock.	
Geotechnical Report Typical Boreholes	Ynon K-112, K111, Del K-13	Mekorot: Ibim 2/7	Mekorot: Bror Hail 3/8, Telamim 4/9, Shikma H	Mekorot: Bror Hail 3/9	Mekorot: Abu-Gaber-2	Road 6-2K-250 Road6 –2k-235		
Remarks	Similar to units K1-K3 in the metro project of Tel-Aviv					Clay thickness is 3-20 m. tunnel depth is 30 m		Medium hard chalk is located at the deepest sections

5. Summary

A. All the alternatives pass through two geomorphological regions: the coastal plain and the Shfela. Alternatives 4, 5 and 6 pass along the western slopes of the Judea Mountains at the eastern end of the routes. The coastal plain is characterized by sandy and silty soils overlying calcareous sandstone. The Shfela is characterized by soft to medium hard Chalk. The western slopes of Judea Mountains are characterized by conglomerate, hard Limestone and Dolomite.

B. The region is defined by low seismic activity. The recommended seismic coefficient is 0.1 (according to Israeli Standard 413).

C. The typical soil/rock units are classified according to their geotechnical properties into 6 geo-units:

Unit I is subdivided to 4 sub-units Ia, Ib, Ic and Id.
Ia – Red silty Sand (Hamra), Sandy Clay and Clayey Sand (CL, SC).
Ib – Silty Clay (Loess) (CL).
Ic – Lean to fat Clay (CL-CH).
Id – Conglomerate (GP, GC).
Unit II is sand to calcareous sandstone.
Unit III is a soft to medium hard chalk.
Unit IV is a medium hard well-bedded chalky rock.
Unit V is a soft plastic marly rock.
Unit VI is a medium to very hard rock (well bedded limestone and dolomite).

D. The region of Beit-Govrin-Tarkumya is characterized by the phenomenon of bell shape caverns (man made large caves), which can influence the stability of the road invert or any other structures. It is recommended to perform geophysical surveys in this region.

E. The regional water level is located at a depth of 30-100 m below the road alignment. Local perched aquifers can be located at the Shfela region at a depth of a few meters below the ground surface.

F. For the tunneling alternatives two methods of excavation are considered (cut-and-cover and bored). For open excavations it is necessary to define the maximum inclination of the excavated slopes according to the depth of the cut-and-cover tunnel. In soil a vertical excavation will not be safe for a depth of more then 3m. For the bored sections two main zones are defined: the western section is within soil where horizontal earth stresses can influence the stability and rate of advance. The eastern section is within chalky rock where the range of rock strength is the main property that influences the stability and rate of advance.

G. This desk study report contains general information that was analyzed from available geotechnical data. A detailed site investigation is required for the primary and detailed stages of design.

APPENDIX 3-5

ELECTRIC POWER AND COMMUNICATIONS CONSIDERATIONS

1.0 Railways

1.1 General Requirements

Diesel Powered Railway: The services necessary to operate a conventional at grade double track diesel powered railway includes:

- Lighting and Power at the Terminal Stations
- Lighting and Power at the Maintenance Depot
- Lighting and Power in the Control Room
- Area lighting at freight loading yards
- Area lighting at Passing Loop Track
- Low voltage sub station at each of the above locations
- Signaling System
- Radio System
- Telephone System
- Fare Collection System
- PA System
- CCTV System
- Clock System

Electrically Powered Railway: In addition to the above services an electrically powered Railway requires:

- Medium voltage Traction Power Substation
- Overhead Catenary System
- Fibre Optic Transmission System
- SCADA system

1.2 Power Requirements

1.2.1 Diesel Powered Railway

The power requirements for the electrical services will be supplied from the nearest SELCO 36kV substation for the Tarcumiya terminus and from the GEDCO 24kV substation in Gaza North. A new MV line will be run to each station substation that will transform and supply power at 440V 3-phase to the station services through a distribution board.
The Gaza Station sub station will also supply power to the Depot, maintenance, service bays and for area lighting.

At the passing loop, power will be available from a local area existing OHL feed generally at 24kV via a suitable 440V distribution transformer.

Power requirements are estimated in Table 3.5-1 as follows:

Table 3.5-1: Power Requirements for Diesel Power Railways

Substation Location	Installed Power	Annual Consumption
Tarcumiya Station	600kVA	1,200MWh
Gaza Station	1000kVA	2,400MWh
Passing Loop	50kVA	100MWh

The costs of the installed power requirements are covered in the construction cost estimates and annual electric power costs are determined in Annex 6-4, Rail Operating and Maintenance Costs.

1.2.2 Additional Power Required for an Electric Traction Railway

In addition to the above requirements for a diesel powered railway, an electrically powered railway will require a traction power system consisting of an Overhead Catenary Line (OCL) connected to a high voltage substation that will be fed from either a 400kV or 161kV transmission line.

The single substation placed approximately half way along the alignment will feed power in each direction to the OCL at 25kV. The substation will include 2 – 30MVA oil cooled transformers, together with associated switchgear and protection equipment.

The substation will be controlled from the Operations Control Center situated at Gaza Terminal using a SCADA system transmitted through a Fiber Optic communications transmission line laid through out the length of the Railway.

The power requirements are estimated in Table 3.5-2 below:

Table 3.5-2: Addition Power Requirements of Electric Traction Power

Electrical System	Installed Power	Annual Train Operating Consumption
Traction Substation 161/25kV	60MVA	Determined in Annex 6-4 @ 0.6kWh per ton km.
SCADA System	50kVA	60,000kWh
OCL	~85km*	10% *

* Assumed 40km length.
** Transformer and transmission losses.

2.0 Power Requirements for a Four lane Highway

It is assumed a four-lane (two in each direction) highway will be built to the latest Israeli Road Standards, or alternatively to an American Standard such as the Roadway Design Manual issued by the NJDOT.
The electrically powered services on a modern roadway include:

- Carriageway Lighting
- Area Lighting at Toll Booth and service areas
- Emergency telephone system
- Traffic Control and Information System
- Surveillance and CCTV System
- Toll Booth Fare Collection System
- Mobile telephone infrastructure

The major power requirement is for carriageway lighting. This is normally based for the main highway on median placed masts 12.2m high at 30.5m intervals each using 2 x 250w pressure sodium luminaries. This equates to 15kW/km based on a 12hour day.

Area lighting at Toll and Service areas will be by 30.5m 'High' mast 6 x 400w pressure sodium luminaries. An estimated 6 masts are anticipated per service area.

The power will be fed to the lighting system from local area distribution transformers, generally placed at 2km intervals along the highway. These will connect as convenient to IEC distribution points that either cross the alignment or are near enough to make a connection along the length of the highway.

The remainder of the services can be considered as light current communications equipment. A backbone communications fiber optic line will run the length of the highway to carry data, CCTV and telephone communications. The systems power will only be required at the control operations center and at the West Bank end of the highway. Power for individual emergency telephones, highway signage and message boards if required will be taken from the lighting circuits.

Standby Power units at each end of the highway will support the communications systems.

The power requirements for a 4-lane highway are estimated with a 40km length in Table 3.5-3 below:

Table 3.5-3: Power Requirements for a 4 Lane Highway

Electrical System	Installed Power	Annual Consumption
Carriage Way Lighting	600kW	2,628,000kWh
Area Lighting	30kW	131,400kWh
Communications	50kW	17,520kWh

APPENDIX 4-1

CONSTRUCTION CONSIDERATIONS AND COSTS FOR ROAD AND RAILWAY TUNNELS

1.0 Construction Considerations for Long Transport Tunnels

Historically, longer lengths of railway tunnels have been constructed than for roads. This is primarily due to the fact that the geometric design criteria for railways is more stringent than for roads, thus more often requiring tunnels to satisfy those design constraints. Also, railway tunnels are of the smaller diameter than road tunnels and have less onerous ventilation and security (safety) requirements. Railway tunnels pose less safety risk because the operations are controlled by trained personnel and electronically monitored, while the safety of road tunnels depends on the performance of many drivers, which cannot be controlled.

Below is a summary table of existing railway and road tunnels over 10 km in length. They are concentrated in only a few countries, mainly in Europe and Japan. There are many more rail tunnels than road tunnels and, on average, rail tunnels are longer than road tunnels.

Road and Railway Tunnels Longer than 10 km Including Those Under Construction					
Road Tunnels			**Railway Tunnels**		
Country	**Number**	**Total Length (km)**	**Country**	**Number**	**Total Length (km)**
Austria	2	24.057	Austria	6	68.842
China	1	18.040	Canada	1	14.723
France	3	34.506	China	3	45.531
Italy	2	20.349	Finland	1	13.500
Japan	3	32.731	France-Italy	1	13.536
Norway	3	47.088	Germany	2	21.293
Switzerland	1	16.918	Great Britain	2	69.450
Taiwan	1	12.900	Italy	15	215.740
Total	16	206.589	Japan	22	370.619
			Norway	3	35.892
			Russia	2	27.500
			South Africa	1	13.400
			Spain	1	28.377
			Switzerland	6	155.764
			Taiwan	1	14.000
			USA	2	23.837
			Total	69	1,132.004

Below are brief descriptions of the longest road and railway tunnel projects, respectively the Laerdal and the Gotthard Base Tunnels. There are no long combined railway/road tunnels.

Long Road Tunnels: The longest road tunnel has a length of 24.5 km and was opened in Laerdal, Norway in 2000. The road tunnel connects Oslo to Bergen and was built to provide a year-round motorized route; the tunnel avoids hazards to a surface route caused by avalanches and rock falls during winter. Traffic traveling between these cities no longer needs to take a ferry. The anticipated traffic on the road is low at around 1,411 AADT[1] of which 23 percent is heavy vehicles. The low traffic volumes determined the need for a single-bore tunnel and less stringent safety features than would normally be implemented. There has recently been some criticism of the low-cost Norwegian tunnels because of the relatively low standards of construction. The cost of this tunnel was 1.08 billion Norwegian Crowns, equivalent to about US$125 million or roughly US$5,000 per linear metre[2]. At this rate, the cost of a road tunnel option for a ~40 km West Bank Gaza Transport Link would be about US$200 million. Assuming that 2 bores (tunnels) are required due to the larger traffic volumes, the cost would double to US$400 million. A second tunnel improves safety considerably by allowing connecting cross tunnels that provide emergency escape in the case of fire in one tunnel and the possibility of operating one tunnel only while maintaining or repairing the other. The traffic in each bore or tunnel would be unidirectional rather than bidirectional. Bidirectional flow increases the risk of oncoming traffic collisions in the single tunnel. Probably the most notorious of this type of accident occurred in the Mont Blanc Tunnel connecting France and Switzerland in 1999. The accident and resulting tunnel fire killed at least 39 people. Because the Mont Blanc Tunnel was a single bore tunnel it had to be closed for several years after the fire for repairs, disrupting cross Alps traffic.

A main concern of road tunnels is ventilation. This requires constructing special adits or shafts to handle air circulation and to control the flow of air during fires. The operating and maintenance (O&M) costs associated with a road tunnel are several times greater than those of a normal road because of seepage control, maintenance, ventilation O&M, lighting, surveillance, standby fire and rescue services, and traffic control and management.

Long Rail Tunnels: The longest rail tunnel, with a length of 57.3 km, is under construction in Switzerland. The Gotthard Base Tunnel is designed for high-speed trains and large volumes of traffic transiting the Swiss Alps from Northern Europe to Italy. This is a two-bore tunnel. The total cost of this section of railway is high, 8.011 billion Swiss Francs, equivalent to US$6.1 billion or US$107,000 per linear metre. The longest operating rail tunnel, the 54 km long Seikan Tunnel in Japan, was completed in 1986 at a cost of approximately US$7 billion.

Long and high-speed rail tunnels have special and costly requirements to ensure safe and efficient operations. High priority is given to passenger and crew safety under emergency conditions. In the case of the Gotthard Base Tunnel these features will include the following:

1. Two single-track tunnels which are linked to each other by connecting galleries at approximately 325 metre intervals;
2. Two multi-function stations at approximately the one-third points of the tunnel housing crossovers that allow trains to change from one tunnel to the other;
3. Emergency stop stations that provide a place for trains to stop in an emergency, from where passengers can escape and be evacuated; and
4. Technical installations for railway operations at these stations.

[1] Similar, relatively low costs are not anticipated for the West Bank Gaza Transport Link. The Laerdal tunnel is constructed in sound rock, minimizing many costs such as a lining associated with tunneling in less desirable materials.
[2] Communication with the Norwegian Road Department.

At the costs indicated above, the prorated cost of a rail tunnel option for a ~40 km West Bank Gaza Transport Link would be about US$4.3 billion.

The Gotthard Base Tunnel is being constructed at great depths, where the stress conditions need to be considered in the design. The tunnel lining is constructed after the tunnel is excavated and some stress relaxation has occurred. The tunnel is supported with an initial or "temporary" lining until the final lining is cast in place. An impervious membrane is placed between the temporary and final lining to keep the tunnel dry, and the permanent lining has to be designed for relatively high hydrostatic loads. These factors contribute to the high cost.

Comparison of Laerdal and Gotthard Base Tunnels: The large difference in costs between these two tunnel projects results from a number of factors such as the design standards, safety features utilized by each and the geological conditions encountered. The rail tunnel consists of two parallel bores, while the road tunnel has only one. The large difference in cost is due to: the design standards; the need for station installations described above for the rail tunnel; the requirements to waterproof the Gotthard Tunnel under a great pressure; and the less favorable geological conditions at the Gotthard Tunnel.

One common characteristic of most long tunnels is the length of time it takes to construct them. The Gotthard Base Tunnel construction began with the first exploratory tunnel in 1993; currently the project is 52 percent complete, with an expected completion date of 2015. Access for construction is available at each end and one intermediate point. The smaller Laerdal tunnel project took five years and eight months to complete, because access was only possible at each end of the tunnel. A West Bank to Gaza tunnel could have several intermediate access points because of the relatively shallow depth of the tunnel, to minimize the overall construction schedule.

2.0 Examples of Tunnel Construction Costs and Advance Rates from Outside Israel

The following are examples of recent TBM (Tunnel Boring Machine) projects and cost estimates that might be considered comparable to the proposed TBM tunnel.

- Channel Tunnel Rail Link, England, Contract 220: 7.5 km of twin bore, 7.15 m inner diameter (id) by Earth Pressure Balance (EPB) TBMs, plus cross passages, two access shafts and 45 m of cut-and-cover section. Average TBM excavation rate 450 m/month. Target price £145 million, approximately US$250 million or US$33,000 per metre. This was the longest of the tunnel contracts for this major project linking London to the Channel Tunnel and was the least hindered by ancillary work such as support of adjacent structures. Completed 2004. [Source: World Tunnelling, September 2003 Supplement]
- Heathrow Airside Road Tunnel, London, England: 1300 m of twin bore, 8.1 m id by EPB TBM, plus access. Average rate 235 and 325 m/month in the two tunnels, built very close to existing infrastructure and with two, relatively small-radius curves. Cost £130 million, approximately US$225 million (cost per metre not relevant due to short tunnel length and significant costs of access and other factors). Completed August 2003. [Source: World Tunnelling, August 2003]
- Oporto Metro, Portugal, Salgueiros – Trindale segment: 2.552 km of single bore, 8.7 m id tunnel in variably-weathered soil, by TBM. Average excavation rate 6.15 m/day (tunneling problems delayed progress by approximately 8 months). Cost €30 million,

approximately US$36 million or US$14,000 per metre; cost is believed to be tender cost, not including impact of the 8 month delay. Completed 2004. [Source: World Tunnelling, March 2004]

- Caracas Metro, Venezuela, twin tunnel: 5.16 m id, 3.666 km long tunnels by EPB TBM with precast concrete lining, completed in 2005. Cost US$84 million or US$23,000 per metre. [Source: Tunnels & Tunneling, June 2005]
- Valenzia Metro, Venezuela: 3.8 km of single-lane, 8.7 m id tunnel in overburden by EPB TBM with precast segmental lining, completed in 2005. Cost US$61 million or approximately US$16,100 per metre. [Source: Tunnels & Tunneling, June 2005]
- Rapid transit project in western Canada: 7.2 km of twin bore, 5.5 m id tunnel by EPB TBM in overburden and weak sandstone. Mid-2005 bid price US$21,000 per metre for tunnel excavation, including precast concrete lining, concrete invert, cross passages at 244 m centers, and one cross-over. [Source: internal project]
- Water supply tunnel in eastern Canada: 10 km of single bore in rock, 12.5 m id tunnel by TBM. Mid-2005 bid price approximately US$50,000 per metre. [Source: internal project]
- Olmos tunnel, Peru: 13.98 km of 5.3 m id water supply tunnel in rock, by TBM, support as required, US$185 million or US$13,200 per metre. [Source: Tunnels & Tunneling, August 2005]
- Wientalsammer tunnel, Vienna, Austria: 2.6 km of single tube 8.6 m id EPB TBM tunnel with precast concrete lining in overburden, average progress 370 m/month, completed in 2005. Cost US$44 million or US$16,900 per metre. [Source, Tunnels & Tunneling, June 2005]
- Wienerwald Tunnel, Germany: twin, 10.7 m dia, 10.73 km long rail tunnels in rock by TBM, US$414.7 million or US$38,600 per metre. [Source: Tunnels & Tunneling, October 2005]
- Cost estimate for San Francisco – Oakland Connector Study: 21 km of twin tube including an underwater section, 5.1 m id transit tunnel by EPB TBM in very weak soil, cross passages at 150 m centers. 2001 estimate for these components, prorating cross passage cost for 244 m centers, US$766 million or approximately US$36,200 per metre. [Source: http://www.flysfo.com/about/runway/docs/SF-Oakland-Appendixc.pdf]
- Cost estimate for King County, WA, USA: 21 km of 5.0 m id TBM tunnel in overburden and shaft access, US$427 million or US$20,000 per metre in 2005. [Source: Adams et al., 2005; Locke and Edgerton, 2005]

The above, published costs are "global" costs and include ancillary structures such as access shafts, special measures to control settlement in some cases, and other project-specific aspects. Most of the projects are in urban areas which result in constraints such as space availability, noise limitations (hours of work), and traffic. However, they provide a confirmation that estimated overall costs for the bored tunnel for this project are reasonable. The projects are mainly in overburden, using EPB machines which are more expensive, and for which excavation progress rates are typically lower, than TBM tunnels in rock. It appears that a "global cost" of $30,000 to $35,000 can be anticipated for tunnel construction in overburden in the order of 8.8 m inner diameter. This would include tunneling and support including the cross passages, and the concrete invert up to the level of the track and track support system.

2.1 Berger Group Data on Tunnel Costs for Metro Projects

The Louis Berger Group, Inc. maintains, for its clients, a database on metro project costs. From this database, examples of tunneling costs for recently completed metro projects are given below. These values exclude the cost of stations.

Location	No.	Type/Method	US$/linear metre
Bangkok	1	Cut-&-Cover	32,000
	2	TBM in clay	30,000
	3	Cut-&-Cover	19,000
	4	TBM in clay	27,000
Taipei	1	Combined	29,000
	2	Combined	38,000
Hong Kong	1	Cut-&-Cover	100,000
	2	Cut-&-Cover	84,000
Canada	1	Cut-&-Cover	35,000
	2	Other	25,000

From the information given, there is a wide variation in costs even within a city. Cut-and-cover construction can be more or less costly than bored or blasted construction, with higher costs particularly in densely populated cities.

2.2 Information on Existing and Proposed Tunnels in Israel

Data on tunnel construction in Israel is summarized below.

Longest Proposed Road Tunnel: The longest road tunnel in Israel is planned to go under the Har Carmel in Haifa. The purpose of the tunnel is to bypass the urbanized areas of Haifa. The justification for the tunnel is that through-traffic must take the circuitous and narrow roads around Har Carmel or use city streets, and the tunnel will shorten the distance and greatly reduce city traffic on certain congested roads. The construction of the tunnel will begin shortly. Construction of the access roads and interchanges has already begun. There will be two tunnels, each 5 km long and each containing two traffic lanes, with connecting cross passages at 250 m intervals. The material through which the tunnel will be driven is hard chalk and dolomite. The estimated construction cost of the entire project is US$150 million. The tunnel portion of the project will cost approximately US$100 million of which about 80% is civil works and the balance is for ventilation and other works. This is equivalent to about US$20,000 per linear metre. For a road tunnel equivalent in the length to the planned ~ 40km West Bank to Gaza Transport Link, the cost would come to about US$800 million assuming comparable geology. However, the western portion of the West Bank to Gaza tunnel would be in overburden, which would require more costly tunneling methods and ground support.

Longest Proposed Rail Tunnel: The New Jerusalem Line or Tel Aviv – Jerusalem A1 Rail Line is about 40 km long. The tunneled portion of this dual track line will be constructed as a double bore with connecting cross passages at 250 m intervals. Each bore has an area of roughly 50 square metres. For the TBM option, an 8.8 m inner diameter tunnel (61 square metres) would be excavated, and concrete would be placed to create a level invert for track placement. Of the 40 km section, approximately 11.5 km will be tunneled of which 4 to 5 km is in soft rock. Estimated total cost of the project is 3 billion NIS, equivalent to US$660 million. The tunnel is estimated to cost about US$220 million or roughly US$21,000 per linear metre. For a rail tunnel, the equivalent cost of the planned ~ 40km West Bank to Gaza Transport Link would be about US$840 million, assuming comparable geology. However, as noted above, the western portion of the West Bank to Gaza tunnel, in overburden, will be more expensive to construct.

Proposed Carmiel–Akko Line Rail Tunnel: The 23 km double track line is estimated to cost 1.2 billion NIS, equivalent to about US$260 million. The line will have a 5 km dual bore tunnel with connecting passages at 250 m intervals. Each bore will have an area of 50 square metres. Estimated cost of the tunnel is US$20,000 per linear metre.

Israel Railways Projects: The following is a list of recent Israel Railway tunnel projects:

- Tel Aviv – Ben Gurion Airport Rail Line, single railway tunnel with two tracks in clay and fill, under forepoling, below the Shafirim Interchange. Work completed. Cost US$6.0 million.
  Owner: Israel Railways Engineer: Yenon – Design and Research.

- Tel Aviv – Ben Gurion Airport Rail Line, two cut-and-cover tunnels, each for two tracks, below Road No. 1. Work completed. Cost US$3.2 million.
  Owner: Israel Railways Engineer: Yenon – Design and Research.

- Ben Gurion Airport - Modiin Rail Line, Single rock tunnel for two tracks at entrance to Modiin. Work completed. Cost US$4.5 million.
  Owner: Israel Railways Engineer: D.E.L. Engineering and Development.

- Tel Aviv – Jerusalem A1 Rail Line, Preliminary Design of four tunnels: three twin bores for single track and a single tunnel for two tracks. Estimated cost US$380 million.
  Owner: Israel Railways Engineer: Hasson-Yerushalmi Engineers.

- Cross Mount Carmel Rail Line, Feasibility study of long rock tunnel. Estimated cost US$150 million.
  Owner: Israel Railways Engineer: D.E.L. Engineering and Development.

- Beer Sheba – Eilat Rail line, Feasibility study of long rock tunnel.
  Owner: Israel Railways Engineer: D.E.L. Engineering and Development.

- Tel Aviv – Jerusalem A1 Rail Line, Detailed Design of the longest rail tunnel (Tunnel No. 3) in Israel (11.5 km). Contractors have been prequalified, bid to come. Estimated cost US$220 million.
  Owner: Israel Railways Engineer: Amy -Metom Engineers.

- Tel Aviv – Jerusalem A1 Rail Line, the access tunnels (Tunnel No. 4) to underground rail station in Jerusalem. Estimated cost US$15 million.
  Owner: Israel Railways Engineer: Amy -Metom Engineers.

- Tel Aviv – Jerusalem A1 Rail Line, large span (22 m) caverns for underground rail station in Jerusalem . Estimated cost US$25 million.
  Owner: Israel Railways Engineer: Amy -Metom Engineers.

Light Rail – Haifa:

- Preliminary design for two-lane LRT tunnel below Bar Yehuda Road in Down Town Haifa
  Owner:. Ministry of Transportation.

Some Road Tunnels in Rock (Completed work):

- Gilo tunnel, 300 m long, two-lane, on Route No. 60. Cost US$3.5 million or US$11,700 per metre.
  Owner: PWD - Public Works Department.

- Beit-Jallah tunnel, 900 m long, two-lane, on Route No. 60. Cost US$11 million or US$12,200 per metre.
  Owners: PWD - Public Works Department.

- Mount Scopus (Har Hazofim), two parallel, 600 m long, two-lane road tunnels. Cost US$15 million or US$25,000 per metre.

- Lifta Tunnels, two parallel, 360 m long, shallow, three-lane road tunnels at the entrance to Jerusalem. Cost US$8.5 million or US$23,600 per metre.

- Two parallel, three lane, 450 m long tunnels at Hadid Hill, US$14,500,000 or US$32,200 per metre.

- Two parallel, 450 m long, two-lane road tunnels along Road No. 9, Northern ring of Jerusalem. Cost US$10 million or US$22,200 per metre.

Other bored tunnels:

- Deep rock tunnel for the main sewage pipe for Jerusalem, 2,080 m long, Rephaim Valley- Sorek Valley. Cost US$10 million or US$4,800 per metre.
  Owner: Jerusalem Development Authority.

- Pilot tunnel for underground oil storage facility at Givat Shemen, Beer Sheva. Cost US$2.5 million.
  Owner: Petroleum Services.

References:

Adams, D.N., Johnson, J., Maday, L., Pecha, D.L., 2005. Design of the Brightwater Conveyance Tunnels. Proceedings, Rapid Excavation and Tunneling Conference, pp590-601. Seattle, June.

Locke, C. and Edgerton, W.W., 2005. King County's Delivery Approach for the Brightwater Project. Proceedings, Rapid Excavation and Tunneling Conference, pp582-589. Seattle, June.

APPENDIX 4-2

RAILWAY TUNNEL AIR HANDLING, FIRE AND SAFETY DESIGN CONSIDERATIONS

1.0 Introduction:

This report summarizes the conceptual design for the ventilation and smoke removal system for railway tunnel alternatives for a Gaza – West Bank Transport Link. The twin railway tunnels from Gaza to West Bank are conceptualized to pass north of Sderot to Lahish and through Judea Mountains to Tarkumiya at a gradient of about 0.5% to 1.65%.Tunnel configuration will be two tunnels in parallel, one tunnel per each direction with each single track. Total tunnel length will be about 38 km.

The line will be operated by electric-locomotive. The ventilation system should be designed for passenger trains as well as freight trains. Total power consumption of the locomotive will be about 5,000 and 6,400 kW.

The train design speed is 200 km/h with operating speeds in the initial years substantially lower (See Section 6.5 of Volume 1) in 2015. During peak hours, the operating timetable calls for one train every 30 minutes in each direction.

2.0 Main Features of the Tunnel Ventilation System

During normal operating conditions, the ventilation system will be able to ventilate the tunnels by utilizing the piston effect created by the train pushing the air through the tunnel. Air is then released naturally through the ventilation shafts and portals. As the trains pass through the tunnel, the ventilation fans won't need to work. It is the train's movement through the tunnel that creates a piston effect in front of the train. This movement increases pressure ahead of the train while the air pressure behind the train is lowered. This effect draws air from the up-flow shaft and blows air through the down-flow shaft creating an air movement in the tunnels to ventilate them.

In case of a train stopping in the tunnel, or during periods of maintenance, the fans will operate in order to exhaust the heat from the condensing units of the air conditioners and create a satisfactory environment for the maintenance crew.

In case of a fire in a train or in the tunnel that causes the train to stop in the tunnel, the fan system will work to direct the smoke away from the evacuation route in order to assist the passengers and crew to evacuate to a clean and safe atmosphere. In the unaffected tunnel, the fans will work to create an overpressure so that the clean air will flow through the cross-passages to the affected tunnel and prevent smoke from reaching the clean tunnel, while passengers escape to the clean tunnel.

For this purpose the fans must be selected to have truly reversible capability. The direction of the ventilation airflow will be in the train direction, since the piston effect is stronger than the stack effect or the wind. The passengers and crew will evacuate "upstream" against the airflow to the cross-passages.

Using these operating characteristics of the rail tunnel system, the following design criteria was developed in Table 4.1-1

Table 4.1-1: Design Criteria of the Tunnel Ventilation System

Description	Details	Dimension
Tunneling type	Single railway track	
Tunnel length		37.5 km
Tunnel diameter		8.8 m
Hydraulic diameter		7.2 m
Tunnel maximum height		6.85 m
Tunnel cross-sectional area		53.2 m²
Tunnel gradient		Up to 1.65%
Number of trains in tunnel	At the same time	2
Train type for design	Electric locomotive & train	
Train power rate	Electric locomotive power	5,000kW
Train length	Maximum	480 m
Train front area		15.6 m²
Train hydraulic diameter		3.89m
Fire release rate		60 MW
No. of passengers trains - each direction (1)	In peak - 10 hours In off-peak -14 hours	2 per hour 1 per hour
No. of freight trains - each direction	Daily	1 every 3 hours in opening year
Total daily transportation	Passengers + freight	
Physical data		
Air density		1.2 kg/m^3
Friction factor		0.05
Wind speed		26 km/h

3.0 Impact of the Tunnel Cross-section Dimensions on the Design

Among the other parameters, the dimensions of the cross-section of the tunnel impacts the following parameters:

a. The capacity of fans necessary to create the thrust required in the tunnel to avoid back layer smoke moving in the same direction as the people escaping in the evacuation routes.

b. The smoke storage volume between the train roof and the tunnel ceiling creates the capability to absorb the smoke for the first few moments after the fire commences and before the operation of the tunnel ventilation system begins. The design volume is a function of the fire smoke release rate.

c. The face area ratio between the train face area and the tunnel cross sectional area. Decreasing this ratio will reduce the impact of the train's overpressure on the passengers as the train enters and leaves the tunnel. At the same time, it will increase the smoke storage volume along the tunnel ceiling and improve time available of the the evacuation of passengers and crew from the tunnel in case of fire.

4.0 Preliminary Ventilation System Design

The tunnels ventilation system will be based on four ventilation shafts per each tunnel at a distance of up to 8,000 m between. Each shaft will be able to naturally ventilate the tunnel, as well as provide mechanical ventilation. Total airflow capacity will be about 200m³/sec per fan station. Two alternative fan systems have been considered for the shafts.

- Alternative 1 has a horizontal fan installation in a fan room with connection to the tunnel and the shaft and control flow dampers to control the air flow, either through the fan in case of fire or congestion or bypassing the fan directly to the atmosphere during normal operation condition. The shaft will be about 30 m² and the fan room will be about 20 m long and 6 m wide
.
- Alternative 2 is to install the fans within the shaft so during normal operation the air will flow in between the fans, while during an incident the fans will operate and create high velocity air or smoke flow in or out of the shaft. Each shaft will be installed with eight fans, 1.2m diameter. Total shaft cross section area will be about 40 m². Each shaft will be able to naturally ventilate the tunnel at normal operation conditions and be able to remove or pressurize the tunnel during incidents. Each portal area will be installed with eight jet fans, 100cm diameter in order to remove smoke out or pressurize the unaffected tunnel. The fans will be installed in both sides of the tunnel wall 4.5 m high and 30 cm from the wall at a distance of 50 meters from the portal and at three additional locations with a distance of 50 meters between fans.

The fans will be designed to be reversible. Each fan station will have a high-tension substation with power input of about 1,000kW. The mechanical rooms for the fans will be developed to include all the ventilation, electrical and communication requirements. In addition, it will serve as a rescue station with a capacity for 2,000 people and emergency exit to the ground level.

While Alternative 1 is slightly more expensive than Alternative 2, there are fewer fans to maintain resulting in lower maintenance costs. When not operating, Alternative 1 is normally isolated from the tunnel environment.

5.0 Smoke Removal Design Scenarios for Tunnels:

In case of a fire in the train or in the tunnel that causes the train to stop on the tunnel, the ventilation systems will work to direct the smoke back layer away from the evacuation route in order to assist the passengers and crews to evacuate to a clean and safe atmosphere. In the unaffected tunnel the fans will work to create an overpressure in the tunnel so the clean air will flow through the cross passage to the affected tunnel and prevent smoke from reaching the clean tunnel while passengers escape to the clean tunnel. Passengers will evacuate upstream (against the air flow) to the cross passages. To meet these criteria, the fans will be selected to have truly reversible capability.

The direction of the ventilation airflow will be the train direction, since the piston effect is stronger than the stack effect or the wind. Table 4.2-1 summarizes the main characteristics of the alternative ventilation systems.

Table 4.2-1: Characteristics and Cost of the Alterative Ventilation Systems

Description	Alternative 1	Alternative 2
Number of fans	8 fans: 280 cm diameter 32 jet fans: 100 cm diameter at portals	100 jet fans 100cm diameter
Power requirement	5,000 kW	5,000 kW
Maintenance	Easy	Easy
Exposure to the tunnel atmosphere	Not exposed to the tunnel atmosphere	Exposed to the tunnel atmosphere
Exposure to fire	Fans not exposed to fire	Fans exposed to fire and smoke
Mechanical room and/or shafts	Mechanical room required 200 m^2 in each location with 6.2 m diameter shaft, ~30 m high for the bored tunnel sections and for the cut and cover sections it will be variable. The outlet must be located 4 m above ground level. .	7.2 m diameter shaft, ~30m high with 8 jet fans installed in each for the bored tunnel sections and for the cut and cover sections it will be variable. The outlet must be located 4 m above ground level. .
Total construction cost, US dollars	Fans $3,500,000 Electrical substations $1,200,000 Control - $ 400,000 Rooms and shafts- $2,900,000 **TOTAL $ 8,000,000**	Fans in the shafts $2,000,000 Electrical substations $1,200,000 Control - $ 400,000 Shafts $2,500,000 **TOTAL $ 6,500,000**

APPENDIX 6-1

COST OF HV TRANSMISSION LINES FOR ELECTRICAL POWER BETWEEN THE WEST BANK AND GAZA STRIP

1.0 Transmission of HV Electric Power

The descriptions of the IEC power distribution network indicates there exists sufficient capacity to supply all foreseen future power requirements of both the West Bank and Gaza. Improvements to the efficiency of the supply to West Bank locations are already in progress in a number of areas. In particular, the IEC has professional working arrangements with the Palestinian Territories that to date have not penalized or restricted power supply through political or financial motives. However, it is also relevant that the future power requirements could wish to more fully utilize power generation capacity in Gaza and feed this as a more efficient line directly to the West Bank consumers. With losses reportedly in the region of 20% through the existing feeders, the use of a high voltage (HV) transmission line running along the West Bank Gaza Transport Link might be justified under the right set of conditions.

2.0 Underground Transmission Line

A 2 circuit 161kV underground transmission line consisting of 6 – 300mm^2 fully insulated cables laid in 2- concrete sand troughs with concrete closure each approximately 1m wide x 1m deep and 1 meter apart will cost US$2.5m/km (US$100m). It will provide effectively a 200MVA connector between the West Bank and Gaza that is sufficient to cover the immediate needs of either territory in the event of a total power failure at either end of the Israeli supply.

The transmission line would be laid in a separate trough along the WBG alignment as convenient to the terrain. No inspection or maintenance facility is required. For the tunnel option it would be preferable for the alignment to be separate from the tunnel and effectively close to the surface. However, it is also possible to include the transmission line in the cross section of the tunnel depending how the space is utilized. However, it would be costly to increase its size just to accommodate the transmission lines.

3.0 Overhead Transmission Line

The alternative overhead transmission line built to IEC standards will typically use 3 strand 250mm^2 aluminum/steel bare conductors on a 6-line circuit with concrete towers. The estimated cost is US$1m/km (US$40m). This would have a capacity of 500MVA that would be sufficient to supply the foreseen future needs of Gaza and the Southern West Bank Systems should the existing Israeli supply fail.

4.0 Connection to the IEC Grid

At the present time there are no 161kV power lines into Palestinian Territory. The 161kV WBG Connector would therefore have to connect to a substation using 36kV feeders. Alternatively and preferably the Connector shall be supplied from the 400kV UHV IEC transmission line that crosses the WBG alignment north of Gaza. There are also several 161kV transmission lines that also cross the alignment at various places and could be used to switch into the Connector. This would give the opportunity for a more efficient supply to either the West Bank or Gaza than the present arrangements. The cost of the switch station and connection to the 161kV grid is estimated at US$8m. For a connection and substation (including transformer) to the 400kV line the estimate is put at US$12m. It would occur roughly mid way along the corridor.

5.0 Connection to Supplies in Gaza and West Bank.

A Switch and Substation would be required at each end of the WBG Transport Link to transform the 161kV and connect it to the already existing 36kV feeders. An estimated cost of such substations is put at 2 x US$8 million or US$ 16 million for both.

6.0 Summary

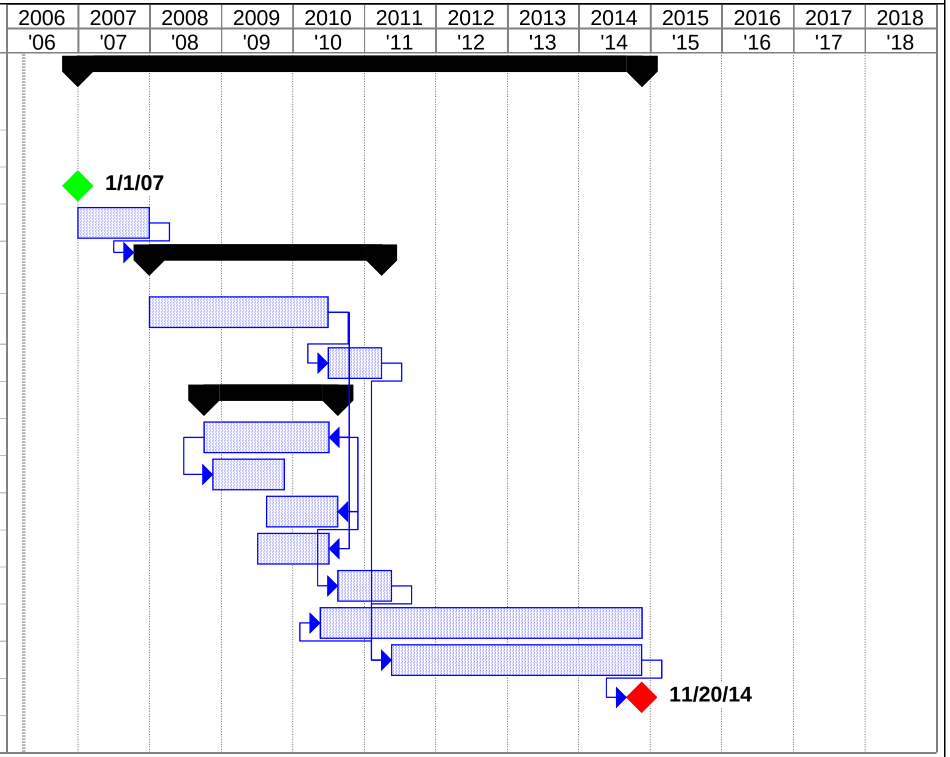
A comparison of the overhead, at grade and tunnel HV power transmission line cost is summarized in **Table 6.1-1** below.

Table 6.1-1: Cost Estimate for Building an Electric Power Transmission Line (Costs in million US$)

Transmission System 161kV	Power Capacity in MVA	Cost per km	Cost for 40km	Sub-station Cost	System Cost
Overhead Transmission	500	1	40	24	64
Underground within "at grade" road right-of-way	200	2.5	100	24	124
Underground within a Railway Tunnel	200	2.5	100	24	124

Appendix 7-1
Implementation Schedules

ID	Task Name	Duration	Start	Finish
1	**Road Only or Rail Only - Same Implementation Period (Alignments 1 and 2)**	**2059 days?**	**Mon 1/1/07**	**Fri 11/21/14**
2				
3	Start	0 days	Mon 1/1/07	Mon 1/1/07
4	Preliminary Design + Supporting Studies	365 edays	Mon 1/1/07	Tue 1/1/08
5	**Permitting Procedures including Land Acquision**	**849 days**	**Tue 1/1/08**	**Sat 4/2/11**
6	Ennvironmental, Cultural & Permitting Activities	913 edays	Tue 1/1/08	Fri 7/2/10
7	Land Acquisition	274 edays	Fri 7/2/10	Sat 4/2/11
8	**Final Design + Bid Documents**	**490 days?**	**Mon 10/6/08**	**Sat 8/21/10**
9	Final Design	639 edays	Mon 10/6/08	Wed 7/7/10
10	Geological Investigations	365 edays	Thu 11/20/08	Fri 11/20/09
11	Bid Documents	365 edays?	Fri 8/21/09	Sat 8/21/10
12	Pre-qualification	365 edays?	Tue 7/7/09	Wed 7/7/10
13	Tendering	274 edays	Sat 8/21/10	Sun 5/22/11
14	Project Management + Construction Supervision	1644 edays	Sat 5/22/10	Fri 11/21/14
15	Construction	1278 edays	Sun 5/22/11	Thu 11/20/14
16	Construction Completed Nov 2014	0 days	Thu 11/20/14	Thu 11/20/14
17				

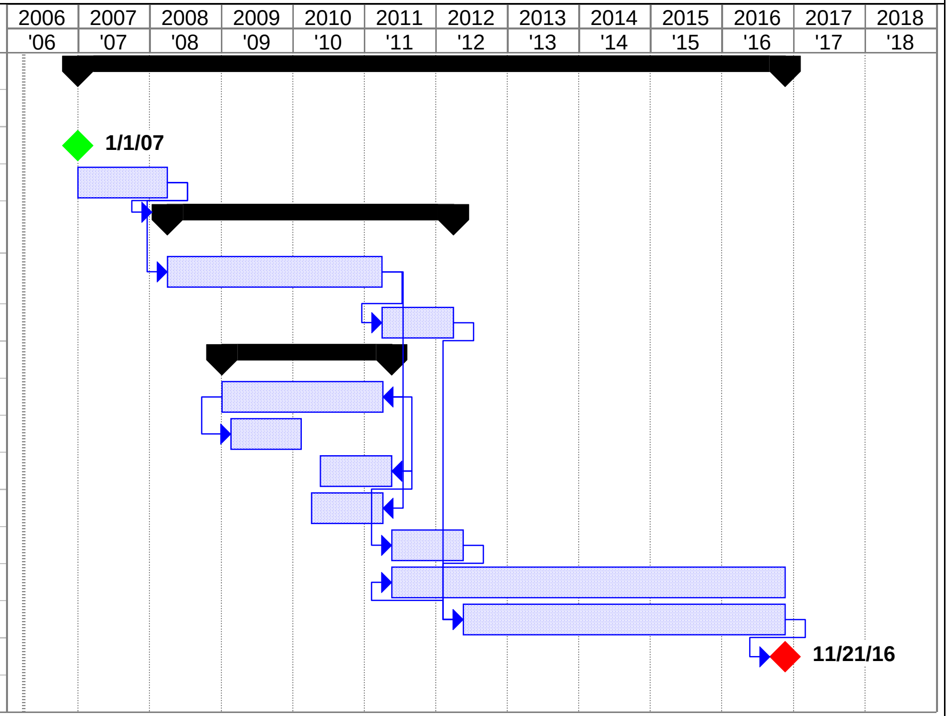


Project: Appendix 8.1 Implementation
Date: Fri 3/24/06

Task	Milestone	External Tasks
Split	Summary	External Milestone
Progress	Project Summary	Deadline

Appendix 7-1
Implementation Schedules

ID	Task Name	Duration	Start	Finish
18	**Combined Road/Rail (Alignments 1 and 2)**	**2580 days?**	**Mon 1/1/07**	**Mon 11/21/16**
19				
20	Start	0 days	Mon 1/1/07	Mon 1/1/07
21	Preliminary Design + Supporting Studies	457 edays	Mon 1/1/07	Wed 4/2/08
22	**Permitting Procedures including Land Acquisiton**	**1043 days**	**Wed 4/2/08**	**Mon 4/2/12**
23	Ennvironmental, Cultural & Permitting Activities	1096 edays	Wed 4/2/08	Sun 4/3/11
24	Land Acquisition	365 edays	Sun 4/3/11	Mon 4/2/12
25	**Final Design + Bid Documents**	**619 days?**	**Tue 1/6/09**	**Mon 5/23/11**
26	Final Design	822 edays	Tue 1/6/09	Fri 4/8/11
27	Geological Investigations	360 edays	Fri 2/20/09	Mon 2/15/10
28	Bid Documents	365 edays?	Sun 5/23/10	Mon 5/23/11
29	Pre-qualification	365 edays?	Thu 4/8/10	Fri 4/8/11
30	Tendering	365 edays?	Mon 5/23/11	Tue 5/22/12
31	Project Management + Construction Supervision	2009 edays?	Mon 5/23/11	Mon 11/21/16
32	Construction	1644 edays?	Tue 5/22/12	Mon 11/21/16
33	Construction Completed Nov 2016	0 days	Mon 11/21/16	Mon 11/21/16
34				

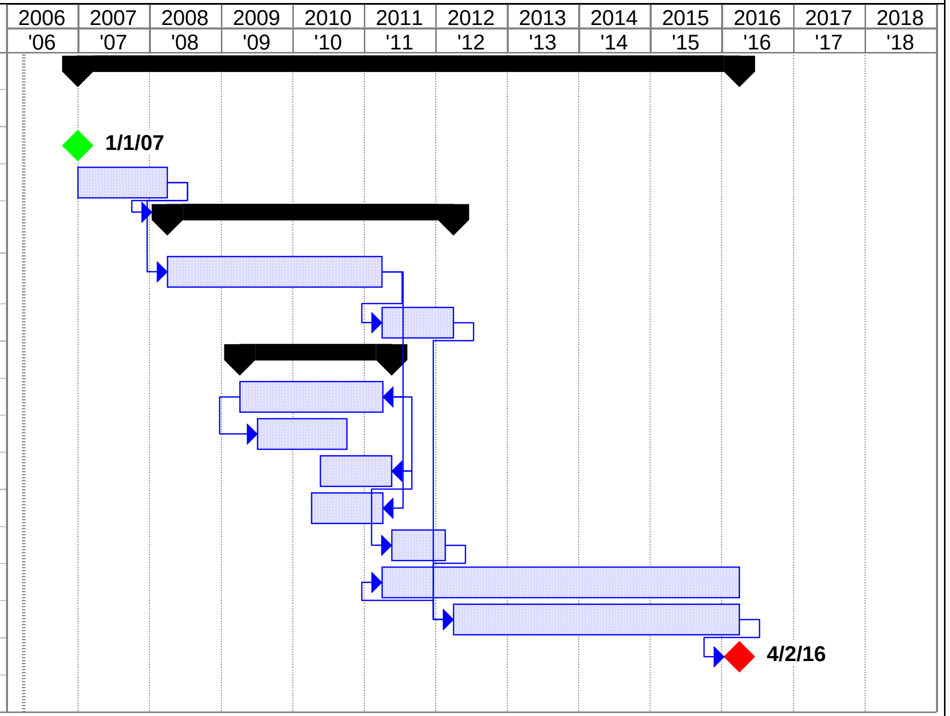


Project: Appendix 8.1 Implementation
Date: Fri 3/24/06

Task	Milestone	External Tasks
Split	Summary	External Milestone
Progress	Project Summary	Deadline

Appendix 7-1
Implementation Schedules

ID	Task Name	Duration	Start	Finish
35	**Sunken or Depressed Road (Alignment 2)**	**2415 days?**	**Mon 1/1/07**	**Sat 4/2/16**
36				
37	Start	0 days	Mon 1/1/07	Mon 1/1/07
38	Preliminary Design + Supporting Studies	457 edays	Mon 1/1/07	Wed 4/2/08
39	**Permitting Procedures including Land Acquisition**	**1043 days**	**Wed 4/2/08**	**Mon 4/2/12**
40	Ennvironmental, Cultural & Permitting Activities	1096 edays	Wed 4/2/08	Sun 4/3/11
41	Land Acquisition	365 edays	Sun 4/3/11	Mon 4/2/12
42	**Final Design + Bid Documents**	**554 days?**	**Tue 4/7/09**	**Mon 5/23/11**
43	Final Design	731 edays	Tue 4/7/09	Fri 4/8/11
44	Geological Investigations	457 edays	Mon 7/6/09	Wed 10/6/10
45	Bid Documents	365 edays?	Sun 5/23/10	Mon 5/23/11
46	Pre-qualification	365 edays?	Thu 4/8/10	Fri 4/8/11
47	Tendering	274 edays?	Mon 5/23/11	Tue 2/21/12
48	Project Management + Construction Supervision	1826 edays?	Sun 4/3/11	Sat 4/2/16
49	Construction	1461 edays?	Mon 4/2/12	Sat 4/2/16
50	Construction Completed Apr 2016	0 days	Sat 4/2/16	Sat 4/2/16
51				

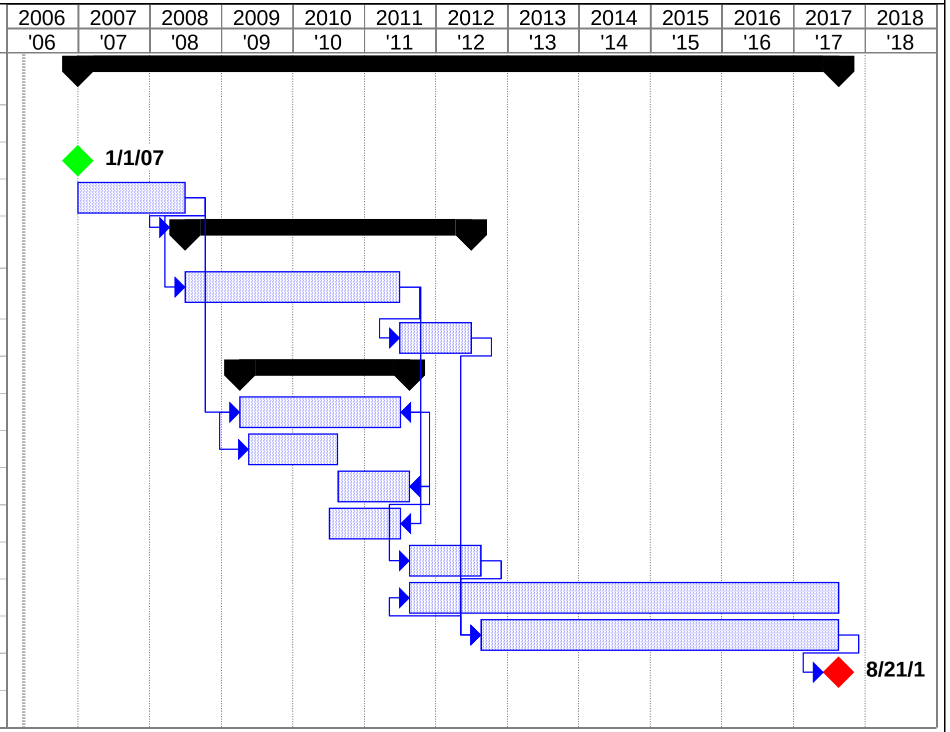


Project: Appendix 8.1 Implementation
Date: Fri 3/24/06

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

Appendix 7-1
Implementation Schedules

ID	Task Name	Duration	Start	Finish
52	**Rail Tunnel Cut & Cover with Bored Section (Alignment 7)**	**2776 days**	**Mon 1/1/07**	**Tue 8/22/17**
53				
54	Start January 1, 2007	0 days	Mon 1/1/07	Mon 1/1/07
55	Preliminary Design + Supporting Studies	548 edays	Mon 1/1/07	Wed 7/2/08
56	**Permitting Procedures including Land Acquisition**	**1043 days**	**Wed 7/2/08**	**Mon 7/2/12**
57	Ennvironmental, Cultural & Permitting Activities	1096 edays	Wed 7/2/08	Sun 7/3/11
58	Land Acquisition	365 edays	Sun 7/3/11	Mon 7/2/12
59	**Final Design + Bid Documents**	**619 days**	**Tue 4/7/09**	**Mon 8/22/11**
60	Final Design	822 edays	Tue 4/7/09	Fri 7/8/11
61	Geological Investigations	454 edays	Fri 5/22/09	Thu 8/19/10
62	Bid Documents	365 edays	Sun 8/22/10	Mon 8/22/11
63	Pre-qualification	365 edays	Thu 7/8/10	Fri 7/8/11
64	Tendering	365 edays	Mon 8/22/11	Tue 8/21/12
65	Project Management + Construction Supervision	2192 edays	Mon 8/22/11	Tue 8/22/17
66	Construction	1826 edays	Tue 8/21/12	Mon 8/21/17
67	Construction Completed Aug 2017	0 days	Mon 8/21/17	Mon 8/21/17
68				

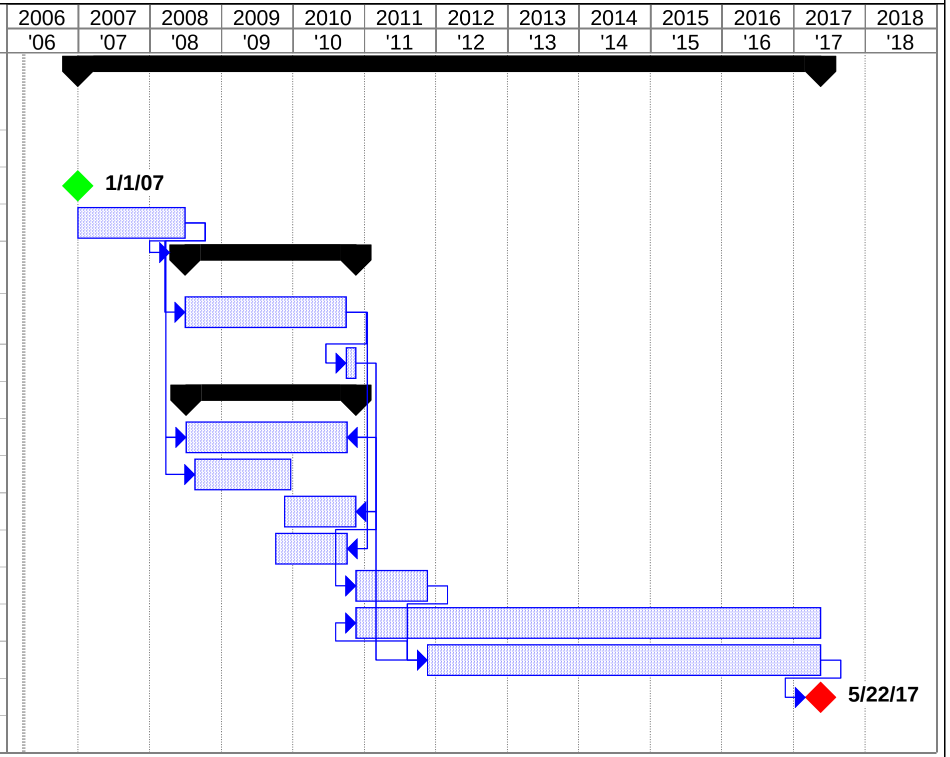


Project: Appendix 8.1 Implementation
Date: Fri 3/24/06

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

Appendix 7-1
Implementation Schedules

ID	Task Name	Duration	Start	Finish
69	**Rail Tunnel Bored Full Length including Interim Use of IR Infrastructure with Bored Tunnel (Alignments 8 and 9)**	**2710 days**	**Mon 1/1/07**	**Mon 5/22/17**
70				
71	Start January 1, 2007	0 days	Mon 1/1/07	Mon 1/1/07
72	Preliminary Design + Supporting Studies	548 edays	Mon 1/1/07	Wed 7/2/08
73	**Permitting Procedures including Land Acquisition**	**623 days**	**Wed 7/2/08**	**Sun 11/21/10**
74	Envvironmental, Cultural & Permitting Activities	822 edays	Wed 7/2/08	Sat 10/2/10
75	Land Acquisition	50 edays	Sat 10/2/10	Sun 11/21/10
76	**Final Design + Bid Documents**	**620 days**	**Mon 7/7/08**	**Sun 11/21/10**
77	Final Design	822 edays	Mon 7/7/08	Thu 10/7/10
78	Geological Investigations	490 edays	Thu 8/21/08	Thu 12/24/09
79	Bid Documents	365 edays	Sat 11/21/09	Sun 11/21/10
80	Pre-qualification	365 edays	Wed 10/7/09	Thu 10/7/10
81	Tendering	365 edays	Sun 11/21/10	Mon 11/21/11
82	Project Management + Construction Supervision	2374 edays	Sun 11/21/10	Mon 5/22/17
83	Constrution Finished	2009 edays	Mon 11/21/11	Mon 5/22/17
84	Construction Completed May 2017	0 days	Mon 5/22/17	Mon 5/22/17
85				

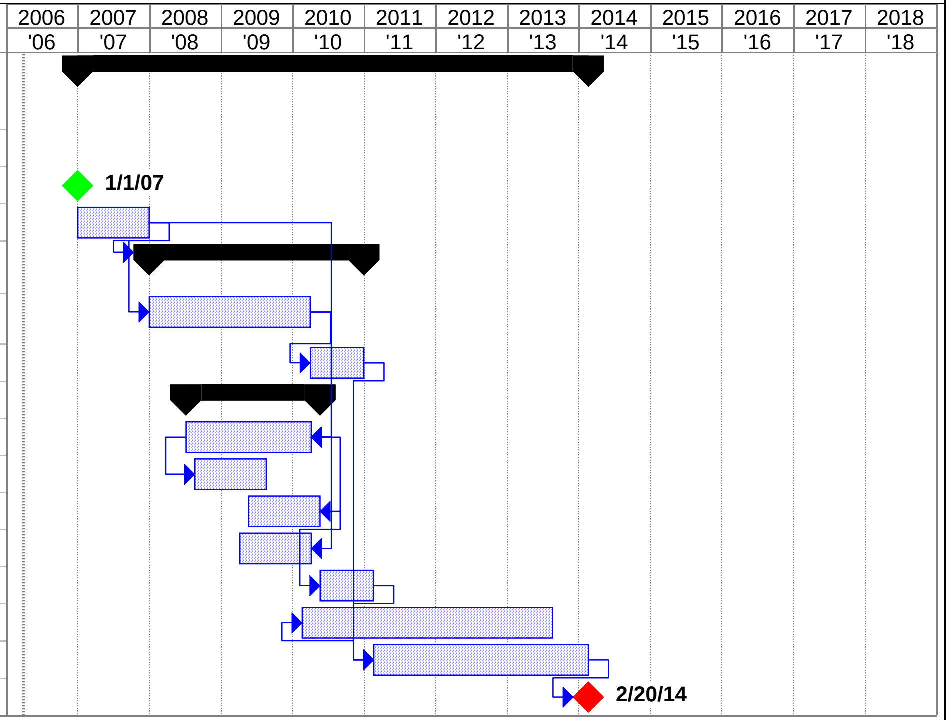


Project: Appendix 8.1 Implementation
Date: Fri 3/24/06

Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	

Appendix 7-1
Implementation Schedules

ID	Task Name	Duration	Start	Finish
86	**Interim Use of IR Infrastructure with At Ground Railway - Eastern Section (Alignment 10)**	**1863 days**	**Mon 1/1/07**	**Thu 2/20/14**
87				
88	Start January 1, 2007	0 days	Mon 1/1/07	Mon 1/1/07
89	Preliminary Design + Supporting Studies	365 edays	Mon 1/1/07	Tue 1/1/08
90	**Permitting Procedures including Land Acquisition**	**784 days**	**Tue 1/1/08**	**Sat 1/1/11**
91	Envvironmental, Cultural & Permitting Activities	822 edays	Tue 1/1/08	Fri 4/2/10
92	Land Acquisition	274 edays	Fri 4/2/10	Sat 1/1/11
93	**Final Design + Bid Documents**	**490 days**	**Mon 7/7/08**	**Sat 5/22/10**
94	Final Design	639 edays	Mon 7/7/08	Wed 4/7/10
95	Geological Investigations	365 edays	Thu 8/21/08	Fri 8/21/09
96	Bid Documents	365 edays	Fri 5/22/09	Sat 5/22/10
97	Pre-qualification	365 edays	Tue 4/7/09	Wed 4/7/10
98	Tendering	274 edays	Sat 5/22/10	Sun 2/20/11
99	Project Management + Construction Superv	1278 edays	Sat 2/20/10	Wed 8/21/13
100	Constrution Finished	1096 edays	Sun 2/20/11	Thu 2/20/14
101	Construction Completed Feb 2014	0 days	Thu 2/20/14	Thu 2/20/14



Project: Appendix 8.1 Implementation
Date: Fri 3/24/06

Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	

APPENDIX 7-2

UNIT PRICES AND CONTINGENCIES

1. Derivation of the Unit Prices

The derivation of the unit prices for the West Bank Gaza Transport Link is based on an assessment of unit price data obtained from a number of sources. They include the following:

1) Bid prices of recently awarded contracts. The project is located in the vicinity of:

   a) Road No. 6 (Sections 19 and 20), which is currently under construction.
   b) Beer Sheva-Dimona Railway Project, which was recently completed and located to the southeast of the project area.

2) Information was gathered from the Israel Railways (ISR), with respect to unit prices of rails, sleepers, rail fastenings, ballast, turnouts, various types of rolling stock and etc.

3) The Consultant's experience preparing cost estimates for a various railway and road projects throughout Israel covering works such as:

   - earthworks (cut and fill) in various materials,
   - bridges and other structures,
   - utility relocation for transport, communication, water supply, and power infrastructure;
   - various smaller drainage works,
   - tunneling,
   - retaining walls,
   - acoustic barriers,
   - safety guardrails,
   - fences,
   - etc.

4) Cost and price data obtained from various organizations in Israel such as: Bezeq (the national telecommunication company), Mekorot (the national water supply company), gas companies, IEC (Israel Electric Corporation), etc.

5) Information obtained from cost estimates of major projects currently in the tendered stage:

   a) Acco-Carmiel railroad (including a 5 km twin tunnel, one tunnel for each track) – designed by TEDEM LTD.
   b) Tel Aviv-Jerusalem railroad (including 21 km of twin tunnels, the longest of which is 11.5 km).
   c) Carmel Road Tunnel (a twin road tunnel, each tunnel comprising two lanes).

6) Land acquisition costs as described elsewhere:

a) In Israel, according to estimates prepared by the land assessor.
b) In the Palestinian Authority, according to estimates by local authorities.

7) Recent international prices for equipment purchased outside of Israel and for specialized construction works including:

- rolling stock,
- ventilation and communication equipment,
- tunnel boring machines,
- cost of tunneling for cut and cover and boring using various types of TBMs ,
- miscellaneous maintenance and operating equipment.

2. Contingencies for the Cost Estimate

The cost estimates are based on an assessment of each type or category of work considered in the conceptual designs. From these considerations, the unit prices are developed and the quantities estimated from the conceptual designs. By multiplying the unit price of a particular category of work by the unit price and the quantity estimates, the cost of that category of work is determined. By summing these estimated costs, the total cost of the project is determined. However, this estimate does not consider contingent costs.

Conceptual designs by their very nature are simplifications of sometimes quite difficult engineering and construction works. Only broad categories of works are considered, which normally consist of several sub-categories of works. For cost estimates based on detailed designs, there might be over 50 categories of works in an engineer's estimate; there are only a few considered in these conceptual estimates. The consequence of oversimplification of what is a complex undertaking is too understate the actual costs of a project and sometimes by a wide margin. First, the description of the category of work is likely to be a simplification of the actual works that will have to be accomplished. The unit prices derived from more refined estimates might not include all the sub-category of works covered in the conceptual design and consequently understate its cost. The quantity estimates are often themselves underestimated due to the simplified design utilized at the conceptual stage of project analysis. To correct for these deficiencies, price and quantity contingencies are added to the base costs derived from the multiplication of unit prices with the estimated quantities[1].

For this study, contingencies are estimated separately for each category of work by making separate estimates of the level of uncertainty associated with the unit prices and the quantities. The derivation of unit prices contingencies as a percentage of the unit prices is dependent on the quality of the basic data from which the unit prices are derived: 1) recent engineer's cost estimates for project ready for tendering, 2) older data that might be out of date even after adjustment for price escalation or 3) recent tender prices. Technical factors are not always similar between projects and this impacts both unit prices and quantity estimates. For example, geotechnical conditions vary considerably between projects and even within a project, and they have a large

[1] What is often done is to estimate the contingencies to the basic cost estimate, that is, after summing the estimated costs of all the work categories. While this approach is probably acceptable for single type of project, the large variation in the types of projects being considered in this study suggested that an alternate approach be taken.

effect on the cost of earthworks in terms of the types of work performed and the determination of unit price used. The level of uncertainty associated with them and therefore the contingencies depend on how similar the projects are and how close in time have the unit prices been estimated.

Quantity estimates are contingent on the complexity of the work with more complex or difficult the project having a higher value for the contingency and on the basic accuracy of the estimate itself. Certain items are known with a relative high degree of certainty; other are estimated with a high degree of uncertainty. For instance the length of the track works is know relatively well compared to the quantity of earthworks.

As a consequence and for each category of work in the cost estimate, contingencies are estimated separately for the unit prices and for the quantity estimate and then totaled as shown in the table below.

Work Category	**Unit Price in %**	**Quantity in %**	**Total in %**
Earth excavation	5.0	20.0	25.0
Rock excavation	5.0	20.0	25.0
Fill	5.0	20.0	25.0
Disposal of excavation surpluses	5.0	20.0	25.0
Earth excavation	5.0	20.0	25.0
Pavement structure	5.0	10.0	15.0
Double railway track (rails, sleepers, ballast)	20.0	15.0	35.0
Type "A" Subbase (Under railway tracks)	20.0	15.0	35.0
Drainage provisions	5.0	15.0	20.0
Culverts of various diameter	5.0	15.0	20.0
Bridges	7.5	17.5	25.0
Retaining walls	10.0	40.0	50.0
Acoustic walls	10.0	20.0	30.0
Relocation of communication lines	10.0	20.0	30.0
Relocation of the national water carrier	10.0	20.0	30.0
Relocation of fuel pipelines	10.0	20.0	30.0
Relocation of gas lines	10.0	20.0	30.0
Relocation of water lines	10.0	20.0	30.0
Relocation of power lines	10.0	20.0	30.0
Relocation of existing and agricultural roads (not include bridges)	10.0	20.0	30.0
Railway communication & signaling lines	7.5	15.0	22.5
Landscaping	5.0	10.0	15.0
Road strip lighting, safety barriers, fencing, marking & signage	10.0	20.0	30.0
Land Acquisition	10.0	20.0	30.0
TBM tunnel in rock	15.0	20.0	35.0
TBM tunnel in soil	10.0	40.0	50.0
Cut & Cover tunnel	15.0	20.0	35.0
Electrification of double tracks	7.5	15.0	22.5
Electric substations	10.0	20.0	30.0

3. Other Assumptions Regarding the Cost Estimates

3.1 Security Infrastructure

The cost estimates do not include the costs associated with the provision of security infrastructure required by the Government of Israel. These costs are likely to be the highest for “at grade” (ground) solutions and lowest for the tunnel alternatives.

3.2 Future Works

The cross section for the “at grade’ (ground) road alternatives includes two lanes in each direction and the future expansion of the roadway to accommodate three lanes in both directions. For the railway alternatives, the terminal at Gaza includes consideration of future expansion and access to the south whether it will be to the Gaza Port or to the border with Egypt.

3.3 Electrification of the Railway Alternatives

Electrification of the railway is considered only for the tunneled alternatives. The “at grade” alternatives are based on diesel operations and do not require any electrification.

3.4 Utility Relocation

As part of the utility relocation estimates for the “at grade” (ground) and sunken alternatives, agricultural road crossings are estimated once every 5 kilometers along the route.

Major utility relocations are estimated based on utility infrastructure (transport, communications, water supply, and power) located along each alignment.

3.5 Items Not Included in the Cost Estimates

Several items were not included in the cost estimate:

- Construction of the utilities within the utility corridor for the “at grade solution”. No utility corridor is considered in the tunneled alternatives;
- Temporary use of land for various construction activities;
- Relocation of private and agricultural pipelines;
- Relocation of liquid waste and sewage pipelines;
- Relocation of agricultural roads along the alignment in excess of what has been estimated. See 3.4 above.
- Archaeological excavation that will be required during construction;
- Mitigating measures and that will be required by various permitting agencies that have not been anticipated in the conceptual designs.

VI. Summary table of cost estimates

Alignment	Mode	Cross Section Type	Cost Estimate between Start & Finish Points								
			US $ without contingencies			Contingencies%			US$ with contingencies		
			Construction Cost	Land Acquisition	Subtotal	-Constuc tion Cost	Land . Acquis	Subtotal	Construction Cost	Land Acquisition	Total
1	Road	At Grade	160,933,000	21,000,000	181,933,000	23.73	30.00	24.45	199,120,000	27,300,000	226,420,000
	Railway	At Grade	193,975,000	36,500,000	230,475,000	20.01	30.00	21.59	232,796,000	47,450,000	280,246,000
	Combined	At Grade	309,986,000	49,500,000	359,486,000	22.09	30.00	23.18	378,472,000	64,350,000	442,822,000
2	Road	At Grade	152,841,000	13,455,000	166,296,000	23.37	30.00	23.91	188,565,000	17,492,000	206,057,000
	Railway	At Grade	190,443,000	32,830,000	223,273,000	23.81	30.00	24.72	235,785,000	42,679,000	278,464,000
	Combined	At Grade	308,778,000	41,545,000	350,323,000	21.86	30.00	22.82	376,266,000	54,009,000	430,275,000
2S	Road	Partial Sunken	157,100,000	15,710,000	172,810,000	23.29	30.00	23.90	193,694,000	20,423,000	214,117,000
7	Railway	Tunnel	884,335,000	26,000,000	910,335,000	31.34	30.00	31.30	1,161,498,000	33,800,000	1,195,298,000
8	Railway	Tunnel	1,200,074,000	26,000,000	1,226,074,000	38.07	30.00	37.90	1,656,915,000	33,800,000	1,690,715,000
9	Railway	At Grade/Tunnel	589,122,000	27,200,000	616,322,000	29.95	30.00	29.95	765,565,000	35,360,000	800,925,000
10	Railway	At Grade	134,815,000	32,650,000	167,465,000	17.67	30.00	20.07	158,638,000	42,445,000	201,083,000

Notes:

1. The cost estimation refers to:
   - 1.1. Earthworks for future stage, of three road lanes, in each direction.
   - 1.2. Construction of two road lanes, in each direction.
   - 1.3. Lighting only for first 1 km in Gaza Strip, first 1 km in West Bank, at bridges and at tunnels.
   - 1.4. Electrification only for the tunnels railway alternatives.
   - 1.5. Agricultural crossings every 5 km along the road/railway route.

2. Items not included in the cost estimation:
   - 2.1. Construction of utilities corridor along the road/railway route.
   - 2.2. Construction and land equisition for access zones.
   - 2.3. Crossing/relocation of private water lines.
   - 2.4. Crossing/relocation of sewage lines.
   - 2.5. Archaeological excavation.
   - 2.6. Agricultural roads along the road/railway route.

3. The cost estimation of the items in chapter No. 4, 'Infrastructure works', might be changed, after getting the relevant authoroties reference.

4. Additional land acquisition cost for the utilities corridor is 2,800,000 US$.

5. Exchange rate to US$ 4.71 NIS/$ (14/02/2006).

APPENDIX 7-4

RAILWAYS OPERATING PLAN

This section of the report details the operating plan for the proposed West Bank-Gaza railway connection. There are two potential at grade and two tunnel alignments for the railway under consideration. From an operating viewpoint, there are no significant differences among the four alternatives. The operating plan presented here applies to all three. There is also the possibility of reducing initial capital investment by utilizing existing and planned Israel Railways (IR) lines to replace a part of the proposed new construction. However, this alternative was not reviewed. If the line is placed underground, it will be necessary to electrify it. This affects the type of equipment to be used, staffing and operating costs, principally energy, but does not require alterations in the operating plan. Impacts of placing the track in tunnel are discussed later in this chapter.

The railway extends from a point near the northwest corner of the Gaza Strip to a point in the West Bank. The railway will have only two stations, the terminals, and will provide non-stop service between them for both passengers and freight. Passengers will not be permitted to leave or board the train except at the two stations. Likewise, freight must move through Israel in a single non-stop train.

Based on Traffic in 2015 and 2030: The operating plan is based upon passenger and freight volumes projected for 2015 and 2030 under the Rail Only and Road/Rail Options[1]. Traffic projections assume that the railway will have been in operation for a sufficient time to penetrate the market and secure the anticipated volume. During the initial stages of operation, volumes are often very low until customers become aware that the railway exists and familiar with its services. When the railway first begins operation, volumes should be well below what is projected. This will be reflected in a reduced level of train operations, possibly no more than two passenger and two freight round-trips per day. This will be reflected in reduced staff and in equipment requirements.

Railway Organization: The railway is conceived as an independent, stand-alone operation. There are no connections to other railways. Its ownership, management, or operational rights are outside the scope of this study. When the railway initiates operations, it will be faced with a lack of experienced railway personnel. In order to minimize this problem, it is possible that the new railway might contract with Israel Railways (IR) or another rail organization to train personnel in rail operations. They will gradually replace the Israelis. In order to reduce the initial capital investment, it has been assumed that heavy repair work on rolling stock will be performed by outside contract, presumably with IR.

Operational Constraints: For security reasons, it is planned that access to the right of way will be highly restricted. Problems that this will make for the Infrastructure Maintenance Department are discussed in that section. A further consideration is the need for emergency access in case of an accident. Normal practice on most railways is to dispatch emergency vehicles to the nearest highway crossing and then use the railway to reach the scene. Since there will be no crossings, it will be necessary to provide an access route either along the track or using the highway in the case of the Road/Rail Option.

[1] From the operational perspective, the Rail Only includes at grade and tunnel cross sections. Both have the same operational plan.

The Tunnel Option: If the tunnel option is selected, the line must be electrified. This requires that electric locomotives replace the diesel locomotives. As the same service frequency is maintained there is no change in the number of locomotives required. Reflecting Eurotunnel's experience, it is not anticipated that the flatcars will require enclosures.

There are some cost impacts from the electrification, principally in fuel cost and infrastructure maintenance. The electricity cost per train kilometer is estimated to be less than diesel fuel. There will be a need to add four infrastructure maintenance persons and to acquire a catenary maintenance vehicle. There should also be some changes in locomotive maintenance costs although these should be minor. The cost impacts of these changes are discussed in Chapter 7.

1.0 The Traffic

The traffic projections used in developing the operating plan are discussed in Chapter 2. These figures provide the basis for estimating how many trains are required per day and the number of cars, which should be included in each. In order to provide a basis for projecting traffic levels, the Medium forecast has been used for the Rail Only and Road Rail Options.

When a new railway initiates operations, it typically starts with a very small volume of traffic. It takes time for customers to learn of the new service, become familiar with it, and start to use it. The same circumstance is expected here. Initial operations are expected to be at a very low level, perhaps no more than two to four round-trips per day each for passenger and freight services. Much of the traffic to be handled does not currently exist and will not develop until the Palestinian economy grows and road connections to Tarkumiya improved. This is discussed in the section dealing with initial operations.

The actual traffic which will be attracted to the railway is expected to be extremely price sensitive with the rates charged for use of the railway and the possibility of tolls on the highway. Assuming that only the railway is built, potential traffic will have no alternate method of moving between the West Bank and Gaza. This would seem to give the railway an almost unlimited ability to set rates at any level. Even in this circumstance, the setting of excessively high rates will act to preclude the economic development of the traffic on which the railway will depend for economically feasible operation. Thus the price level established for passage is extremely important.

The cargo operation, as described below, is assumed to transport cargo only in trucks as a shuttle or ferry service. Although not discussed below, this service can also transport buses and automobiles in a manner similar to that of the Channel Tunnel. The traffic forecasts indicate that there will be a substantial movement of buses and light passenger vehicles through the Corridor under all of the road options. This may offer another opportunity for increasing rail traffic although this service will also be severely price constrained.

1.1 Passenger Traffic

The passenger forecasts for 2015, under the Rail Only Option, indicate that traffic will average 50,327 passengers per day under the low growth forecast, increasing to 61,986 per day under the medium forecast and to 76,312 under the high growth forecast. Under the Road Rail Option, the average number of passengers per day range from 22,018 under the low growth forecast to 27,119 under the medium and 33,386 under the high growth forecasts. Construction of the highway has the impact of reducing rail passenger traffic by 56 percent. Under each option, it is estimated that passenger flows are equal in both directions. For purposes of developing the operating plan, the medium growth forecast for the Rail Only and Road Rail Options have been used.

The market study estimates that about 35 percent of the projected volume will be commuters. Commuter traffic moves in both directions reflecting the assumption that as many West Bank residents work in Gaza as Gaza residents work in the West Bank. This level of commuters indicates that service must be oriented to the working hours of the residents which are assumed to be between 8 AM and 5 PM.

The projected volume of commuters is 10,848 or 5,424 in each direction during the two hour peak periods. Assuming that double deck coaches are used similar to those used by IR, with about 250 passenger capacity, including standees, 22 coach trips are required in each direction per hour during the peak travel periods. This requires two trips in each direction during the two morning and evening peak hours, each with 10 cars. Although this is slightly below the projected demand, the extra persons can be accommodated with some extra crowding. There will be a total of eight round-trips per day, Monday through Friday, with 10 car trains.

Assuming that the trains will operate sixteen hours per day, seven days per week, the average off-peak volume is approximately 1,679 per hour, Four coach trips are required in each direction per hour. This can be met by the operation of one four-car train per hour during off peak hours, including all day on weekends.

Running time for trains is estimated at about 45 minutes since there are no intermediate stops. This leaves about 15 minutes for loading and unloading passengers. While not long, it is adequate and permits trains to leave the terminals on the hour.

The railway terminals will not be convenient to any of the employment or residential areas. Virtually all passengers must reach and leave the terminals by car or bus. Many passengers will be making bus-rail-bus journeys. The train schedules must recognize the time required for bus movement to insure that prospective passengers arrive at the workplace on time. While not considered in this analysis, the transport of buses on the trains is feasible and may offer another source of revenue for the rail operator.

If the Road Rail Option is built, it may be difficult for the railway to compete with through bus services and the forecasts reflect this. Most prospective passengers are expected to have through buses available from near their homes to places of work or other destinations. With through bus service available, there is concern about the extent to which passengers will shift to a bus-rail-bus system. While railway services have competed successfully in other countries, they have required extensive promotion in order to attract sufficient ridership to make the operation economically feasible. Promoting rail services over competing bus services, in a market without the commercial background of developed countries may prove difficult. Only where there is a significant difference in cost or transit time will prospective passengers readily shift to the rail option. This may be difficult to achieve, given the relatively short distance involved.

Table 7.4-1: Projected Railway Volume

	Rail Only		Road Rail	
	2015	**2030**	**2015**	**2030**
Passengers	61,986	142,823	27,119	62,485
Freight (Tons)	5,851	14,399	2,127	5,253

Source: Chapter 2

1.2 Freight Traffic

The market studies referred to above indicate that the average tonnage transported by rail in 2015 under the Rail Only Option will range between 4,525 and 7,597 tons per day, increasing to a range of 8,845 to 18,280 tons per day in 2030. These tonnage figures vary depending on whether high or low growth economic forecasts are used.

For the Road Rail Option, 2015 tonnage is forecast to range between 1,646 and 2,760 tons per day, increasing to a range of 3,231 to 6,660 tons in 2030, again depending on whether high or low growth forecasts are used. Construction of the highway as well as the railway has the effect of reducing rail freight traffic by 64 percent under all of the scenarios.

For the purposes of preparing an operating plan, the Medium Growth Scenario has been used. This indicates that the railway, under the Rail Only Option, will transport 5,851 tons per day in 2015, increasing to 14,399 tons per day in 2030. Under the Road Rail Option, railway tonnage will be 2,127 tons in 2015 and 5,253 tons in 2030. In order to convert tonnage figures to the number of vehicles, an average load of 12.1 tons is used. This is slightly higher than the value used in making the market projections and is based on the average weight per container handled at Israeli ports. The specialized nature of the shuttle service suggests that this assumption is more realistic than the 8 tons per truck used in preparing projections of the number of vehicles, which will travel in the Corridor.

Directional flows are important in developing railway-operating plans. Freight traffic is seldom balanced in both directions. Figures developed as a part of the market studies indicate that approximately 75 percent of the projected traffic will move eastbound from Gaza to the West Bank. Rail Only Option eastbound volumes are estimated as 3,394 tons in 2015 and 5,698 tons in 2030. Assuming construction of the paralleling highway, eastbound tonnages are 1,595 and 3,940 per day.

Detailed information on the specific commodities included in the above figures is not available. There is some data on the value of the different types of commodities from which estimates can be made of the type of commodity movements that can be expected. Reviewing this information indicates that manufactured goods are the largest import category, followed by food products, mineral fuels, machinery, and chemicals. Manufactured goods are the only significant export category. Total reported export value is a small percentage of imports. While some food products and mineral fuels can be transported in conventional rail wagons, all are feasible for truck and intermodal movement. This is a major influence on the development of the rail services to be offered as discussed below.

It is important to note certain competitive aspects of the proposed service. The initial railway terminals are located just inside Palestinian Territory and not near any large industrial complex.[2] All freight must be moved by truck between the railway and the shipper or consignee's location. Since the freight is already on a truck and must be put on a truck for delivery, use of conventional wagonload service requires that the freight be transloaded between the wagon and trucks at each end of the rail movement. Transloading is very expensive ands raises the cost to the point that rail service cannot compete with through truck movement. In order to compete effectively, the railway must offer an intermodal service. There are three methods of providing intermodal service, conventional, RoadRailer, and what is known as the Rolling Motorway.

Conventional Intermodal Service: Conventional intermodal service assumes the use of standard highway trailers (including marine containers mounted on chassis), which are loaded onto specialized flatcars for rail movement. There are two methods available for transferring trailers between road and rail. The oldest method is to use a fixed ramp at the end of a track and to have the trailer backed onto the car by a highway tractor. At the destination, the trailer is pulled from the car by a tractor. This method is sometimes referred to as Circus Loading, reflecting its origin with the circus trains of many years ago. So long as volumes are low and destinations limited (the proposed service has one), this system provides an effective way of offering intermodal service with limited investment. However, it is slow and results in delays between the trailer's arrival at the terminal and the departure of the train. It also requires that the flatcars be shunted to and from the ramp, another expensive operation. At the projected volume, the circus loading method will require four loading tracks, each with ramps, and a total staffing of 72 persons at each terminal. Investment requirements, other than tracks and fixed facilities, are fourteen tractors at each terminal.

In order to overcome the problems of the end loading methods, overhead cranes have been developed which lift the trailer on and off the flatcar. This system, which can also handle containers without chassis, is much faster than the end loading method. Complete trains are often loaded and unloaded in the terminal without the need for switching. The major disadvantage of this system is the high capital cost of the cranes and related terminal handling equipment. When compared with other systems, it has significantly higher terminal costs. A crane operation requires a staff of 51 persons at each terminal, plus investment in three cranes and ten tractors at each terminal. At the projected volumes, estimated terminal costs are approximately $ 3,305,000 for labor plus $ 7 million in investment. As a consequence, this type of intermodal service is not recommended.

RoadRailer: One of the newer technologies developed in recent years for short-haul intermodal services is the RoadRailer. RoadRailer uses a special design trailer with a reinforced frame which can operate over both rail lines and highways. On the highway, it operates as a conventional trailer. Upon arrival at the rail terminal, the trailer is positioned over the track and pushed onto a rail bogie which supports both the rear of one trailer and the front of the following trailer. Once the train is made up, the forward bogie has a coupler installed that permits attachment of the locomotive to the train.

The major disadvantage of this system is the special trailer required and the control of these units when they are not in possession of the railway. Motor carriers using this service may use the trailer for other local transport services after delivery of the initial load and before returning the unit to the railway. It will be necessary for the railway to design and install a system for controlling the trailers while they are not in railway possession. This will require that the railway have personnel to monitor trailer use and insure that trailers are returned promptly. The inability to control equipment and the necessary increase

[2] There is a small industrial estate just west of the Erez Crossing

in the size of the fleet required to cover local delivery requirements works against use of this approach. Required terminal staff is 47 persons at each terminal. Terminal investment is two tractors for each. Terminal operating costs, including trailer control, are estimated as $ 3 million, principally for labor. The major investment is in trailers. The number of trailers needed depends on flows but may be as high as 800 at a cost of $ 80,000 each that represents an investment of $ 64 million. With this investment requirement, this system cannot be recommended.

Rolling Motorway: This intermodal service concept is found on a limited basis in Europe and is referred to as the "Rolling Motorway." With this system, the railway transports not only the trailer but also the tractor and driver.[3] The driver drives his tractor and trailer onto a flatcar, using the end loading method, and positions it as directed by railway personnel who secure the tractor and trailer to the car. Loading ramps are so arranged that trucks are always faced forward. This is important in avoiding having trailers moving backwards into rain that can cause water damage to the contents. The driver travels in a passenger coach included in the train where refreshments are often available.

While most European services operate over relatively long distances, the proposed service covers a very short distance making it more in the nature of a ferry rather than a normal rail service. This system uses standard flatcars which are available "off-the-shelf" and requires no terminal handling equipment. The customer's tractor and driver perform all of the necessary terminal movement. This system also minimizes terminal handling time, a very important competitive aspect. Terminal staffing consists of 38 persons at each terminal. Terminal handling costs are estimated as $ 2.5 million. Other than the terminal tracks, ramp and driveways, this system requires no investment. A comparison of the costs of each of these systems is summarized in Table 6.5-2.

Table 7.4-2: Comparison of Intermodal Systems (1)

Item	Conventional	RoadRailer	Motorway
Term. Staff Needed	102	94	76
Operating Cost (Million)	$ 3.3	$ 3.0	$ 2.5
Investment (Million) (2)	$ 7.0	$ 64.0 (3)	0

1. At the 2015 Rail Only volume level.
2. Investment does not include tracks, ramps, driveways which are about the same for all options.
3. Primarily trailers.

The Rolling Motorway has the lowest terminal investment and operating costs of any of the three systems. It also minimizes the time between arrival of the truck at the terminal and train departure. This is a very important consideration for a short ferry service such as proposed here. Although the operating plan assumes scheduled train departures, it is also possible to establish a system where the train will depart as soon as it is fully loaded, further reducing terminal time. It is also possible for the Motorway to transport buses and automobiles as well as trucks. In view of the investment, cost, and handling time advantages, the Rolling Motorway has been selected as the best approach for intermodal service.

[3] Standard highway tractor-trailers as well as conventional trucks may use the Rolling Motorway

Should the railway be extended at some future date, there may be opportunities for the development of conventional wagonload services. These can be designed at the time the extensions are opened and would supplement, rather than replace, the intermodal service.

3.0 The Route

The proposed railway extends from Gaza to the West Bank through Israel. As all of this line involves new construction, several surface alignments have been evaluated and two selected for detailed analysis. In addition, a third alignment, which would place the entire line in the tunnel is evaluated. The railway is being designed for operation at 160 kph and the alignments have been selected so as to avoid built up and/or areas of archeological, cultural or environmental significance. Although the railway may be extended in the future to the proposed Port of Gaza and north within the West Bank, the feasibility of these extensions has not been evaluated and is not a part of this analysis.

From an operating standpoint, there is little difference between the two at grade alignments or the tunnel. They are approximately the same length and operating costs should be very similar. They provide the same level of service as measured by transit time and to a large extent by cost. As these routes are so similar, a single analysis has been made which is equally applicable. The tunnel alignment requires that the railway be electrified which will have some impact on operating costs.[4] These impacts are discussed later in this chapter.

4.0 Train Operations

All trains, both passenger and freight, will operate the full length of the route without intermediate stops. This permits trains to operate at a constant speed without the need to frequently accelerate or decelerate. Both passenger and freight train weights will be relatively low so that a high horsepower locomotive will not be required. For the at-grade alignments, the Electro-Motive Diesel model JT42CW as used by IR adequately meets the needs of both services and has been used for developing the operating plan and estimating operating costs. All locomotives are equipped with head-end power for supplying the coaches so that they can be used interchangeably between both services. For the tunnel alternative` a 6KW electric locomotive is assumed.

The operating plan discussed here assumes that the railway will be handling the traffic level assumed in the forecasts (Chapter 2). When the railway initiates service, traffic will be much lower and will continue until passengers and freight shippers become familiar with the service and decide to use it. Even after the service has been in operation for some time, it may be necessary to adjust services based on actual patronage. Some trains may be under utilized while others are overloaded. Thus in planning services, a flexible approach must be used so that train services reflect actual demand by day and by hour.

Passenger Service: Under the Rail Only Option, at the 2015 forecast volume, it is planned that trains will operate 16 hours per day, seven days per week. Operating hours will be from about 6 AM to 10 PM. During peak hours, 6 AM to 9 AM and 5 PM to 7PM, trains will operate at 30 minute intervals in each direction. At other times, trains will operate at one-hour intervals. Trains will leave each terminal on the hour during these off peak periods. The 10 PM - 6 AM period provides a “window” for Infrastructure Maintenance to perform heavy track repairs as discussed under freight operations.

[4] Energy cost will vary for rail.

In 2030, again using the Rail Only Option, medium growth scenario, and passenger traffic will increase by 130 percent to 142,823 per day. In order to handle this volume, it will be necessary to increase peak period operations to six eight car trains per hour (10 minute headway). Off-peak operations require the operation of three eight car trains per hour at 20 minute intervals. This service level will require doubling of the terminal facilities at each end of the railway. However, as the same size trains will be operated all day, it will no longer be necessary to have a cab control coach in the middle of the train.

Under the Road Rail Option, 2015 traffic is forecast to be 44 percent of that of the Rail Only Option. With this reduction in traffic, train service is reduced to once per hour in each direction. Peak period trains will operate with nine coaches while off-peak trains operate with three. The 2030 volume is projected to be almost equal to the 2015 Rail Only level. Requirements for train service will be the same as the 2015 Rail Only Option.

Trains will operate in push-pull mode, such that the locomotive pulls the train in one direction and pushes it in the other. This avoids the need to turn trains at the terminals and reduces terminal handling time as well as eliminating the need for turning facilities.

At the 2015 Rail Only volume, four ten-car trainsets are required for peak period operations. These consist of locomotive, eight coaches, and two control coaches. The second control coach is the fourth coach in the train as measured from the locomotive. When the peak period ends, two trainsets are removed from service and stored on one of the station tracks. Train sizes are reduced from ten to four coaches at this time. With a control coach in the middle of the train, the extra coaches can be left at the end of the station track until required for evening peak period operations. This avoids the need for switching cars and minimizes operating costs. In order to facilitate this type of operation, two of the trainsets must have the locomotive on the east end of the train and the other two must have it on the west end. Trainsets with the locomotive on the west end will leave their extra cars at the east terminal and those with locomotive on the east end will leave the cars at the west terminal.

At the 2030 Rail Only traffic levels, six eight-car trainsets are required. Since the same size trains will be operated in both peak and off peak periods, it will no longer be necessary to have a control cab coach in the middle of the train. Trainsets will consist of locomotive, seven coaches and one control cab coach.

At the 2015 Road Rail level, operations are once per hour, eliminating the need for two trainsets. The two remaining trainsets will consist of locomotive, two coaches, cab control coach, five additional coaches, and second cab control coach. This consist permits a reduction of train size to three coaches at the end of the peak period. At the 2030 traffic level, operations are identical to those planned for the 2015 Rail Only Option.

The control coaches should, if possible, be equipped with end doors permitting passage between cars. This is not essential as there will be no conductor and no need for passage except for passengers seeking seats. As a result of several serious collisions between trains and highway vehicles, some push-pull operators are now requiring heavy end frames on control coaches in order to protect passengers. This does not seem necessary in this instance as the railway will have no at-grade highway crossings.

As there will be no intermediate stops, trains will be operated with driver only. As doors will be sealed upon leaving each terminal, there will be no need for the conductor of the train to collect fares, open doors, nor to assist passengers on or off the train.

The layout drawings of passenger and freight station facilities at each end of the line are found in Volume 3, Drawings. This includes the facilities to be built immediately and those required for projected demand through 2030. Identical facilities are provided at each end of the railway, with the exception that the Gaza terminal has a workshop for light to medium repairs. Note that extensive parking facilities for buses are included since it is anticipated that most passengers will arrive by this mode. A fence secures the station platform area. A passenger will purchase a ticket from the office at the entrance and enter the secured area. His ticket will be used to open a gate to the platform, similar to the system used by IR, and given to a railway agent as he boards the train. Once the train is loaded, railway personnel will lock the doors and the train will depart. An alternate is the use of coin operated fare gates which would avoid the need to sell tickets.

If required, security personnel can travel with the train. These potential requirements and their costs have not been included in the evaluation.

Freight Service: For freight, the railway, at least in the initial stages, will offer only intermodal service. This reflects the limited market for conventional wagonload service, at least until the railway is extended further into Palestinian territory. Service will be provided using the Rolling Motorway system as described earlier in this chapter. The layout drawings of the terminal facilities are found in Volume 3, Drawings.

Under the Rail Only Option, medium growth scenario, 2015 potential traffic totals 484 loaded trailers per day. Since the market studies indicated that westbound traffic would be about one-third of the eastbound, two thirds of the trucks will return empty to Gaza. Including empty movements, there are 363 trucks to be moved in each direction. At 25 trucks per train, this requires 15 trips in each direction. This requires a total of four trainsets.

At the 2030 projected level, there will be 595 loaded trucks moving east and 198 loaded and 397 empty moving west. At 25 trucks per train, 24 trips per day are required. This requires six trainsets.

Under the Road Rail Option, rail freight traffic is projected to be 36 percent of that under the Rail Only Option. At the 2015 level, there will be 132 trucks in each direction. This requires six round-trips per day and a total of two trainsets.

At the 2030 level, there will be 214 trucks moving in each direction. This will require nine round-trips per day and three trainsets.

Under the initial operation, using the Rail Only Option and the 2015 forecast volume, there will be 15 round trips per day, or about one each hour and one-half. Each train is allowed as running time of approximately one hour plus one hour to load and one hour to unload. Each trainset requires a minimum of six hours to complete a round-trip, permitting four round-trips per day, per set. For this level of service, the terminal will require two active loading/unloading tracks plus a third track between them for use as a “run-around” but which can also be used as a loading track when necessary. Each track is approximately 2,000 feet in length, sufficient to hold 25 of the wagons required to transport complete highway units, locomotive and driver’s coach. All tracks have a fixed ramp at the end of the track.

At the 2030 Rail-Only volume level, trains will arrive and depart on an hourly basis. This will require a third loading/unloading track as well as an additional run-around track for future construction.

Under the Road Rail Option, one of the two initial loading/unloading tracks can be eliminated. A single working track and the "run-around" are adequate for the volume projected through 2030.

The operation is as follows. Upon arrival at the terminal, the driver and railway personnel jointly inspect a tractor-trailer for pre-existing damage. Once the cars are positioned against the ramp, trucks are loaded by having the drivers operate their vehicles onto the wagons and position them for movement as directed by railway terminal staff. They are then secured to the cars by railway staff and the drivers directed to the coach in which they will ride. Once loading is completed, the train departs.

Rail operations at the destination terminal are as follows. Upon arrival, the train enters one unloading tracks stopping short of the crossover near the ramp. The locomotive and driver's coach proceed to the end of track, reverse direction and pass through the crossover to the other track, using it to run around the train. In the process, the locomotive drops the coach in the short run-around at the rail entrance to the terminal and runs around it. The locomotive now pushes the coach against the train and pushes the entire train until the end car is against the ramp. Drivers leave the coach and unloading begins.

Railway personnel release the vehicle fastenings, whereupon the drivers drive off the flatcars and leave the terminal. If a driver feels his equipment has been damaged while in transit, he must bring this to the attention of a railway staff person before leaving the terminal. The railway inspector will examine the damage, compare it with the origin arrival report, and try to resolve the issue with the driver. If the issue can not be resolved, the inspector refers it to management while the driver goes on his way while waiting for resolution.

Staffing at each terminal consists of a terminal supervisor, two clerks to accept trucks arriving for movement, two inspectors, two tie down persons and one person to resolve damage claims by drivers. All of these are 24 hours per day, seven days per week, positions. A total of 33 staff persons are needed at each terminal to fill these positions on a full time basis including vacations, illness and similar causes.

In order to maximize use of the rolling stock, the freight service is planned to operate 24 hours per day, seven days per week. This creates one problem for the Infrastructure Maintenance Department. In designing train schedules, it is customary to leave "windows" (periods when no trains operate) for heavy maintenance work. While this type of work will not be necessary during the first few years as the railway is new, schedules must be planned to allow for it. Passenger service is planned to operate 16 hours per day leaving the 10 PM - 6AM period available for maintenance. In the case of freight service, operations are planned for 24 hours per day without a window. Once a window becomes necessary, train schedules can be adjusted based on experience. It may be found that some or all of the night trains can be discontinued without significant impact due to low levels of use.

The operating plan for the different alternatives are summarized in Table

Table 7.4-3: Summary of the Rail Operating Plan for the Three Options

	Train Size Cars/Wagon		Frequency of Service per hour		Hours per day of	No.	Train - km per year		Wagon/car - km per year	
	2015	2030	2015	2030	Service	Dir.	2015	2030	2015	2030
RAIL ONLY - AT GRADE										
Passenger										
Peak	10	8	2	6	4	2	274,480	823,440	2,744,800	6,587,520
Off Peak	4	8	1	3	12	2	411,720	1,235,160	1,646,880	9,881,280
Subtotal							686,200	2,058,600	4,391,680	16,468,800
Freight										
Peak/Off peak	25	25	0.33	1	24	2	271,735	823,440	6,793,380	20,586,000
RAIL ONLY - TUNNEL										
Passenger										
Peak	10	8	2	6	4	2	245,280	735,840	2,452,800	5,886,720
Off Peak	4	8	1	3	12	2	367,920	1,103,760	1,471,680	8,830,080
Subtotal							613,200	1,839,600	3,924,480	14,716,800
Freight										
Peak/Off peak	25	25	0.33	1	24	2	242,827	735,840	6,070,680	18,396,000
ROAD/RAIL										
Passenger										
Peak	8	10	1	2	4	2	137,240	274,480	1,097,920	2,744,800
Off Peak	3	4	1	1	12	2	411,720	411,720	1,235,160	1,646,880
							548,960	686,200	2,333,080	4,391,680
Freight										
Peak/Off peak	25	25	0.33	0.33	16	2	181,157	181,157	4,528,920	4,528,920

Length at grade	47	km
Length tunnel	42	km
Operating days	365	

5.0 Rolling Stock Requirements

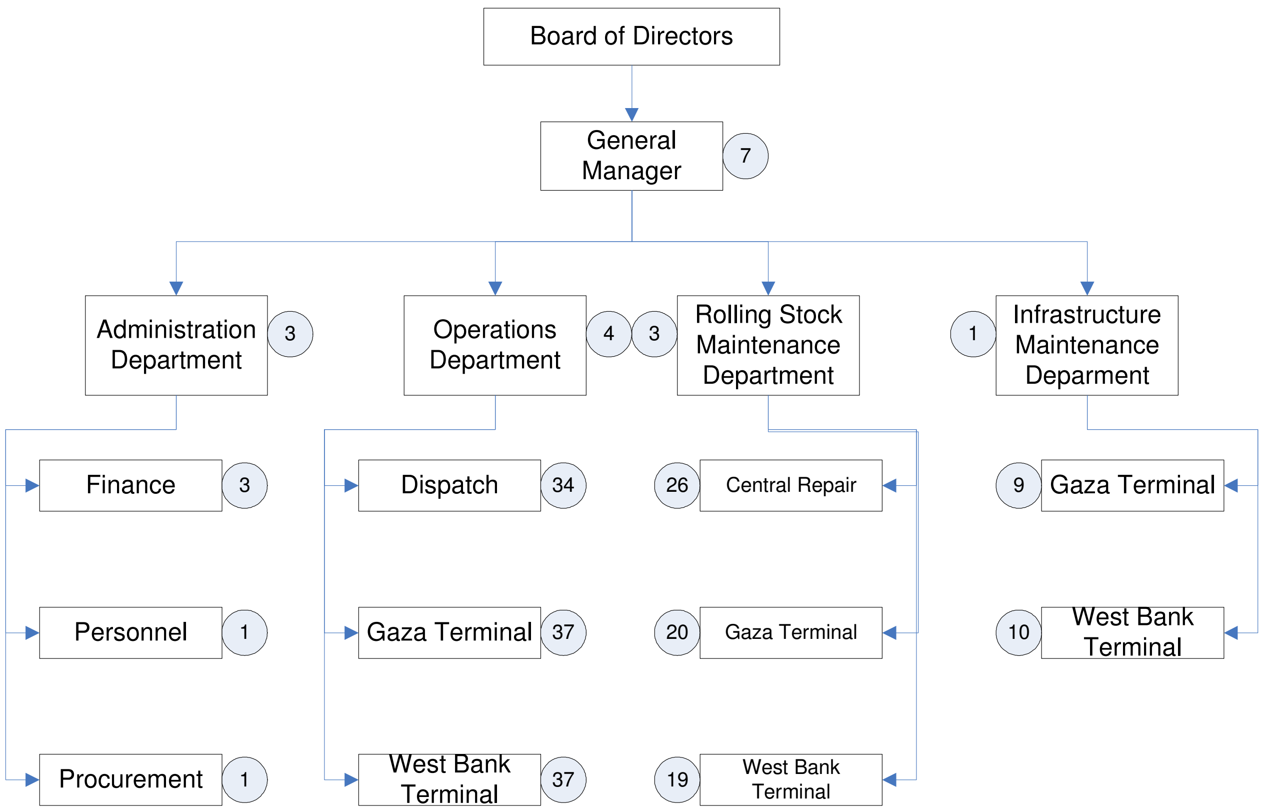
The requirements for each type of rolling stock are shown in Table 6.5-4 below.

Table 7.4-4: Rolling Stock Requirements by Option and Year

TYPE	RAIL ONLY		ROAD/RAIL	
	2015	**2030**	**2015**	**2030**
Locomotives(1)	10	14	6	9
Cont. Coaches	9	7	3	9
Coaches	40	54	20	40
Flatcars	110	170	60	110

1. Electric locomotives for "at grade" operations or diesel locomotives for tunnel operations.

Figure 7.4-1: Organization Chart - 2015



The numbers indicate the personnel assigned in 2015 for Rail Only.

4.1 Locomotives

Under the Rail Only Option, the passenger service requires a fleet of five locomotives including one spare. The freight service requires four locomotives plus one spare for a total of ten. The Electro-Motive Diesel Model JT42CW as operated by IR is recommended for this service. All locomotives equipped with head-end power for supplying the electrical needs of the coaches used in both services. Locomotives are operated interchangeably between passenger and freight services. This is more cost effective than equipping the control coaches and the coaches used in freight service with head end power units. For the tunnel alternate, the same number of electric (6.4 kW) locomotives will be required.

Locomotive requirements for the 2030 demand level are 14 units reflecting the greater number of trainsets being operated.

Under the Road Rail option, traffic is sharply reduced permitting a reduction in the number of trainsets in both passenger and freight services. Locomotive requirements are reduced to 6 units in 2015 and 9 in 2030.

4.2 Passenger Coaches

Since this operation is small when compared to other railways, it is logical to use rolling stock which is compatible with that operated by Israel Railways. That avoids the need to negotiate prices for what will be a very small order. If IR is ordering rolling stock at the right time, it should be possible to add these cars to that order, receiving the cost benefit of volume production. Passenger train operations are similar to those of IR, making use of the same rolling stock designs feasible. With the projected peak hour demand, the use of double deck cars is required. At the required train sizes, the operation of DMUs is not cost effective.

At the 2015 Rail Only volume, the passenger service requires a fleet of 36 double-deck coaches and 9 double-deck coaches with control cabs. The freight operation requires three coaches for the drivers. While the capacity of a double deck coach is not required for this service, the use the same car as the passenger operation standardizes the rolling stock and permits the freight service to share coaches, avoiding the need to have a separate spare. This minimizes the total rolling stock required. The total need for coaches is 49 double-deck, of which nine are equipped with control cabs.

At the 2030 demand level, the coach requirement increases to 61, of which 7 have control cabs. This reflects the elimination of one control coach per train while the number of trainsets increases to six.

Under the Road Rail Option, the 2015 requirement is reduced to 23 of which 3 have cabs. The 2030 coach requirement is 49 of which 9 have cabs. This is the same level as required under 2015 Rail Only Option.

4.3 Freight Cars

The 2015 level freight service requires a fleet of 110 flatcars which are assembled in four sets of 25 cars with 10 spares for used when required. These trainsets also operate in shuttle service with the cars being uncoupled only when necessary to remove cars for repair. With the increase in projected volume in 2030, the car requirement increases to 170. Comparable figures for the Road Rail Option are 60 in 2015 and 90 in 2030, again reflecting the diversion of traffic to road movement.

5.0 Maintenance Requirements

5.1 Rolling Stock

Rolling stock is maintained in accordance with the practices of IR and follows the same schedule of inspections and servicing. Daily inspections, servicing and light repairs are performed while rolling stock is idle at the terminals and is performed by maintenance staff assigned at these locations. This includes inspections up through the three-month level. Higher-level inspections and repairs exceeding what can be performed in the terminal are completed at the central repair shop located at the Gaza terminal. This facility is equipped to deal with all but the heaviest repairs. It has a wheel lathe and overhead crane capable of lifting a locomotive. The central repair shop has an assigned high-rail truck equipped with tools and spare parts for dealing with breakdowns along the railway. Personnel from the workshop man this truck.

5.2 Infrastructure Maintenance

The Infrastructure Maintenance Section maintains all infrastructure including tracks, buildings and other structures, and roadways on railway property. Track is maintained to the standards of IR for the speeds at which trains are operated (100kph). All main line track is inspected daily for defects. This section is organized in two gangs with one based at each terminal. This practice minimizes travel for the gang between its base and work site. When heavy work is being performed, the two gangs are combined in order to provide the necessary manpower.

As planned, access to the right of way is highly restricted for security purposes. The lack of access may create significant problems in maintaining the infrastructure. Modern railway practice is to equip the maintenance gangs with hi-rail vehicles, which are capable of operating equally well on railway tracks or the highway. When necessary to remove the vehicle from the track to allow passage of a train, it is run to the nearest grade crossing and driven onto the roadway. Once the train has passed, the vehicle is placed on the track and returned to the work site. With the absence of highway crossings and the restricted right of way access, it is necessary to provide "pull offs" where these vehicles can be removed from the track. Assuming that the line is built, this requirement can be met by providing occasional crossovers between the two tracks. In the absence of the second track, it is necessary to provide a small paved area at frequent intervals. A failure to provide these points will result in delays to trains while vehicles are driven to a siding. Hi-rail vehicles are frequently limited to low speeds while on the track which creates further delay. If the road is built as well, the highway can be used for access.

Each maintenance gang is equipped with an inspection car (track motor) for the inspector and a second vehicle for transporting the gang to work sites. Each gang also has small flatcars towed by the track motor for moving materials to work sites. All vehicles are equipped for easy removal from the track when necessary to permit passage of a train. Provision has been made for providing places where the equipment can be removed from the track. Since most track maintenance will be done at night, the track motors are equipped with floodlights for illuminating the work site.

One maintenance gang has a small crane for handling materials which is shared with the other gang on an as needed basis. When a larger crane is required, it is assumed that this will be rented on an as needed basis.

Under the tunnel alternative, it has been assumed that the track will be laid with a concrete slab replacing the normal sleepers and ballast. This will reduce the amount of routine maintenance which must be performed. This will permit a reduction in infrastructure maintenance personnel to 10. It will be necessary to add a four-person gang for catenary maintenance. This gang will also require a catenary maintenance vehicle.

6.0 Staffing Requirements

The organization discussed in this section assumes that the railway is in full operation and has reached the volume levels indicated by the 2015 Rail Only Option market projections. During the early period of operations, when the traffic volume is low and train operations limited, many of these positions can be combined in order to reduce administrative costs. During the initial period of operations, it is assumed that management and skilled operating personnel will be contracted from another railway, which will also provide training for local staff. As these individuals are trained, they will replace the individuals provided by the contractor.

Staffing levels are sensitive to the volume of traffic being transported. Changes necessary to accommodate the different volumes in 2030 and under the Road+Rail Option are discussed at the end of this section.

The organizational structure is shown in Figure 6.5-1. Functions of each position are discussed below. The total staffing for the railway is 203 persons.

6.1 Senior Management

Determining the management and ownership rights of agency that will operate the railway is beyond the scope of this study. It is assumed that it will operate the railway through a Board of Directors who will set policy and oversee the railway. A General Manager appointed by the Board will supervise the day-to-day operations. He will have two Assistant General Managers. These positions will be necessary as the railway will operate 24 hours per day, seven days per week, so that there will be a senior manager on duty at all times. This office will also have a single clerk on duty at all times, requiring a total of four persons. Total staffing in this function is seven persons.

6.2 Train Operations Department

Overall train operations will be managed by the Manager, Operations who is assisted by three trainmasters so that supervision is available at all times when trains are operating. The Operations Section also includes the train dispatchers. One dispatcher will be on duty at all times, requiring a total of four persons for this function. A clerical position, working three shifts per day and seven days per week, is responsible for assigning drivers to trains and insuring that they report to work as scheduled, and for maintaining records. Four employees are required to provide full coverage for this position.

One person, the driver, will operate trains. A conductor or security person is considered at this point as a superfluous position. However, circumstances might require their presence. Drivers will normally work eight-hour shifts, which may be either continuous or split. Peak hour shifts, for example, may consist of four hours in the morning and four hours in the afternoon with a long break between. For the operations as proposed, a total of 22 drivers are required with one half working in passenger and one half in freight services. Drivers will work interchangeably between the two services. In order to provide relief for vacations, illness, etc., four additional drivers are required making a total of 26. One half of the drivers are based at each terminal.

Including two employees assigned to relief work, the total employment in this function is 38 persons.

Terminal Operations - Passenger Services: There is also a need for clerical staff at the passenger stations when trains are operating. The station platforms will be secured by fencing or similar material. Access to the platform is restricted to one or two entrances, such that one can obtain access only by passing these points. The primary function of the clerks is to monitor station activities and respond to passenger requests for information. As the clerical positions will work two shifts, seven days per week, three persons are required for each terminal, making a total of six positions. There must also be a janitor responsible for keeping the station area clean at each terminal. Total staffing for the passenger terminals is 8 persons.

Terminal Operations – Freight Services: The freight terminals will operate 24 hours per day, seven days per week and must be staffed accordingly. All positions are required to be filled around the clock. A supervisor reporting to the Manager of Operations will manage each terminal. The terminal staff consists of two clerks for receiving trucks, two inspectors, two tie down men responsible for securing trucks to the flatcars, and one clerk to resolve damage claims. Total staffing per shift is 8 at each terminal. In order to fill these positions, on a 24-hour, 7-day basis, 33 persons are required at each terminal, or a total of 66.

6.3 Rolling Stock Maintenance Department

All rolling stock maintenance will be performed at the terminals or the repair facility. Inspection and minor repairs will be made while the trainsets are in the loading/unloading tracks. Repairs which can not be made in the loading tracks but which do not require movement to a major workshop will be made at the repair facility located at one of the terminals. It is assumed that heavy repairs, such as accident damage, will be sent to IR's main repair facility.

Total repair requirements have been estimated using information obtained from IR and reflect their maintenance practices. In their estimates of maintenance manpower needs, IR has included a significant amount of time for unplanned or damage repair work. This has been reduced as the railway will have no highway crossings with operations consisting of shuttle trains operating non-stop between terminals. There will be little opportunity for collisions with other trains or vehicles. Accidents will, of course happen. However, these should be minor given the type of operation and do not require including time for repair. Should major damage occur from such an incident, the rolling stock involved will be sent to IR for repair.

The Rolling Stock Maintenance Group will be equipped with a high rail truck for handling problems with rolling stock which occur between terminals. The truck will carry a stock of frequently used parts and tools. Should the repair crew need parts, which are not on the truck, it can return to the terminal and pick up what is needed. The truck will be staffed by personnel from the Central Repair Shop.

Rolling Stock Maintenance is organized in three sections, the Central Repair Shop and maintenance sections located within the two terminals. The Central Repair Shop is planned to work two shifts per day, seven days per week. There will be staff on duty for the third shift primarily to deal with emergencies. The majority of staff will work between 10PM and 6AM as this is when all passenger cars are available for maintenance. The Central Repair Shop includes the office of the Maintenance Manager who provides supervision for one shift per day, five days per week. At other times, the supervisors who work under the direction of the Manager provide supervision. The mechanical staff consists of 26 mechanics. At each of the terminals, there are two mechanics on duty at all times trains are operating. This consists of two shifts per day, seven days per week, at the passenger terminals and three per day at the intermodal terminals. There are also two coach cleaners at each terminal who work between 10 PM and 6 AM when all coaches are parked for the night. Total staffing for the Rolling Stock Maintenance Department, including supervision, is 68 persons.

6.4 Infrastructure Maintenance Department

Infrastructure maintenance will be handled by a single maintenance group, which is organized in two gangs based at the terminals. These gangs handle routine maintenance. When major repairs are required, it is planned that this work will be contracted to others equipped to provide such services. The Manager, Infrastructure Maintenance Department, who also serves as General Foreman, will head this department. The manning requirements consist of a total of 19 personnel reflecting typical manning practice of other railways. Two of the staff will be qualified as track inspectors.

6.5 Administrative Department

The railway will require some administrative functions including accounting and financial control, personnel, and purchasing. For some seldom used services such as legal advice, it is assumed that specialists will be hired on a short-term, as needed basis and will not represent a significant expense.

The Manager, Administration, and whose office staff consists of a secretary and one clerk will head the Administrative Department. He supervises the functions described below.

The financial section is responsible for insuring that all moneys collected are deposited to the railway's account and for maintaining the books. It is assumed that the railway will have a modern mechanized accounting system, which reduces the need for manual record keeping. This section will consist of a supervisor and two clerks. One clerk has the responsibility of monitoring receipts and insuring that all funds collected at the terminals are forwarded to the central office. The other clerk maintains necessary accounting records.

Personnel section will consists of a single supervisor who will have the responsibility for all personnel actions including hiring, termination and training. When additional positions will be requested by one of the operating departments, he will review the justification and make appropriate recommendations to the General Manager.

Procurement section likewise will consist of a single supervisor who is responsible for purchasing all supplies and materials required by the railway. He is also responsible for disposing of surplus materials and scrap.

The marketing section represents an unsettled issue. If the rail only option is selected, the railway will have no effective competition and the need for marketing is questionable since Palestinians will have no other effective way of moving between the West Bank and Gaza. The primary objective of marketing would be to let potential customers know the service is available. If the road-rail option is selected, the railway must compete for passengers with direct bus services, which will provide through service while use of the railway requires a bus transfer on each end of the journey. Automobiles will also provide some level of competition. The freight operation must also compete with direct highway movement such that time via rail must be competitive with the highway and the charge must not exceed what the driver perceives as his saving in out of pocket cost. This will require an active marketing program requiring two persons, one for passenger and one for freight. This section has not been included in the organization since the need for it is questionable and the cost is comparatively minor.

Total staffing in the administrative area, not including marketing, is seven persons.

6.6 Staffing Requirements over Time

Staffing levels will change with the increase in volume of traffic. Table ___ below shows the staff levels by department for the Rail Only and Road Rail Options for 2015 and 2030.

Table 7.4-5: Staff Levels by Functional Area

Area	**Rail Only**		**Road/Rail**	
	2015	**2030**	**2015**	**2030**
Management	7	7	7	7
Train Operation	38	115	34	38
Terminal Oper.	74	90	49	74
Roll. Stock	65	116	42	65
Infrastructure	20	20	20	20
Administration	8	8	8	8
Total	**212**	**356**	**160**	**212**

Changes in Train Operations reflect changes in the number of trains being operated which change the number of drivers required. Drivers are the only positions affected by these changes. Changes in terminal operations staff are directly related to the frequency of trains. The reduction in Road+Rail staffing in this area results from the reduction of freight terminal hours by closing for one shift per day.

Rolling Stock Maintenance staffing is affected by the number of locomotives and cars that need to be serviced and maintained. For example, under the Rail Only Option, between 2015 and 2030, the number of units in service increases 45 percent. This requires a 45 percent increase in the number of mechanics. Likewise, under the Road/Rail Option, train operations are sharply reduced. Rolling stock is reduced by about one third, permitting a 33 percent reduction in mechanics.

In all departments, there is no change in the number of supervisory functions with changes in the number of lower level personnel.

6.7 Staff Training

At the time operations are initiated, it is assumed that there will be no Palestinians with railway experience available and it will be necessary to train all levels of staff from senior management to laborer. This will require a complete training course. An efficient method of training is to contract with IR or another rail operating company to train these employees. IR has developed appropriate programs for all levels of training and might be able to provide this service at a lower cost than other possible suppliers. IR has also recently purchased a locomotive simulator for training which will be used for training drivers and which will greatly increase IR capabilities in the training area.

Once the initial training has been completed, it will be necessary to adopt a continuing training program for new employees as well as refresher courses for existing staff. As the railway operation will be small, it is anticipated that future training requirements will also be small. Training will be the responsibility of the Personnel Section Manager.

7.0 Rail Costs

Appendix 7-6, Railway Operating and Maintenance Costs, describes in considerable detail the estimation of rail O&M costs. This section provides a brief summary of the assumptions used and results of rail cost analysis. Since the rolling stock proposed is similar to that presently in use by Israel Railways, much of the operating costs are based on the results of its operations.

APPENDIX 7-5

RAILWAYS OPERATING AND MAINTENANCE COSTS

1.0 Introduction

The operating costs as discussed in this annex are largely based on information obtained from Israel Railways (IR) in connection with another study[1], referred to as the Rolling Stock Study, or from other international sources felt to be accurate. Specific sources of cost information are indicated in the discussion of individual cost categories. Costs are estimated in U.S. dollars at the 2006 level unless otherwise stated. Costs are presented for three main options, rail only at grade (ground level) and tunnel cross sections, and combined road/rail, using the Medium Growth Scenario.

2.0 Labor Costs

Labor costs for the railway are based on wage rates paid in Palestine in the private sector. Wage rates for various classes of employee are shown in Table 1 below. The annual costs shown include employer paid social costs, assuming they will be 75 percent of direct wages paid and include a premium for shift work. Although these costs can vary widely, this figure is comparable with Israel Railways, whose social costs are 84 percent of direct wages. The above figures assume effective working hours of 2,000 per employee per year, which is higher than the average for Israel Railways.

Table 1: Wage Rates for Railway Employees

Position	Wage Rates in NIS per Month		
	Low	High	Value Used
Managing Director	20,000	25,000	20,000
Managers	10,000	12,000	10,500
Skilled -Senior	5,000	10,000	7,500
Skilled -Junior	3,000	5,000	4,400
Unskilled	2,000	3,000	2,500

In order to calculate labor costs, it has been necessary to determine how many employees are in each of these categories. Assignments by skill level and function are shown in Table 2

[1] The Louis Berger Group, Inc., Optiminization of Rolling Stock Procurement, 2005 for the Israel Railways.

Table 2: Number of Employees by Skill Level Required in 2015 for Rail Only

Department	Man-aging. Director	Man-agers	Senior Skilled	Junior Skilled.	Un-skilled
Senior Managers.	1	2	4		
Train Operations		4	21	13	
Terminal. Operations.		8	39	25	2
Rolling Stock. Maintenance		7	46	10	2
Infrastructure Maintenance.		1	10	9	
Administration		4	4		
Total	**1**	**26**	**124**	**57**	**4**

Management positions include all staff who supervise others. This definition covers senior management, managers and front line supervisors. There are a total of 26 persons in this category.

Senior skilled workers include some drivers, mechanics, and one half of the infrastructure maintenance staff. Some clerks are also in this category reflecting the type of work being performed. There are 124 personnel in this category. Junior-Skilled employees include the remaining infrastructure maintenance staff and clerks, as well as less experienced drivers and mechanics. There are 57 staff included in this classification. Unskilled staff includes the very bottom level of staff filling positions such as coach cleaner and janitor. There are 4 individuals at this level.

Staff costs are shown in Table 3 below.

Table 3: Wage Costs for 2015 and 2030 for Rail Only

Position	Employees		Annual Cost Per Employee	Annual Wage Costs in $	
	2015	2030		2015	2030
Managing Director	1	1	$93,333	$93,333	$93,333
Managers	26	26	$49,000	1,274,000	1,274,000
Skilled -Senior	124	194	$35,000	4,340,000	6,790,000
Skilled -Junior	57	131	$20,533	1,170,400	2,689,867
Unskilled	4	4	$11,667	46,667	46,667
Total	212	356		$ 6,924,400	$10,893,867

In the case of the rail tunnel, there will be a requirement to maintain infrastructure not found in the at grade option. In this case, the specialized services to maintain the ventilation, drainage and specialized electronic systems will be contracted out. The labor costs associated with these maintenance activities are included in the estimates of the contracted maintenance cost. No additional labor is included for the Rail Tunnel alternative.

Under the Road/Rail Option, for 2015, the projected passenger and freight traffic is reduced by approximately 55 percent. In order to respond to this reduction, peak hour passenger trains are eliminated, as are freight trains between 10 PM and 6 AM. The number of drivers required is reduced by four, and one work shift at the freight terminals is cancelled, eliminating ten employees at each. With the reduction in rolling stock, the number of employees needed rolling stock repairs reduced by 26. The wage costs for this option is shown in Table 4 below.

Table 4: Wage Costs for 2015 and 2030 for Combined Road/Rail

Position	Employees		Annual Cost Per Employee	Annual Wage Costs in $	
	2015	2030		2015	2030
Managing Director	1	1	$93,333	$93,333	$93,333
Managers	24	26	$49,000	1,176,000	1,274,000
Skilled -Senior	99	124	$35,000	3,465,000	4,340,000
Skilled -Junior	32	57	$ 20,533	657,067	1,170,400
Unskilled	4	4	$11,667	46,667	46,667
Total	160	212		$5,438,067	$6,924,400

3.0 Energy and Lubrication Costs

Energy costs are estimated for diesel and electrical operations. Electric locomotives are required for the tunnel option. In order to estimate energy costs for diesel locomotives, it has been necessary to estimate fuel consumption rates for the various services operated by the railroad. There will also be some consumption for the operation of track maintenance machines and other vehicles. Fuel consumption by train operations has been estimated as follows.

Diesel Fuel: The Rolling Stock Study developed some detailed estimates of fuel consumption based on IR's operation for diesel powered trains. These estimates were based on operation of the same type of locomotives and rolling stock proposed for the West Bank-Gaza passenger service. Fuel consumption for a locomotive and train of ten double deck coaches, including that consumed by the head end power unit, was estimated as 5.26 liters per kilometer. This figure has been used for the10 car trains. The Rolling Stock Study also estimated the consumption of a locomotive and five double deck car train as 4.18 liters per kilometer. As the off peak trains for this service will operate with four rather than five cars, this figure cannot be used directly. The difference between the five and ten car trains is 1.08 liters per kilometer. On a per car basis, this is 0.216 liters per kilometer per car. Thus, for a four-car train, the fuel consumption is 4.18 liters less 0.216 liters or 3.964 liters per kilometer. This figure has been used for estimating fuel consumption.

Calculating freight train consumption requires a slightly different approach. A loaded flatcar is approximately the same gross weight as a double deck passenger car. The fuel consumption per car per kilometer should be about the same as the passenger trains. Using the per car kilometer consumption figure of 0.216 liters and subtracting the five car amount from the total gives a locomotive only consumption estimate of 3.1 liters per kilometer.

The freight train consists of one coach and 25 flatcars. Fuel consumption per train kilometer is 3.1 liters for the locomotive and 0.216 liters for each of the 26 cars, (5.616 liters) or a total of

8.716 liters. This figure has been used for freight train operations. This figure may be slightly overestimated since it assumes all trains will operate fully loaded.

In addition to train operations, there will be some fuel consumed by track and rolling stock maintenance vehicles. These vehicles typically have high fuel consumption per kilometer since they spend much of their time being used to supply work crews with compressed air or electricity for the operation of tools. These functions often require that the engine be operated at a relatively high speed. This often results in a consumption of 15 to 20 liters per hour. For purposes of estimating fuel consumption, it has been assumed that each of the vehicles assigned to these areas will be used three days per week and will spend four hours each day at a consumption rate of 15 liters per hour. This results in an annual consumption of 54,000 liters. While there may be some other consumption related to automobile travel by staff, this should be extremely small and will not have a significant impact on cost.

Fuel cost for IR is presently 3.4 NIS or $0.755 per liter. The annual fuel costs in 2015 and 2030 for the Rail Only option is given in Table 5.

Table 5: Annual Fuel Costs in 2015 and 2030 for Rail Only

Item	Cars/Wagons		2015		2030		Fuel Consumption (liters)		Annual Cost $	
	2015	2030	lt/km	no.	lt/km	no.	2015	2030	2015	2030
Passenger										
Peak	10	8	4.18	2	3.964	2	2,294,653	6,528,232	1,733,738	4,932,442
Off Peak	4	8	3.78	1	3.964	2	1,556,302	9,792,348	1,175,872	7,398,663
Subtotal									2,909,610	12,331,105
Freight										
Peak/Off peak	25	25	8.7	1	8.716	1	2,364,096	7,177,103	1,786,206	5,422,700
Maintenance							54,000	80,000	40,800	60,444
Subtotal							6,269,051	23,577,684	4,736,616	17,814,250
Lubricants									473,662	1,781,425
Total Energy & Lubricants									$ 5,210,278	$19,595,675

In addition to fuel, railroads also require oils and greases for lubrication purposes. Locomotives require periodic oil changes while coach and car axles require lubrication. Reflecting the experience of other railroads, this is estimated as ten percent of the fuel cost.

Under the Combined Road/Rail Option, train operations are reduced to some extent with a reduction in fuel consumption and cost. With the reduction in ridership, operation of additional peak hour trains is eliminated. It will still be necessary to operate ten car trains in order to meet peak demand. The remainder of trains will be operated with four cars. Four car trains will operate the same number of train kilometers as under the rail only option. The annual fuel costs in 2015 and 2030 for the Combined Road/Rail Only option is given in Table 6.

Table 6: Annual Fuel Costs in 2015 and 2030 for Combined Road/Rail Only

Item	Cars/Wagons		2015		2030		Fuel Consumption (liters)		Annual Cost $	
	2015	2030	lt/km	no.	lt/km	no.	2015	2030	2015	2030
Passenger										
Peak	8	10	3.964	2	4.18	2	1,088,039	2,294,653	822,074	1,733,738
Off Peak	3	4	3.568	1	3.964	1	1,468,852	1,632,058	1,109,799	1,233,111
Subtotal									1,931,873	2,966,848
Freight										
Peak/Off peak	25	25	8.7	1	8.716	1	1,576,064	1,578,963	1,190,804	1,192,994
Maintenance							54,000	60000	40,800	45,333
Subtotal							4,186,955	5,565,674	3,163,477	4,205,176
Lubricants									316,348	420,518
Total Energy & Lubricants									$ 3,479,825	$ 4,625,693

In the case of the Rail Only Tunnel cross section, the power requirements are estimated on the basis of 60 watts per ton-km and power costs are estimated on the basis of 11 US Cents per kilowatt hour including losses. Lubrication requirements for electric motive equipment is less than that needed for the diesel powered equipment.

4.0 Rolling Stock Maintenance Parts

Labor costs for rolling stock maintenance are included in the direct labor category described above. This category includes spare parts for rolling stock. Studies on other railroads have indicated that, for locomotives operating approximately 480 kilometers per day, 84 percent of locomotive parts expense is time, rather than distance based. This is not surprising when it is recognized that most parts are replaced on the regular, time based, inspections (3 month, 6 month, 3 years, etc.) which most locomotive maintenance programs require.

The Rolling Stock Report includes estimates of locomotive maintenance cost as $ 1.02 per kilometer based on 180,100 km per year or 493 km per day. This is directly comparable with the studies on other railroads referred to above. Materials cost in the Report was estimated as $ 37,247 per year. 84 percent of this figure is $ 31,288. This has been used as the time related parts cost per locomotive. The balance of this expense, $ 5,959, is the distance related portion of locomotive parts cost. At 179,9456 km/yr (493 x 365), this represents a cost of $ 0.033 per kilometer.

For electric locomotives, parts costs are lower than diesel, and they ranges from 60 to 80 percent, a value of 70 percent for both fixed and variable cost.

The same considerations apply to the passenger coaches including those with driving cabs. Using the Rolling Stock Report, parts cost for double-deck coaches with driving cabs totaled $ 20,677. 84 percent, or $ 17,369 is time related. The balance, $ 3,308 or $ 0.016 per kilometer, is distance based. These coaches will average 82,449 kilometers per year resulting in an annual cost of $ 17,369 plus $ 1,356 (0.016 x 82,449) or $ 18,725. For the nine coaches with control cabs, the annual maintenance cost is $ 168,523. As these costs are based on IR experience, they are overstated. Cab control coaches on IR include the head-end power equipment with the maintenance cost included in the total. For the new railroad, the head-end power equipment will be installed on the locomotives rather than the coaches. Coaches without control cabs have lower maintenance costs; however, the more conservative value is used.

Since there is nothing comparable to the cargo flatcars included in the above report, it has been necessary to estimate these costs based on typical experience elsewhere. As the majority of parts replacement also occurs during regular inspections, it is anticipated that about 75 percent of parts costs will be time related. As these cars do not have the passenger comfort features of the coaches, parts cost is estimated as 50 percent of the coach cost. Using this approach, annual parts cost per car is $ 6,559. The fixed, or time portion is $ 5,509, and the distance portion $ 1,050 per year or 11 cents per kilometer based on a use of 100,000 km per year. The rolling stock parts costs are given in Table 7.

Table 7: Rolling Stock Parts Cost

1. RAIL ONLY - AT GRADE

	Fixed	Variable	Total per year ($) - 2015			Total per year ($) - 2030		
	$/unit	per km	Fixed	Variable	Subtotal	Fixed	Variable	Subtotal
Locomotives	$31,288	$ 0.033	$ 312,880	$ 31,612	$ 344,492	$ 438,032	$ 95,107	$ 533,139
Passenger Coaches								
Coach + Control Cab	$17,369	$ 0.016	$ 851,081	$ 70,267	$ 921,348	$1,059,509	$263,501	$ 1,323,010
Flat Cars	$ 5,509	$ 0.011	$ 605,990	$ 75,250	$ 681,240	$ 936,530	$228,030	$ 1,164,560
Total Parts Cost			$1,769,951	$ 177,129	$1,947,080	$2,434,071	$586,639	$ 3,020,710

2. RAIL ONLY - TUNNEL

	Fixed	Variable	Total per year ($) - 2015			Total per year ($) - 2030		
	$/unit	per km	Fixed	Variable	Subtotal	Fixed	Variable	Subtotal
Locomotives	$21,902	$ 0.023	$ 219,016	$ 19,774	$ 238,790	$ 350,426	$ 76,086	$ 426,511
Passenger Coaches								
Coach + Control Cab	$17,369	$ 0.016	$ 851,081	$ 70,267	$ 921,348	$1,059,509	$263,501	$ 1,323,010
Flat Cars	$ 5,509	$ 0.011	$ 605,990	$ 75,250	$ 681,240	$ 936,530	$228,030	$ 1,164,560
Total Parts Cost			$1,676,087	$ 165,291	$1,841,378	$2,346,465	$567,617	$ 2,914,082

3. ROAD/RAIL

	Fixed	Variable	Total per year ($) - 2015			Total per year ($) - 2030		
	$/unit	per km	Fixed	Variable	Subtotal	Fixed	Variable	Subtotal
Locomotives	$31,288	$ 0.033	$ 187,728	$ 24,094	$ 211,822	$ 281,592	$ 28,623	$ 310,215
Passenger Coaches								
Coach + Control Cab	$17,369	$ 0.016	$ 399,487	$ 37,329	$ 436,816	$ 851,081	$ 70,267	$ 921,348
Flat Cars	$ 5,509	$ 0.011	$ 330,540	$ 50,167	$ 380,707	$ 605,990	$ 50,167	$ 656,157
Total Parts Cost			$ 917,755	$ 111,590	$1,029,345	$1,738,663	$149,056	$ 1,887,719

The cost of repairs resulting from accident damage is difficult to estimate due to the unusual environment within which the railroad operates and have not been estimated.

5.0 Infrastructure Maintenance

Most railroad infrastructure maintenance varies widely in cost from one year to another. Repairs typically involve major work performed infrequently. The cost in one year may not be typical of what will be incurred on a long-term basis. For this reason, infrastructure costs are estimated on a "normalized" basis reflecting average annual costs assuming that the railroad will continue in operation for an infinite period of time. This also avoids the problem of understated costs since this is a new railroad for which maintenance costs should minimal in the first few years. It is assumed that the railroad will be built to the highest current standards and this will be reflected in reduced long term maintenance cost.

Rail life should be about 35 years. Under the normalized approach, 3 percent of the rail should be replaced each year. This cost is included in annual expense even though it is not actually spent. In this case, the line is 48 kilometers in length. It is assumed that the line is laid with welded rail weighing 136 pounds per yard or UIC 60, weighing 60 kilos per meter.

The railroad will use modern concrete sleepers laid at the rate of 1,500 per kilometer. These sleepers are estimated to last fifty years, indicating that 2 percent, or 30 per year, should be replaced.

Ballast likewise will need periodic replacement. This work is normally combined with resurfacing. With the relatively light trains using the railroad, this work should be performed at ten-year intervals. In order to maximize efficiency, the entire railroad will be surfaced at the same time with one tenth of the cost charged to each year.

The Infrastructure Maintenance Department also has the responsibility of maintaining the various trucks and other vehicles used by the Department. There are six such vehicles, most of which are built on heavy truck chassis. Costs are more characteristic of trucks. As they spend much of their time at work sites with the engine running in order to supply power, compressed air or lighting, it is as if the vehicle were operating most of the day.

Under the Combined Road/Rail Option, train kilometers are reduced by about fifty percent. All costs are to a greater or lesser extent affected by the reduced traffic. Lower traffic volumes affect rail replacement, by reducing the requirements to replace the ballast and sleepers.

The Rail Tunnel will not use sleepers. However, there are other costs associated with ventilation, drainage, and safety that added to the maintenances costs of this alternative. Additional maintenance costs associated with the tunnel are described in annex on ventilation. The Infrastructure Maintenance costs are summarized in Table 8.

Table 8: Infrastructure Maintenance Costs

1. RAIL ONLY - AT GRADE

Item	Frequency	Unit	Unit Cost in US $	Per km	Annual Costs in US $	
					Total 2015	Total 2030
Rail - UIC 60	0.03	Meter	$ 140.00	1,000	$ 176,400	$ 211,680
Ties	0.02	Meter	$ 37.20	1,500	$ 46,872	$ 46,872
Ballast	0.1	Cubic Meter	$ 20.00	1,800	$ 151,200	$ 151,200
Other					$ 56,171	$ 61,463
Yearly Total					$ 430,643	$ 471,215

2. RAIL/ROAD

Item	Frequency	Unit	Unit Cost in US $	Per km	Annual Costs in US $	
Rail - UIC 60	0.02	Meter	$ 140.00	1,000	$ 117,600	$ 176,400
Ties	0.02	Meter	$ 37.20	1,500	$ 46,872	$ 46,872
Ballast	0.08	Cubic Meter	$ 20.00	1,800	$ 120,960	$ 151,200
Other					$ 42,815	$ 56,171
Yearly Total					$ 328,247	$ 430,643

3. RAIL ONLY - TUNNEL

Item	Frequency or Unit Cost	Unit	Unit Cost in US $	Per km	Annual Costs in US $	
					Total 2015	Total 2030
Rail - UIC 60	0.03	Meter	$ 140.00	1,000	$ 176,400	$ 211,680
Ties	0	Meter	$ 37.20	1,500	$ -	$ -
Ballast	0	Cubic Meter	$ 20.00	1,800	$ -	$ -
Centenary Maintenance	1.5	%	1%	$ 15,000	$ 570,000	$ 684,000
Tunnel Structure	2.5	%	0.1%	$ 2,500	$ 95,000	$ 114,000
Drainage/Fire	1	%	1%	$ 10,000	$ 380,000	$ 456,000
Ventilation Maintenance	2	%	1%	$ 20,000	$ 760,000	$ 912,000
Other	0.5	%	1%	$ 5,000	$ 190,000	$ 228,000
Total per Year					$2,171,400	$ 2,605,680

6.0 Accidents and Derailments

Accidents, especially collisions with highway vehicles, and derailments represent a significant expense for many railroads. In this instance, there will be no grade crossings and thus limited opportunity for such collisions except at the terminals. It is possible for trains to collide with each other. There is also the possibility that employees will have on-the-job accidents. A commonly used practice for estimating this expense is to assign a cost per train kilometer based on experience. Based on experience elsewhere, this would result in a cost of $ 2.07 per kilometer. With the elimination of virtually all grade crossings, this cost seems excessive. It has been reduced by fifty percent to $ 1.035 per train kilometer. This results in an annual cost of $ 123,000.

Under the Combined Road/Rail Option, train kilometers are reduced by fifty percent. This reduces this cost to $ 62,000 per year. For the Rail Tunnel, it is increased by 50% because of the seriousness of a tunnel accident.

7.0 Utilities

The railroad will have a need for water, electricity and possibly gas, as well as such services as garbage collection. The cost estimates for these services are based on limited information on rates and experience with consumption on other railroads. Water is required for cleaning and sanitation purposes at each of the terminals and the central repair shop. It will also be required for the car washer. Water cost is estimated based on 500 cubic meters per day.

Electricity will also be required for the terminals and workshop. Electricity is required for much of the workshop machinery, lighting and miscellaneous uses. This cost is estimated at $370,000. See the Annex - Electric power

Communications, solid waste management and other services are required at the two terminals and the central repair shop. They are estimated to cost $50,000 per year. Table 9 summarizes the utility costs.

Table 9: Utility Costs

1. RAIL ONLY - AT GRADE

Item	Unit	No. Units	Unit Cost in $	Annual Cost in US $	
				Total 2015	Total 2030
Water	cm	182500	$ 0.60	$ 109,500	$ 219,000
Electricity-Takumiya	mwh	1200	$ 110.00	$ 132,000	$ 158,400
- Gaza	mwh	2400	$ 110.00	$ 264,000	$ 316,800
Miscellaneous	ls	1	$50,000.00	$ 50,000	$ 60,000
Yearly Total				$ 555,500	$ 754,200

2. RAIL/ROAD

Item	Unit	No. Units	Unit Cost in $	Annual Cost in US $	
Water	cm	150000	$ 0.60	$ 90,000	$ 109,500
Electricity-Takumiya	mwh	1100	$ 110.00	$ 121,000	$ 132,000
- Gaza	mwh	2000	$ 110.00	$ 220,000	$ 264,000
Miscellaneous	ls	1	$40,000.00	$ 40,000	$ 50,000
Yearly Total				$ 471,000	$ 555,500

3. RAIL ONLY - TUNNEL

Item	Unit	No. Units	Unit Cost in $	Annual Cost in US $	
Water	cm	182500	$ 0.60	$ 109,500	$ 219,000
Electricity-Takumiya	mwh	1200	$ 110.00	$ 132,000	$ 158,400
- Gaza	mwh	2400	$ 110.00	$ 264,000	$ 316,800
- Ventilation	mwh	3000	$ 110.00	$ 330,000	$ 330,000
Miscellaneous	ls	1	$50,000.00	$ 50,000	$ 60,000
Yearly Total				$ 885,500	$ 1,084,200

Under the Combined Road/Rail Option, utility cost should be reduced slightly reflecting lower traffic and number of employees. For the Rail Tunnel alternative, there is the additional energy costs of ventilation, lighting and safety not normal required for at grade operations. These operational considerations are discussed in the annex on ventilation.

8.0 Office Expense

The railroad will have a need for various forms, paper, computer supplies and various other supplies for maintaining necessary records, handling correspondence, and similar functions. These supplies are estimated at $ 44,500 per year. Under the Combined Road/Rail Option, these supplies are estimated to cost $ 30,000 per year.

9.0 Staff Training

As this represents a new railroad, there will be a need for extensive staff training by experienced railroad personnel. It has been assumed that the initial training will be provided by IR or a similarly qualified company under contract, and is included in initial investment costs. However, training will be an ongoing expense, as new recruits must be trained to replace those leaving the railroad through normal attrition or required due to increases. It is estimated that attrition will be approximately ten percent per year resulting in a requirement for training about 14 new employees per year. Since it will take several years for railroad staff to develop the level of expertise required for effective training, it is assumed that training will continue to be performed by IR under contract, including use of the simulator.

Training cost includes the salary and benefits of the trainer and the trainee as well as the cost of supporting equipment. Trainer salary cost is estimated as $ 40.13 and that of the trainee as $ 23.33. Twenty days of trainer and trainee time are required for each new hire. Training materials are estimated as $100.00 per trainee. In addition, there is the cost of using IR's locomotive simulator for training. Based on the purchase price ($ 7 million), it is assumed that the hourly cost of the simulator is $ 608 or $ 4,864 per eight-hour day. One-half of the trainees are estimated to require ten days of simulator training. The average cost per trainee is $ 25,700, resulting in an annual cost of $ 360,000.

Under the Combined Road/Rail Option, initial training requirements will remain the same. Annual training requirements will be reduced to 10 persons per year, reducing the annual cost to $257,000.

10.0 Total Operating Expense

The total operating and maintenance cost is summarized in Table 10.

Table 10: Summary of the Operating and Maintenance Costs

Item	2015			2030		
	Rail Only	Road/Rail	Rail Tunnel	Rail Only	Road/Rail	Rail Tunnel
Labor	6,924,400	5,438,067	6,924,400	10,893,867	6,924,400	10,893,867
Motive Energy	4,237,061	2,831,278	3,816,300	15,925,547	3,762,639	13,194,158
Lubricants	423,706	283,128	317,780	1,592,555	376,264	1,194,416
Rolling Stock - Parts	1,928,236	1,017,474	1,824,014	2,958,301	1,871,862	2,853,697
Infrastructure Maintenance	430,643	328,247	2,171,400	471,215	430,643	2,605,680
Accidents & Derailment	123,000	62,000	184,500	246,000	124,000	369,000
Utilities	555,500	471,000	885,500	754,200	555,500	1,084,200
Office Expenses	44,500	30,000	44,500	66,750	45,000	66,750
Staff Training	360,000	257,000	360,000	360,000	257,000	360,000
Total	**$ 15,027,046**	**$ 10,718,192**	**$ 16,528,394**	**$ 33,268,435**	**$ 14,347,308**	**$ 32,621,768**

APPENDIX 7-6

HDM-4 Version 2 VOC Main Inputs & Outputs

Part of the analysis regarding the road options has been carried out using the Highway Deterioration Model (HDM-4), which has been produced by the International Study of Highway Development and Management Tools (ISOHDM), sponsored by The World Bank, the Asian Development Bank, and the Department for International Development (UK), the Swedish National Road Administration, and other sponsors[1]. The Consultant used the latest version of HDM, namely HDM-4 Version 2.

1. Main VOC Inputs

Vehicle attributes	Car	Large bus	Med. Truck	Heavy truck	Car	Large bus	Med. Truck	Heavy truck
	GAZA				WEST BANK			
Basic Characteristic								
Pass. Car Space Equiv.	1.0	1.6	1.4	1.6	1.0	1.6	1.4	1.6
No. of wheels	4	6	6	12	4	6	6	12
No. of axles	2	2	2	3	2	2	2	3
Tire Types	Radial-ply	Bias-ply	Bias-ply	Bias-ply	Radial-ply	Bias-ply	Bias-ply	Bias-ply
Base no. of recaps	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Retread cost	15%	15%	15%	15%	15%	15%	15%	15%
Annual km	25,000	70,000	50,000	60,000	25,000	70,000	50,000	60,000
Working hours	600	2,000	2,000	2,000	600	2,000	2,000	2,000
Average life in years	15	15	15	15	15	15	15	15
Private use	62%	0%	0%	0%	62%	0%	0%	0%
No. of passengers	2.6	20	0	0	2.6	20	0	0
Work-related pass.Trips	50%	50%	100%	100%	50%	50%	100%	100%
Equivalent standart axles	0.01	0.80	1.25	2.28	0.01	0.80	1.25	2.28
Operating weight in tons	1.5	12.0	7.5	13.0	1.5	12.0	7.5	13.0
Average load in tons	-	-	7.0	12.1	-	-	7.0	12.1
Financial unit costs (USD)								
New Vehicle	35,000	120,000	78,000	110,000	35,000	120,000	78,000	110,000
Replacement tire	80	260	200	310	90	290	220	350
Gas/diesel per liter	1.2	0.78	0.78	0.78	1.2	0.78	0.78	0.78
Lubricating oil per liter	1.6	1.6	1.6	1.6	1.8	1.8	1.8	1.8
Maintenance labor per hour	1.62	1.82	1.82	2.42	2.23	2.50	2.50	3.33
Crew wages per hour	1.20	2.00	2.00	2.00	1.65	2.75	2.75	2.75
Annual overhead	950	5,200	3,560	4,600	950	5,200	3,560	4,600
Annual interest	16%	16%	16%	16%	16%	16%	16%	16%
Pass. Working time/hour	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87
Pass.nonwork.time/hour	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
Cargo per hour	-	-	0.08	0.13	-	-	0.08	0.13

Sources:

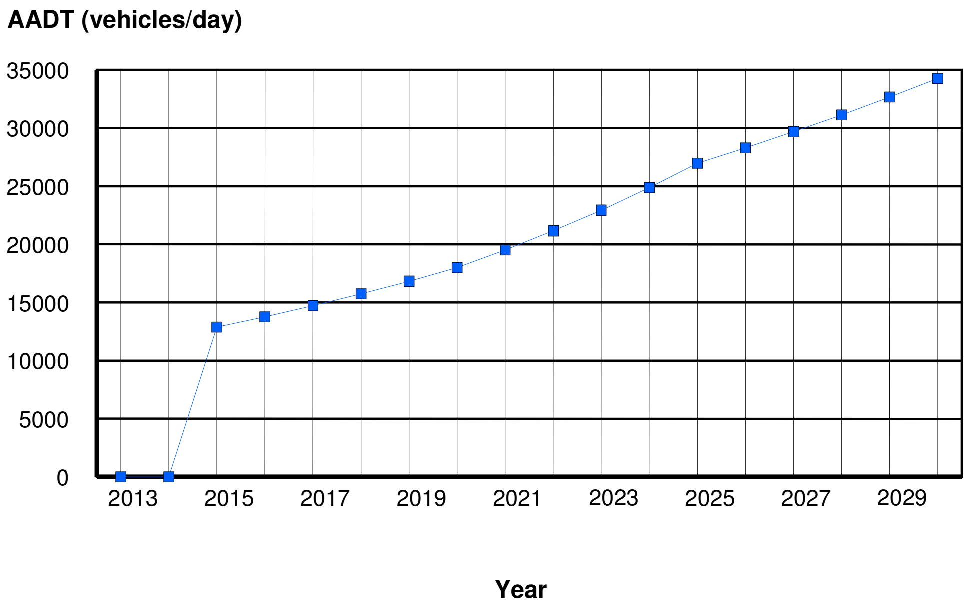
- Consultant's estimates based on surveys carried out in Gaza and the West Bank.
- Palestine Central Bureau of Statistics.
- Abu-Eisheh, S., Al-Sahili, K., and Kobari, F., Infrastructure Assessment in the West Bank and Gaza: The Transport Sector Assessment, Final Report, Universal Group for Engineering & Consulting, Submitted to the World Bank. 2004.

[1] / The HDM-4 products are jointly published by The World Road Association (PIARC), Paris and The World Bank, Washington, DC.

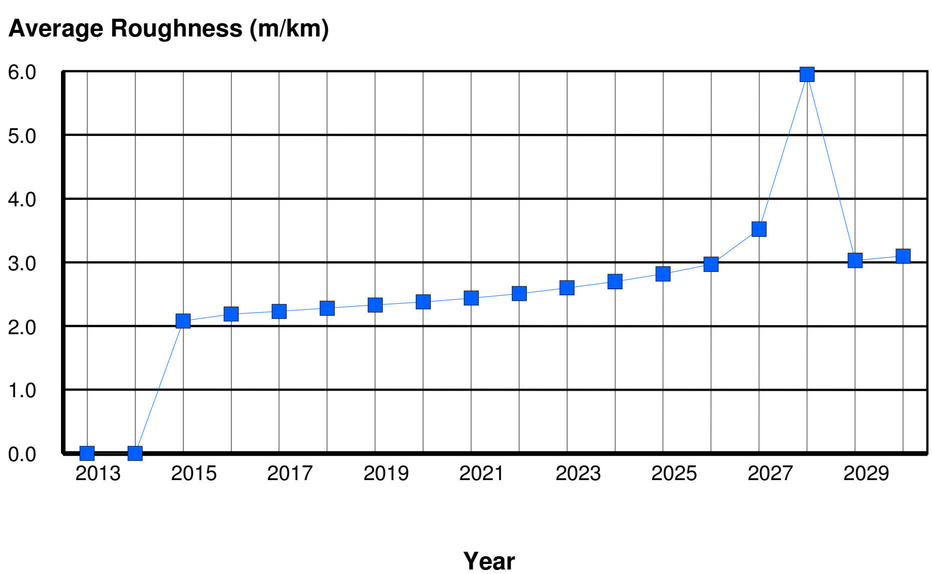
- Al-Sahili, K. and Sadeq Abdulmajid. "Ridership Demand Modeling for Palestinian Intercity Public Transport." Journal of Public Transportation, Center for Urban Transportation Research, Vol. 6, No. 2, 2003.

2. Main Outputs – Road-only option

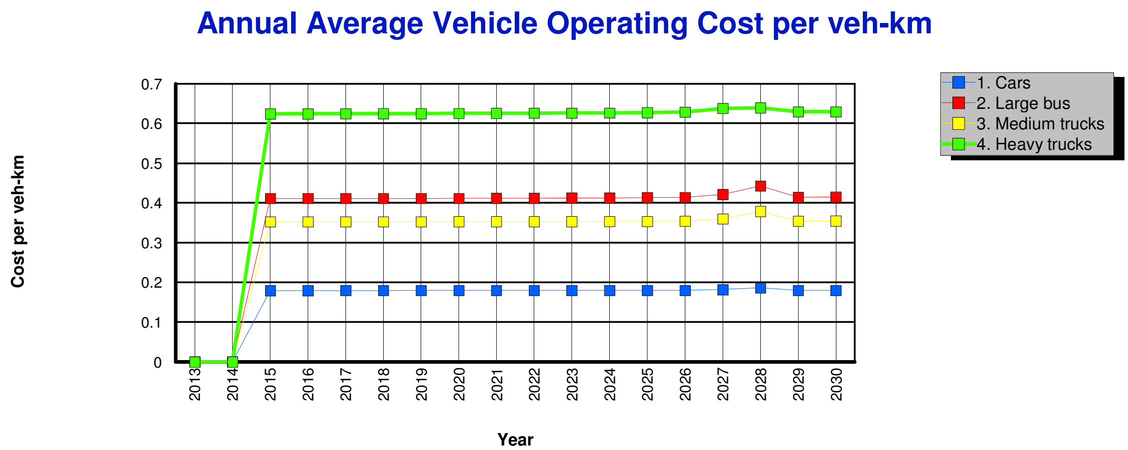
2.1 Traffic Levels



2.2 Average roughness



2.3. Vehicle operating costs per vehicle type (in US$)



3. Road user cost components per vehicle type (in US$)

	Fuel	Lubricatin Oil	Tyres	Spare Parts	Maint Labour	Capital	Crew	Overhead	TOTAL VOC	*VOC on train*
Economic per thousand km										
1. Cars	85.44	0.82	3.00	33.78	4.22	45.58	3.96	3.20	**180.00**	
2. Large bus	234.98	3.56	11.15	58.37	15.13	54.17	18.91	19.34	**415.60**	
3. Medium tru	172.42	2.31	9.46	77.17	17.80	44.99	18.44	13.16	**355.75**	***76.59***
4. Heavy truck	361.44	4.66	29.80	116.34	30.59	53.31	17.81	15.90	**629.86**	***87.03***
									TOTAL VOC	***VOC on train***
Economic on the corridor										
1. Cars	3.76	0.04	0.13	1.49	0.19	2.01	0.17	0.14	**7.92**	
2. Large bus	10.34	0.16	0.49	2.57	0.67	2.38	0.83	0.85	**18.29**	
3. Medium tru	7.59	0.10	0.42	3.40	0.78	1.98	0.81	0.58	**15.65**	***3.37***
4. Heavy truck	15.90	0.20	1.31	5.12	1.35	2.35	0.78	0.70	**27.71**	***3.83***
Standard conversion factor									**Average**	***Average***
1. Cars	0.58	0.63	0.63	0.63	0.73	0.51	0.73	0.57	**0.58**	
2. Large bus	0.86	0.63	0.63	0.63	0.73	0.51	0.73	0.73	**0.73**	
3. Medium tru	0.86	0.63	0.63	0.63	0.73	0.48	0.73	0.74	**0.71**	***0.56***
4. Heavy truck	0.86	0.63	0.63	0.63	0.73	0.49	0.73	0.72	**0.74**	***0.56***
									TOTAL VOC	***VOC on train***
Financial per thousand km										
1. Cars	146.47	1.29	4.74	53.45	5.75	89.16	5.40	5.66	**311.92**	
2. Large bus	273.96	5.63	17.64	92.36	20.63	107.14	25.78	26.57	**569.71**	
3. Medium tru	201.03	3.66	14.96	122.11	24.27	93.12	25.14	17.74	**502.03**	***136.00***
4. Heavy truck	421.41	7.37	47.16	184.08	41.70	107.95	24.28	22.14	**856.10**	***154.37***
									TOTAL VOC	***VOC on train***
Financial on the corridor										
1. Cars	6.44	0.06	0.21	2.35	0.25	3.92	0.24	0.25	**13.72**	
2. Large bus	12.05	0.25	0.78	4.06	0.91	4.71	1.13	1.17	**25.07**	
3. Medium tru	8.85	0.16	0.66	5.37	1.07	4.10	1.11	0.78	**22.09**	***5.98***
4. Heavy truck	18.54	0.32	2.07	8.10	1.83	4.75	1.07	0.97	**37.67**	***6.79***

Appendix 9-1

Environmental Actions and Specific Impacts

The following section provides an analysis of the impact that each alternative (action) might have on the environment, based on location (plains, hills, mountain) and receiving media (nature reserves, streams, open spaces, etc.), and time (during construction and operation).

As previously indicated, the following semi-quantitative environmental impact analysis was based on the ecological information collected from government agencies and academic institutions, interviews with experts, secondary data, site visits, and professional judgment. In-depth environmental assessments will be required for the recommended alternatives.

Impacts to nearby nature reserves, national forests, and other sensitive habitats

Alternative A-1: At-grade road, rail, combination, in coastal plains (Gaza-border to Lahish)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	High	4
	Extend (EX) =	Extensive	4
	Duration (D) =	Temporal	2
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Periodic	2
	Value = + / - (DD+EX+D+RV+RO)		**-16**
Importance		***Medium***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts from road construction activities on nearby nature reserves and forests are considered to be low due to the distances established during the design. Preliminary screenings of alignments took this element into consideration for the design and siting of the alignments by avoiding (to the extent possible) a close proximity to these areas. Some of the potential indirect impacts during construction include increased traffic (emissions), noise, air particulates, and they have a cumulative effect on these habitats. However, some of these impacts (e.g. increased air particulates, emissions from heavy machinery) are mitigable, temporary, and reversible upon completion of works. Operational impacts derived from an at-grade road (e.g. emissions, noise) near protected areas are permanent, irreversible, but of low intensity. Some impacts such as emissions can be reduced through implementation of typical transport emission minimization environmental guidelines. The segment of the road between the Gaza-border and the hills of Lahish is located in the proximity (100 meters to 1 km) of the some National Parks, water bodies, and forests.

Operational impacts to forests are divided into those originated from an enclosed alignment and those from an open one.

Operation (Enclosed Alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	High	4
	Extend (EX) =	Partial	2
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-18**
Importance		***High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Medium	2
	Extend (EX) =	Partial	2
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-16**
Importance		***Medium***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Once again, the difference in expected impact importance is due to the barrier effect produced by enclosed alignments.

Impacts to nearby nature reserves, national forests, and other sensitive habitats

Alternative A-1: At-grade road, rail, combination, in Hills (Lahish-Tarkoumiya)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Medium	2
	Extend (EX) =	Partial	2
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Periodic	2
	Value = + / - (DD+EX+D+RV+RO)		**-14**
Importance		***Medium***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts to forested areas are considered to be of medium importance due to the proximity to a proposed national park and existing forests around Beth Guvrin area.

Operation (Enclosed Alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	High	4
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-18**
Importance		***High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Medium	2
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-16**
Importance		***Medium***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

The difference in impact importance resides in the effects an enclosed alignment has for forest wildlife compared to an open alignment in this region.

Impacts to nearby nature reserves, national forests, and other sensitive habitats

<u>Alternative A-1: At-grade road, rail, combination, in plains (Tarkoumiya-Hebron)</u>

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Partial	2
	Duration (D) =	Temporal	2
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Periodic	2
	Value = + / - (DD+EX+D+RV+RO)		**-9**
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts to forested areas are considered to be of low importance due to the lack of significant forested areas near this portion of the alignment. No enclosed alignment is expected to be built in Palestinian controlled areas thereby only Open-type alignment is evaluated.

Operation (Open alignment)

Impact	**Valuation**		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Partial	2
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-13**
Importance		***Medium***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Slightly higher impact is expected from operation than from construction due to the continuous effect on vegetation from vehicular emissions.

Impacts to nearby streams and associated habitats

Impacts to nearby streams and associated habitats derived from the construction of an at-grade road are significant but can be appropriately mitigated through the implementation of engineering mitigation and restoration measures that include river bank stabilization, restoration of riparian vegetation in affected areas, and seasonal construction measures such as avoidance of rainy seasons in intermittent streams. Effects of construction and operation activities are summarized below. It is important to emphasize that the assessment of potential impacts took into consideration the previously recommended mitigation measures. In addition, the impacts of an At-grade road will probably depend on topography (in the mountains the impact is lesser due to bridging) and number of stream-crossings.

Alternative A-1: At-grade road, rail, combination, in coastal plains (Gaza-border to Lahish)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	High	4
	Extend (EX) =	Partial	2
	Duration (D) =	Temporal	2
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Periodic	2
	Value = + / - (DD+EX+D+RV+RO)		**-14**
Importance		***Medium***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Enclosed Alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Punctual	1
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-12**
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Punctual	1
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-12**
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Construction impacts are higher than operational ones and in the case of the studied streams mitigation and remediation are feasible options.

Impacts to nearby streams and associated habitats

Alternative A-1: At-grade road, rail, combination, in Hills (Lahish-Tarkoumiya)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Partial	2
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Periodic	2
	Value = + / - (DD+EX+D+RV+RO)		**-11**
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Enclosed Alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Punctual	1
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-12**
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Punctual	1
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-12**
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Construction impacts in hilly areas were considered to be lower than in the plains due to the reduced number of stream crossings.

Impacts to nearby streams and associated habitats

Alternative A-1: At-grade road, rail, combination, in Mountains (Tarkoumiya-Hebron)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Punctual	1
	Duration (D) =	Temporal	2
	Reversibility (RV) =	Short-term	1
	Ocurrence (RO) =	Periodic	2
	Value = + / - (DD+EX+D+RV+RO)		**-7**
Importance		***Very Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

No enclosed alignment is expected to be built in Palestinian controlled areas so only Open-type alignment is evaluated.

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Punctual	1
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Short-term	1
	Ocurrence (RO) =	Periodic	2
	Value = + / - (DD+EX+D+RV+RO)		**-9**
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Landscape Impacts (visual effects, free wildlife passage, open spaces)

Alternative A-1: At-grade road, rail, combination, in coastal plains (Gaza-border to Lahish)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-28**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Enclosed Alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-28**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-26**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Landscape impacts are considered one the most important both during construction and operation activities. The issue of open spaces, and free human and wildlife movement are central components of this impact.

Landscape Impacts (visual effects, free wildlife passage, open spaces)

Alternative A-1: At-grade road, rail, combination, in Hills (Lahish-Tarkoumiya)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Temporal	2
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-26**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Enclosed Alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-28**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-26**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

In the hilly areas of Lahish the impact on landscape is equally high to those in lower areas of the alignment.

Landscape Impacts (visual effects, free wildlife passage, open spaces)

Alternative A-1: At-grade road, rail, combination, in Mountains (Tarkoumiya-Hebron)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Temporal	2
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-26**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

No enclosed alignment is expected to be built in Palestinian controlled areas so only Open-type alignment is evaluated. However, impacts during construction and during operations are expected to be as high as in hilly areas or in the plains.

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-26**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts to biological corridors and biological bottlenecks

Alternative A-1: At-grade road, rail, combination, in coastal plains (Gaza-border to Lahish)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Very High	8
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-24**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Enclosed Alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-28**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-28**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts to biological corridors are almost unavoidable and represent a level of impact importance similar to those represented by the impact on open spaces and landscapes.

Impacts to biological corridors and biological bottlenecks

Alternative A-1: At-grade road, rail, combination, in Hills (Lahish-Tarkoumiya)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	High	4
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Periodic	2
	Value = + / - (DD+EX+D+RV+RO)		-18
Importance		***High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Enclosed Alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	High	4
	Extend (EX) =	Partial	2
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		-18
Importance		***High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	High	4
	Extend (EX) =	Partial	2
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		-18
Importance		***High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

The slightly reduced impact of this alternative on biological corridors is due primarily to the location of the alignment, the corridors, and the type of terrain. However, it continues to be of high importance.

Impacts to biological corridors and biological bottlenecks

Alternative A-1: At-grade road, rail, combination, in Mountains (Tarkoumiya-Hebron)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	High	4
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Periodic	2
	Value = + / - (DD+EX+D+RV+RO)		**-18**
Importance		***High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Since no enclosed alignment is expected to be built in Palestinian controlled areas, impacts to biological corridors are lesser than in previous segments of the alignment. However, it might still have a significantly impact on biological movements.

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	High	4
	Extend (EX) =	Partial	2
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-18**
Importance		***High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts to planned biosphere (within Israeli territory)

Alternative A-1: At-grade road, rail, combination, in coastal plains (Gaza-border to Lahish)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Temporal	2
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Periodic	2
	Value = + / - (DD+EX+D+RV+RO)		**-24**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Enclosed Alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Very High	8
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-24**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Very High	8
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-24**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

This alternative crosses through the southern portion of the proposed Biosphere and subsequently, impacts are considered to be very high. Some engineering mitigations are possible and might reduce the impact levels.

Alternative A-1: At-grade road, rail, combination, in Hills (Lahish-Tarkoumiya)

No impacts to Biosphere in this segment of the road

Alternative A-1: At-grade road, rail, combination, in Mountains (Tarkoumiya-Hebron)

No impacts to Biosphere in this segment of the road

Impacts to nearby nature reserves, national forests, and other sensitive habitats

Alternative A-2: At-grade road, rail, combination, in coastal plains (Gaza-border to Lahish)

The area established for the siting of alignment 2 is in closer proximity of (and in one case crosses over) nature reserves and forests. This condition produces an increase in the estimated environmental impact, both from construction and operation activities.

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Very High	8
	Extend (EX) =	Extensive	4
	Duration (D) =	Temporal	2
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Periodic	2
	Value = + / - (DD+EX+D+RV+RO)		**-20**
Importance		***High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operational impacts to forests are divided into those originated from an enclosed alignment and those from an open one.

Operation (Enclosed Alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	High	4
	Extend (EX) =	Partial	2
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-18**
Importance		***High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	High	4
	Extend (EX) =	Partial	2
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-18**
Importance		***High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts to nearby nature reserves, national forests, and other sensitive habitats

Alternative A-2: At-grade road, rail, combination, in Hills (Lahish-Tarkoumiya)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Medium	2
	Extend (EX) =	Partial	2
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Periodic	2
	Value = + / - (DD+EX+D+RV+RO)		**-14**
Importance		***Medium***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts to forested areas are considered to be of medium-high importance due to the proximity to a proposed national park and existing forests around Beth Guvrin area.

Operation (Enclosed Alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	High	4
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-18**
Importance		***High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Medium	2
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-16**
Importance		***Medium***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts to nearby nature reserves, national forests, and other sensitive habitats

Alternative A-2: At-grade road, rail, combination, in Mountains (Tarkoumiya-Hebron)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Partial	2
	Duration (D) =	Temporal	2
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Periodic	2
	Value = + / - (DD+EX+D+RV+RO)		**-9**
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts to forested areas are considered to be of low importance due to the lack of significant forested areas near this portion of the alignment. No enclosed alignment is expected to be built in Palestinian controlled areas so only Open-type alignment is evaluated.

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Partial	2
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-13**
Importance		***Medium***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Slightly higher impact is expected from operation than from construction due to the continuous effect on vegetation from vehicular emissions, human intrusion, and potentially increased traffic and access to areas which were remote prior to alignment construction.

Impacts to nearby nature reserves, national forests, and other sensitive habitats

Alternative A-2: Sunken road in coastal plains (Gaza-border to Lahish)

This option is only considered for the coastal plains, and it is considered to represent a very high environmental impact, and remediation options are limited.

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Periodic	2
	Value = + / - (DD+EX+D+RV+RO)		**-26**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Not Feasible	

Operation (Enclosed Alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Total	8
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-32**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Not Feasible	

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Total	8
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-32**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Not Feasible	

Impacts to nearby streams and associated habitats

Alternative A-2: At-grade road, rail, combination in coastal plains (Gaza-border to Lahish)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	High	4
	Extend (EX) =	Partial	2
	Duration (D) =	Temporal	2
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Periodic	2
	Value = + / - (DD+EX+D+RV+RO)		**-14**
Importance		***Medium***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Enclosed Alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Punctual	1
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-12**
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Punctual	1
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-12**
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts are similar to those identified for A-1 in coastal plains.

Impacts to nearby streams and associated habitats

Alternative A-2: At-grade road, rail, combination in (Lahish-Tarkoumiya)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Partial	2
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Periodic	2
	Value = + / - (DD+EX+D+RV+RO)		-11
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Enclosed Alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Punctual	1
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		-12
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Punctual	1
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		-12
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts are similar to those identified for A-1 in hilly areas.

Impacts to nearby streams and associated habitats

Alternative A-2: At-grade road, rail, combination in (Tarkoumiya-Hebron)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Punctual	1
	Duration (D) =	Temporal	2
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Periodic	2
	Value = + / - (DD+EX+D+RV+RO)		**-8**
Importance		***Very Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

No enclosed alignment is expected to be built in Palestinian controlled areas so only Open-type alignment is evaluated.

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Punctual	1
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Short-term	1
	Ocurrence (RO) =	Periodic	2
	Value = + / - (DD+EX+D+RV+RO)		**-9**
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts to streams in this area are considered to be limited when compared to the coastal plain or hilly areas of Lahish region.

Impacts to nearby streams and associated habitats

Alternative A-2: Sunken road in coastal plains (Gaza-border to Lahish)

This alternative is being contemplated only for the coastal plains

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Total	8
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		-32
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Enclosed Alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Total	8
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		-32
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Total	8
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		-32
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

The impact of a sunken road on existing streams is total and permanent, making it one of very high importance.

Landscape Impacts (visual effects, free wildlife passage, open spaces)

Alternative A-2: At-grade road, rail, combination, in coastal plains (Gaza-border to Lahish)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-28**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Enclosed Alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-28**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-26**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Similar impacts to those identified for A-1 can be expected for this alternative.

Landscape Impacts (visual effects, free wildlife passage, open spaces)

Alternative A-2: At-grade road, rail, combination, in Hills (Lahish-Tarkoumiya)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Temporal	2
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-26**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Enclosed Alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-28**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-26**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Similar impacts to those identified for A-1 can be expected for this alternative.

Landscape Impacts (visual effects, free wildlife passage, open spaces)

Alternative A-2: At-grade road, rail, combination, in Mountains (Tarkoumiya-Hebron)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Temporal	2
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-26**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

No enclosed alignment is expected to be built in Palestinian controlled areas so only Open-type alignment is evaluated. Similar impacts to those identified for A-1 can be expected for this alternative.

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-26**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Landscape Impacts (visual effects, free wildlife passage, open spaces)

Alternative A-2: Sunken road in coastal plains (Gaza-border to Lahish)

This alternative is being contemplated only for the coastal plains. Similar impacts to those identified for A-1 can be expected for this alternative.

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Total	8
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		-32
Importance		*Very High*	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Enclosed Alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Total	8
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		-32
Importance		*Very High*	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Total	8
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		-32
Importance		*Very High*	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts to biological corridors and biological bottlenecks

Alternative A-2: At-grade road, rail, combination, in coastal plains (Gaza-border to Lahish)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Very High	8
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-24**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Enclosed Alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-28**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-28**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Similar impacts to those identified for A-1 can be expected for this alternative, although some segments of the alignment travel away from critical areas affected by A-1.

Impacts to biological corridors and biological bottlenecks

Alternative A-2: At-grade road, rail, combination, in Hills (Lahish-Tarkoumiya)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	High	4
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Periodic	2
	Value = + / - (DD+EX+D+RV+RO)		**-18**
Importance		***High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Enclosed Alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	High	4
	Extend (EX) =	Partial	2
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-18**
Importance		***High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	High	4
	Extend (EX) =	Partial	2
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-18**
Importance		***High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Similar impacts to those identified for A-1 can be expected for this alternative.

Impacts to biological corridors and biological bottlenecks

Alternative A-2: At-grade road, rail, combination, in Mountains (Tarkoumiya-Hebron)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	High	4
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Periodic	2
	Value = + / - (DD+EX+D+RV+RO)		**-18**
Importance		***High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

No enclosed alignment is expected to be built in Palestinian controlled areas so only Open-type alignment is evaluated. Similar impacts to those identified for A-1 can be expected for this alternative.

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	High	4
	Extend (EX) =	Partial	2
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-18**
Importance		***High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts to biological corridors and biological bottlenecks

Alternative A-2: Sunken road in coastal plains (Gaza-border to Lahish)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Critical	12
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-36**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Enclosed Alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Critical	12
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-36**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Critical	12
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-36**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Similar impacts to those identified for landscapes can be expected for this alternative.

Impacts to planned biosphere (within Israeli territory)

Alternative A-2: At-grade road, rail, combination, in coastal plains (Gaza-border to Lahish)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Temporal	2
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Periodic	2
	Value = + / - (DD+EX+D+RV+RO)		-24
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Enclosed Alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Very High	8
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		-24
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Very High	8
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		-24
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Similar impacts to those identified for A-1 can be expected for this alternative.

Alternative A-2: At-grade road, rail, combination, in Hills (Lahish-Tarkoumiya)

No impacts to Biosphere in this segment of the road

Alternative A-2: At-grade road, rail, combination, in Mountains (Tarkoumiya-Hebron)

No impacts to Biosphere in this segment of the road

Impacts to planned biosphere (within Israeli territory)

Alternative A-2: Sunken road in coastal plains (Gaza-border to Lahish)

This alternative is being contemplated only for the coastal plains

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Critical	12
	Duration (D) =	Temporal	2
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-34**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Enclosed Alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Critical	12
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-36**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Operation (Open alignment)

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Critical	12
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-36**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Similar impacts to those identified for landscapes and biological corridors can be expected for this alternative.

Impacts to nearby nature reserves, national forests, and other sensitive habitats

Alternative A-7: Rail Only – Cut-and-Cover (Gaza-border to Lahish)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Temporal	2
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Irregular	1
	Value = + / - (DD+EX+D+RV+RO)		**-23**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts during Operation

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Punctual	1
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-12**
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

In general terms the impacts of construction are considered total but this alternative offers a feasible option for ecological restoration and enhancement (e.g. forest restoration on top of alignment). The impacts from operations are "punctual" because they refer to exit and support facilities for the "buried rail" which are located at 250-meter intervals along the alignment.

Impacts to nearby nature reserves, national forests, and other sensitive habitats

Alternative A-7: Tunnel (Lahish-Tarkoumiya-Hebron)

The potential environmental impacts from tunnel construction are listed at the beginning of this section. In general terms the impacts of construction are not minimal but are manageable. Significantly higher impacts are usually expected on the infrastructure system (roads) that will be recipients of heavy truck traffic, and in deposition areas of excavation material. Punctual impacts are associated with the required excavation points and construction of maintenance, emergency exits, and aeration points to be located at 250meter-intervals.

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Medium	2
	Extend (EX) =	Partial	2
	Duration (D) =	Temporal	2
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Irregular	1
	Value = + / - (DD+EX+D+RV+RO)		**-11**
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts during Operation

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Punctual	1
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-12**
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts to nearby streams and associated habitats

Alternative A-7: Rail Only – Cut-and-Cover (Gaza-border to Lahish)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Partial	2
	Duration (D) =	Temporal	2
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Irregular	1
	Value = + / - (DD+EX+D+RV+RO)		**-21**
Importance		***High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts during Operation

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Punctual	1
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-12**
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

The impacts from operations are “punctual” because they refer to exit and support facilities for the “buried rail” which are located at 250-meter intervals along the alignment, and because the need to provide for remedial alternatives at pointed stream-crossings.

Impacts to nearby streams and associated habitats

Alternative A-7: Tunnel (Lahish-Tarkoumiya-Hebron)

Environmental impacts from tunnel construction as described before.

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Medium	2
	Extend (EX) =	Partial	2
	Duration (D) =	Temporal	2
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Irregular	1
	Value = + / - (DD+EX+D+RV+RO)		**-11**
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts during Operation

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Punctual	1
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-12**
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts to Landscapes

Alternative A-7: Rail Only – Cut-and-Cover (Gaza-border to Lahish)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Temporal	2
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Irregular	1
	Value = + / - (DD+EX+D+RV+RO)		**-23**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts during Operation

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Punctual	1
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-12**
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

The impacts from operations are “punctual” because they refer to exit and support facilities for the “buried rail” which are located at 250-meter intervals along the alignment. Similar impacts to those previously described.

Impacts to Landscapes

Alternative A-7: Tunnel (Lahish-Tarkoumiya-Hebron)

Environmental impacts from tunnel construction as described before.

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Medium	2
	Extend (EX) =	Extensive	4
	Duration (D) =	Temporal	2
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Irregular	1
	Value = + / - (DD+EX+D+RV+RO)		**-13**
Importance		***Medium***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts during Operation

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Punctual	1
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-12**
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts to Biological Corridors and Bottlenecks

Alternative A-7: Rail Only – Cut-and-Cover (Gaza-border to Lahish)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Temporal	2
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Irregular	1
	Value = + / - (DD+EX+D+RV+RO)		**-23**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts during Operation

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Punctual	1
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-12**
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

As previously described, in general terms the impacts of construction are considered total but this alternative offers a feasible option for ecological restoration and enhancement (e.g. forest restoration on top of alignment). The impacts from operations are "punctual" because they refer to exit and support facilities for the "buried rail" which are located at 250-meter intervals along the alignment.

Impacts to Biological Corridors and Bottlenecks

Alternative A-7: Tunnel (Lahish-Tarkoumiya-Hebron)

Environmental impacts from tunnel construction as described before.

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Medium	2
	Extend (EX) =	Extensive	4
	Duration (D) =	Temporal	2
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Irregular	1
	Value = + / - (DD+EX+D+RV+RO)		**-13**
Importance		***Medium***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts during Operation

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Punctual	1
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-12**
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts to Planned Biosphere

Alternative A-7: Rail Only – Cut-and-Cover (Gaza-border to Lahish)

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Total	12
	Extend (EX) =	Extensive	4
	Duration (D) =	Temporal	2
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Irregular	1
	Value = + / - (DD+EX+D+RV+RO)		**-23**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts during Operation

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Punctual	1
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-12**
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

In general terms the impacts of construction are considered total but this alternative offers a feasible option for ecological restoration and enhancement (e.g. forest restoration on top of alignment). The impacts from operations are "punctual" because they refer to exit and support facilities for the "buried rail" which are located at 250-meter intervals along the alignment.

Impacts to all critical factors

Alternative A-8: Tunnel

The characterizations of environmental impacts from tunnel construction require additional information on the nature of the project, the geological characteristics of the excavation areas, and environmental conditions of the disposal sites for the excavated material. For the purpose of this study it is important to identify those drivers that will need to be considered during the full Environmental Impact Studies. These include, among others:

- Extent of impacts at the local level
  - Excavations sites
  - Punctual impacts from operations, which are "punctual" because they refer to exit and support facilities for the "buried rail" which are located at 250-meter intervals along the alignment.
  - Transport of extensive amounts of excavation material and its effect on local infrastructure (roads), noise and emissions of heavy machinery operation
  - Potential impacts to groundwater flows
  - Potential impacts to cultural resources (vibrations)
  - Potential impacts of disruption of local populations (traffic increases, etc.)
- Impacts related to deposition areas of excavation material
  - Identification of discharge areas
  - Identification of positive uses of excavation material
  -

These are some examples associated with tunnel construction. The following analysis takes into consideration the potential impacts previously described.

Impacts during Construction

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	High	4
	Extend (EX) =	Partial	2
	Duration (D) =	Temporal	2
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Irregular	1
	Value = + / - (DD+EX+D+RV+RO)		**-13**
Importance		***Medium***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

Impacts during Operation

Impact	Valuation		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	Low	1
	Extend (EX) =	Punctual	1
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Mid-term	2
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-12**
Importance		***Low***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Feasible	

The potential environmental impacts from tunnel construction are listed at the beginning of this section. In general terms the impacts of construction are not minimal but are manageable. Significantly higher impacts are usually expected on the infrastructure system (roads) that will be recipients of heavy truck traffic, and in deposition areas of excavation material. Punctual impacts are associated with the required excavation points and construction of maintenance, emergency exits, and aeration points to be located at 250meter-intervals.