

IRRIGATION MASTER PLAN FOR PUTRAJAYA

FINAL REPORT

Volume II - Main Report

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1. INTRODUCTION

The Putrajaya development boundary encompasses 4,400 hectares and the whole project area is represented by 20 precincts as shown in Map 1 (Volume I - Executive Summary Report).

Putrajaya will be developed in phases viz 1A, 1B and 2, and is expected to complete by year 2010.

The scope covered in this Final Report comprises the following:

- Identification of irrigation areas in each precinct. The irrigation areas had been classified in accordance to use class order and are grouped into public as well as private realms respectively.
- Determination of plant water demand at various growth stage and development phasing from year 2000 to 2010.
- Hydrological studies and assessment of Putrajaya Lake draw down due to various irrigation demand scenarios.
- Identification of water sources including groundwater.
- Water quality assessment.
- Formulation of irrigation and landscape strategies.
- Identification of intake points.
- Evaluation and recommendation of irrigation options and concept design.
- Integrated Irrigation Management System (IIMS)
- Legal requirement on irrigation practices, policy and guidelines for irrigation infrastructure development.
- Checklists for irrigation development approval.

2. HYDROLOGY

Hydrological studies were carried out to assess the climatic conditions in Putrajaya which would affect the crop water requirements of plants in the area and to estimate the flows into lakes, ponds and other water storage system planned for Putrajaya. In addition, the hydrology of Sungai Langat was also examined as it is considered a potential source of external water supply nearby. Hydrology of nearby river basins will serve as a check on results obtained for Putrajaya.

Past studies on hydrology had been carried out for Putrajaya and this include the Putrajaya Lake Development Study by Minconsult et al (1996), the Catchment Development and Management Plan for Putrajaya Lake by NAHRIM et al (1999) and their results were treated as a source of additional information which we could build on under this study and they also serve as a reference for cross-checking our results.

2.1 General Hydrology

Sungai Chuau is the main river flowing through Putrajaya and is the main source of water for the Putrajaya Lake. The catchment of Putrajaya is 32 km² at the present temporary dam (phase 1A) and is 60 km² if the catchment up to the downstream main dam site (phase 1B) as shown in Figure 2.1 is considered.

The annual rainfall in Putrajaya is about 2200 mm. Rainfall is slightly higher during March, April and October, November, December (see Figure 2.2). Pan evaporation recorded at Prang Besar shows a fairly even evaporation rate of 4.8 mm/day. The potential evapotranspiration (E_{to}) estimated from Perkhidmatan Kajicuaca's climate data is 3.64 mm/day.

Except for a brief period of data collection (1994), there is no other runoff data available for analysis. Estimates of annual runoff based on other river basins nearby shows that the average annual runoff is 800 mm to 1200 mm.

2.2 Rainfall Analysis

Of particular interest to this study is the distribution of rainfall in Putrajaya, the number of consecutive dry days when irrigation would be required and water storage critically depleted. Rainfall data is also required to estimate flows into proposed rainwater harvesting systems and the Putrajaya Lake.

Daily rainfall data were obtained from Jabatan Pengairan dan Saliran (JPS)'s hydrological database for this study. The rainfall stations are listed in Table 2.1 below.

Table 2.1 Existing Rainfall Station Around Putrajaya

JPS Station number	Location	Average Annual Rainfall
2917001	Stor JPS Kajang	2036 mm
2917106	Ladang West Country	2319 mm
2916001	Prang Besar	2148 mm
2816112	Ladang Galloway	2087 mm

The annual average rainfall is slightly lower than the overall average rainfall in Peninsular Malaysia which is about 2500 mm. The monthly rainfall distribution indicates that rainfall is slightly lower in the months of Jun, July and August but the severity of drought is not as extreme as that experienced in the northwestern part of Peninsular Malaysia.

2.3 No-Rain Days Analysis

Of the four rainfall stations only the stations at Ladang West Country and Ladang Galloway have long-term records for reliable statistical analysis as tabulated in Table 2.2 and 2.3. No rain days analysis shows that on the average the number of consecutive days of zero rainfall is 15 days. The analysis was extended to categorise rainfall less than 5mm/day and 10mm/day as no-rain day. The results of no-rain day's analysis are presented the following Table 2.4.

Table 2.4 Results of No-Rain Analysis

	Average	10-yr	20-yr	50-yr
Number of consecutive days of rain				
0 mm/day	15	20	22	24
< 5 mm/day	22	31	33	36
< 10 mm/day	29	40	43	47
< 15 mm/day	36	50	55	67
Total days of rain				
0 mm/day	204	–	–	–
< 5 mm/day	264	–	–	–
< 10 mm/day	290	–	–	–
< 15 mm/day	310	–	–	–

2.4 Stacked Frequency Analysis Of Rainfall

Stacked frequency analyses are normally carried out on flow data. The methodology involved is clearly documented in Twort et al (1994). This methodology was extended to analyse cumulative monthly rainfall data so as to determine the cumulative rainfall depth during drought periods of various durations i.e. 1-month, 2-month 3-month etc. The probability distribution used to fit the data is the 3-parameter log-normal distribution. Again only the data from Ladang West Country and Ladang Galloway were analysed as the amount of data from this two stations are substantial. Results of rainfall frequency analysis are as shown in Figures 2.3 and 2.4. These curves coupled with suitable rainfall-runoff relationship could be used to determine flows into proposed storage systems during drought periods.

2.5 Estimation Of Potential Evapotranspiration

Potential evapotranspiration (Eto) values are required for estimation of crop water requirement and hence the irrigation demand. Annual evapotranspiration in the country varies between 1000 mm to 1600mm. The highest Eto in Peninsular Malaysia occurs in the Kedah area.

Eto values were computed using climate data extracted from Perkhidmatan Kajiucaca Malaysia's annual publications. The Penman-Montieth method was used to estimate Eto. Adjustment had to be carried out to reduce the wind speed data to equivalent wind speed at 2m above ground level. (PKM's station measures wind speed at 10 m above the ground level) before being used in the Penman-Montieth equation of Eto estimation. Details on Eto data and its derivation are presented in Table 2.5.

Pan evaporation data from JPS's stations at Prang Besar was also obtained. A factor of 0.75 was multiplied to JPS's pan evaporation values to convert them to Eto values.

2.6 Rainfall-Runoff Analysis

It is necessary to estimate the runoff in Putrajaya as this would be the main source of water to the Lake and to rainfall harvesting ponds. The only runoff data available within Putrajaya is from the pressure bulb recorder at Putrajaya's temporary weir. The daily runoff records between March and November 1994 were extracted by NAHRIM and these values were used to calibrate a rainfall-runoff model for Putrajaya Lake. The main purpose is to derive a long series of daily runoff records, which would be useful for irrigation simulation studies.

The model used is the Institute of Hydrology U.K's lumped catchment model (Blackie and Eeles 1985). A schematic of this model is as shown in Figure 2.5.

Model parameters adopted are tabulated in Table 2.6.

The calibration exercise attempts to fit the simulated hydrograph to the observed hydrograph. The result is as presented in Figure 2.6. In fitting the model, it was found that the observed flow at Prang Besar is extremely low. In order for the model to fit the observed hydrograph better, the evapotranspiration parameters FS and FC would have to be increased and the annual flow would be about 300mm as tabulated in Table 2.7, a value which we felt is unreasonable. Hydrology of nearby rivers indicates that the annual flow in most catchment in Selangor is about 1000 mm. The model adopted at this stage of the study yields 800mm of runoff per annum, which is slightly on the conservative side. Finally the calibrated model was used to generate the daily flows from 1948 to 1998 using rainfall data from Ladang West country. The graph of daily inflows simulated using the model is presented in Figure 2.7.

2.7 Derivation Of Low Flow Sequences

Synthetic low flow sequences of various durations were derived for reservoir simulation studies. The flow sequences were derived using the nested low-flow frequency analysis where low flows of various durations are plotted in a single graph. Detailed documentation of this method can be found in the textbook on Water Supply by Twort et al (1994). The advantage of this technique is that the synthetic drought sequence derived contains within it droughts of every duration from 1 to 12 months all of which has the same drought recurrence interval. No assumptions, therefore, need to be made on the critical duration of drought or the relative severity of historical drought of different durations (Walsh, 1987).

The procedure adopted for deriving the monthly low flow sequence is as follows:

- Annual series of 1-day low flow, 3-day low flow, etc up to 365-day low flow were extracted from historical monthly flow records.
- The annual series of flows were ranked in ascending order
- The plotting position of the low flows were computed using the Blom's plotting position formula

$$P = \frac{M - 0.375}{N + 0.25}$$

where P is the probability of non-exceedance
M the rank of the data and
N the number of data

- Attempt was first made to fit a 2-parameter log-normal distribution to the data. The best fit frequency distributions were derived using the frequency factor method (Chow et al, 1988)

If it is visually obvious from the plot that the fitted distribution should not be a straight line,

3. LAND USES

The land uses described in this report are based on information collected from Perbadanan Putrajaya. As the development is ongoing and land used are subject to changes, the discussion on land uses are based on Map 1 (Executive Summary).

3.1 Land Use Distribution

With the prevalent theme of the “City in a Garden”, keeping the open spaces within the public and private realms in a reasonable and acceptable “green” condition are paramount. At the public realm level, open spaces are provided in the form of planned metropolitan parks; urban parks like the *dataran*, *halaman*, street piazzas and courtyards; waterfront promenade; city, local and neighbourhood playing fields and recreational grounds and roadside green connectors or landscaped buffers. At the development parcel level for public facilities, open space is in the form of planned, manicured and landscaped lawns. At the private realm level, open space is in the form of gardens and roof gardens within residential and commercial areas.

Government institutional land uses, comprising areas designated for government reserves and offices, official residences and other institutional use, total about 271 hectares. It is, however, open space (excluding Putrajaya Lake and the wetlands) that remains the largest land use component of the new city comprising approximately 1133 hectares of the overall land use budget. Public amenity facilities take approximately another 400 hectares. These include facilities for religion, education, health, sports and recreation, civic and cultural uses, cemetery, police, emergency response and rescue services and neighbourhoods services centres. Generally, public utility facilities constitute only 71 hectares (excluding the existing Semenyih Water Treatment Plant and planned water detention ponds in Precincts 9, 11, 14 and 20). These facilities include TNB reserves, water reservoir reserves, sewage treatment plants and other utility reserves. Refer to Table 3.1.

Areas designated for commercial use and service industry comprise 151 hectares and 5 hectares respectively. Residential uses make up the second largest category of uses, covering an area of approximately 911 hectares.

Major and secondary roads (U2, U3, U4 and U5) cover approximately 62555m of roadway, within and outside which are landscaped buffer zones and street planting reserves of varying

widths.

3.2 Planning Of Irrigation Areas

The amount of water required to maintain these public and private open spaces is tremendous. Drawing upon the Putrajaya Lake system as the major source of irrigation water supply would impose unreasonable pressure on the lake system whose primary design intention is to act as the “ultimate sink and treatment system” for water discharging into the lake from the surrounding urban growth of Putrajaya. Its other key role is to enhance the aesthetics of the whole development including promoting multifarious water-related recreational and commercial activities.

Legislative and planning regulatory controls are presently in place to control activities and use of the Lake and its land reserve and to ensure that the quality and design integrity of both the water and the lakefront are maintained.

Along the same thinking, the current Irrigation Master Plan study aims to formulate rational ground rules for the extraction of water from the lake as well as a physical planning framework and accompanying guidelines to coordinate and regulate land planning efforts with a sustainable and practical irrigation system.

3.2.1 Inventory Of Areas For Irrigation

An inventory of areas in the public and private realms that require irrigation as well as their development schedule within the overall land development programme is listed in Appendix SC.

The land use areas are identified and inventoried by precincts and according to the Use Class Order to facilitate water demand estimation and design of the irrigation system, i.e. locating water intake points, ascertaining the size of each irrigation catchment area and reticulating the irrigation network. Refer to Map 1 (Irrigation Areas by Use Class).

3.2.2 Critical Use Areas And Routes

Not all land use areas within the new administrative city merit the same degree of irrigation intensity or duration. For purpose of rationalizing the distribution of available irrigation water and without placing undue pressure on the Putrajaya Lake system and sewage treatment plants, land use areas within the public realm are to be given priority over the private realm. These public realm areas are to be given priority in the event of severe or protracted drought. These areas include the following:

1. Class II(a) Government institutional facilities in Precincts 1, 2, 3, 4, 10, 14 and 16.
2. Class II(g) Public sports and recreation facilities in Precincts 5 and 11.
3. Class III(a) Metropolitan parks in Precincts 1, 2 and 13
4. Class III(a) Urban parks in Precincts 1, 2, 3 and 4
5. Class III(c) Civic areas in Precincts 1, 2, 3 and 4
6. Class VI(a) Road reserve (only the landscape buffer zones of U5, U4 and U3 roads)

3.2.3 Allocation Of Nurseries

As required by Putrajaya, a nursery is planned and allocated in each precinct. The size of the nursery is either approximately 1-2 acre per precinct or the intended supply requirement of the nursery for example, in Precinct 13 and 20.

4. HORTICULTURAL AND LANDSCAPE STRATEGIES

4.1 Introduction

In addition to the irrigation strategies that has been previously described, it is also important to look at the horticultural and landscape strategies in the study of Putrajaya Irrigation Master Plan. One of the objectives of this irrigation study is to prepare guidelines that would enable Perbadanan Putrajaya to formulate ways to overcome the shortage of irrigation water should the situation arise. The horticultural and landscape strategies that will be proposed shall consider the public realm, which comprised of all public parks and civic areas, government institutional reserves and road reserves.

4.2 Characters of Parks

To have a better understanding of the scope of works involved, the character and theme of each park needs to be studied before the horticultural and landscape strategies can be formulated.

A broad description of each character and theme of the parks has been provided in the Urban Design Guidelines. Therefore, based from the Urban Design Guidelines, the following description shall give a summary of the character of parks in Putrajaya.

Taman

- The taman shall have a lowland rainforest character with a composition of dominant species, hardwood and mixed forest species
- The mixed forest tree species shall provide the middle storey and lower storey lowland rainforest stratification
- Forest regeneration: The higher peaks within the taman shall be reafforested with a broad variety of indigenous lowland rainforest species. The plant material initially planted shall create a basic framework and through succession shall eventually grow into a lowland *rainforest ecosystem*. The planting strategy shall allow for the creation of diverse habitats.
- Examples: Taman Rimba Alam, Taman Warisan Pertanian, Taman Wetland.

Ridge Line Parks

- It is intended that the ridge-line parks shall have a naturalistic landscape character and vegetation species composition.
- Regeneration of a hardwood forest will assist with habitat creation.
- The plant material initially planted shall create a basic framework and through succession shall eventually grow into a lowland rain forest ecosystem.
- Examples: Taman Rimba Desa, Taman Saujana Hijau, Taman Puncak Banjaran, Taman Selatan, Metropolitan parks, Taman Lindungan

Dataran

- The dataran represent a series of special events along the linear boulevard, created by a widening of boulevard and being defined by the surrounding
- The dataran are intended to be places for people in relation to scale and function and shall be punctuated by various events and activities which shall include, water features, sculpture, performance stages and shaded seating areas
- The dataran shall have its own individual characters and themes in order to reflect their location along the boulevard.
- The dataran shall be framed by trees and the paving pattern providing a strong spatial arrangement for the spaces
- Examples: Dataran Putra, Dataran Wawasan, Dataran Putrajaya, Dataran Rakyat and Dataran Khazanah.

Based from the previously described characters and themes of the public realm areas and the level of development that has already taken place, the following paragraphs shall describe the horticultural and landscape strategies that shall be adopted. These strategies shall be considered in relation with the irrigation strategies.

4.3 Public Realm

According to the Use Class Order, the open spaces belonging to the public realm are classified as Metropolitan Parks, Urban Parks, City and Local Parks, Civic Areas, Government Institutional Reserves and Road Buffer. The following paragraphs shall explain the proposed strategies according to the use class order.

4.3.1 *Taman*

Taman is classified as the metropolitan parks in the use class order. Taman is intended as major public spaces that serve the population of the whole city. The wide-open spaces shall act as a green 'lungs' for the city and consists mainly of naturalistic reforested landscape. It shall have a natural lowland rainforest character with a composition of dominant species, hardwood and mixed forest species.

Strategies

However, the drought tolerance factor of plant species should be considered as part of the design factor in the selection of plant materials. It is a relevant factor to consider since the water demand of these plants is lower and one of the objectives of this study is to find alternatives to save water should there be an event of water shortage or dry seasons. Since there are parks that have not been designed or are still in the early stage of design development, park designers are encouraged to look into this factor in their design.

After reviewing the list of plants as indicated in the Urban Design Guidelines, it is recommended that the following list of plant materials should be considered as an addition to the list due to their drought tolerant characteristics:

- 1) *Ficus benjamina*
- 2) *Ficus elastica*
- 3) *Tamarindus indica*
- 4) *Peltophorum pterocarpum*
- 5) *Cinnamomum iners*
- 6) *Dillenia indica*
- 7) *Pandanus spp*

A list of drought tolerant plant has been prepared in Table S1 (Executive Summary) and can be used as reference.

The open space categorised as Tamans are as follows:

- i) Taman Botani (Precinct 1)

Since Taman Botani is in the advanced stage of development, it is suggested that the existing irrigation system to be used. The landscape design of the Taman Botani need not have to change.

- ii) **Taman Putra Perdana (Precinct 1)**
Similar to Taman Botani in terms of physical development, the irrigation system that has been designed for Taman Putra Perdana shall be adopted for the existing landscape design.
- iii) **Taman Wawasan (Precinct 2)**
The Taman Wawasan is presently being designed together with the irrigation system. Since it is located close to the lake, the irrigation design has been proposed to utilise water from the lake. Wherever possible, it is recommended that the landscape design should consider incorporating drought tolerant plant species if the plants selected could justify the design theme.
- iv) **Metropolitan Park (Precinct 4, 5 & 6, 17)**
Similar to Taman Wawasan, the Metropolitan Parks at Precinct 4, 5 & 6 and Precinct 17 are located near water sources. Therefore the provision of water from the irrigation main should be able to provide sufficient water to the parks. Although the strategy is not intended to curb the selection of plant materials, the park designers are encouraged to utilise the drought tolerant plants where possible without affecting their design to help to conserve water.
- v) **Lake Valley Park (Precinct 8)**
Since it is fully developed and located next to the lake, it is suggested that no change should be done to the landscape area. The lake will supply irrigation water.
- vi) **Taman Rimba Desa (Precinct 9)**
It is located on high and undulating ground that irrigation facilities are hard to install. Therefore, it is suggested that a reforestation concept be adopted. It is a concept whereby the saplings of forest plant species are planted in between the existing oil palms. The oil palms shall act as a cover to assist the growth of the saplings. Eventually, as the forest plants grow bigger, the oil palms are then removed gradually from the place. Rainfall will be used as the source for irrigation.
- vii) **Taman Saujana Hijau (Precinct 11)**
Due to undulating and high ground of Taman Saujana Hijau, the irrigation system is difficult to design and requires a high capacity pump to bring water to the irrigation

network. Therefore, it is recommended that the planting scheme of this park should take into consideration location and physical characters of the landform. Similar to Taman Rimba Desa, the reforestation concept is proposed as the landscape strategy for this taman. Thus, no permanent irrigation facilities will be proposed.

- viii) **Taman Wetland (Precinct 12, 13)**
No amendment is proposed on the landscape design as implementation is currently ongoing it is completed. The plant species selected for both the wetland zone and the zone of intermittent inundation is able to self-sustain and perpetuate themselves after a period of drought. Hence, a permanent centralized irrigation system is not required for both the zone of intermittent inundation and the macrophytic zone.
- ix) **Taman Rimba Alam (Precinct 14 & 15)**
Similar to Taman Rimba Desa and Taman Saujana Hijau, the landscape strategy for Taman Rimba Alam is proposed to adopt the reforestation concept. No permanent irrigation system will be required.
- x) **Taman Warisan Pertanian (Precinct 16)**
Since Taman Warisan Pertanian is in the advanced stage of development, it is therefore suggested that no change is proposed in the landscape design. The designed system will be adopted and irrigation water will be supplemented by trucking where necessary.
- xi) **Riparian Park (Precinct 16)**
Since the design for Riparian Park is completed, it is recommended that the landscape design to be maintained. It is a self-generating park and thus, plants will rely solely on the lake for their water supply.
- xii) **Taman Puncak Banjaran (Precinct 18)**
The development stage of Taman Puncak Banjaran is still in planning stage. Owing to its hilly topography, it is preferred that the park be reforested similar to Taman Rimba Desa such that permanent irrigation facilities are not required. However, currently it has been decided to landscape the park by PPJ. Owing to this strategy, irrigation facilities will therefore be required.

xiii) Taman Lindungan (Precinct 19)

Similar to Taman Puncak Banjaran in Taman Lindungan is still in preliminary stage of planning. Since it is sited on hilly ground, it is preferred that the park to maintain its natural habitat and reforestation concept similar to Taman Rimba Desa, such that permanent irrigation facilities are not required. However, currently it has been decided to reforest the park with bamboo and palm by PPJ. Owing to this strategy, irrigation facilities will therefore be required.

xiv) Taman Selatan (Precinct 20)

Similar to Taman Rimba Desa is still in preliminary stage of development. The park is located on high and undulating ground, it is therefore proposed the landscape strategy to adopt the reforestation concept.

4.3.2 *Urban Parks, Civic Areas and City and Local Parks*

The urban parks, civic areas and city and local parks refer to public open space that shall be accessible to the public.

- The plant of that type of space shall be hardy but with high visual impact as the environment is harsh.
- Strong architectural formed plant species shall be used in the pedestrian malls and plazas.
- Palm trees shall be used for tight urban spaces.

Strategies

Horticultural and landscape strategies for urban parks, civic areas and city and local parks shall be based on the above characters. These strategies shall be considered in relation with the irrigation strategies.

Similar to the strategies proposed to the Taman, the long term planning of Urban Parks, Civic areas and City and Local Parks shall take into consideration that only shrubs will be irrigated continuously. Trees, palms and grass will not be irrigated upon their establishment and shall depend on rainfall.

Drought tolerant plants shall be considered as part of the design factor in the selection of plant materials to reduce the demand for irrigation water as well as to reduce the cost for irrigation.

The recommended plants for those areas are as follow:

- i) *Bauhinia pupurea*
- ii) *Caesalpinia ferrea*
- iii) *Swetenia macrophylla*
- iv) *Tabebuia pentaphylla*

A list of drought tolerant plant has been prepared in Table S1 (Executive Summary) and can be used as reference.

The area includes:

- i) *Urban Park (Precincts 1, 2, 4, 5 & 6, 8, 9, 16, 18, 19)*
 - a) Development was completed and existing irrigation system was installed. It is suggested that no change shall be done on landscape and existing irrigation system will be used for irrigation purpose – Precinct 1.
 - b) The development is still in preliminary stage. Although its location is nearby to the irrigation main line, it is recommended that drought tolerant species be planted. Irrigation water will be tapped from supply main for irrigating the plants. – Precinct 5 & 6
 - c) Development is in the progress of planning. Its location is adjacent to the irrigation main line or lake; drought tolerant species will help reduce demand. Irrigation water will be tapped from supply main or lake. – Precinct 2, 4.

- iii) *City and Local Park (Precincts 2, 4, 5 & 6, 7, 8, 9, 10, 11, 12, 14/15 & DE, 18, 19)*
 - a) It is surrounded by construction or road system. JBA water or pipeline where possible is recommended to be used as irrigation water source. – Precinct 7, 8, 9, 10
 - b) The planning and construction of the area is still in progress. Drought tolerant species are suggested to be planted to conserve water. Irrigation water will be supplied by trucking or JBA main – Precinct 11

- c). Where water sources/lake or pipe mains are adjacent to the landscape areas, irrigation water will be supplied by nearby supply main or lake – Precinct 2, 3, 4.
 - d). Planning is still in preliminary stage. Due to its location nearby to the irrigation main line or storage pond, no constraint in the selection of plants is required. However, park designers are encouraged to select the drought tolerant plants in their design to reduce the water demand. Irrigation water can be tapped from the irrigation supply main. – Precinct 5 & 6, 12, 14/15 & DE, 18, 19.
- iii) *Civic areas (Promenade Precinct 1, 2, 3, 4, 5, 6, 7, 8, 10, 12, 16, 17, 18 & 19) and Boulevard (Precinct 2, 3 & 4)*
- a) Refers mainly to the promenade and the boulevard. Due to the importance of the areas as in the case of the boulevard, and the close proximity to water source for the promenade, in areas yet to be developed, it is not necessary to impose constraints to the landscape designer in the selection of plants. This is due to the proximity of water supply for irrigation to the area. However, park designers are encouraged to select the drought tolerant plants in their design to reduce the water demand. Irrigation water can be tapped from supply main or lake.

4.3.3 Government Institutional Reserves

Government institutional reserves are broadly classified as public amenities and public utilities facilities.

4.3.4 Public Amenities

Public amenities (all precincts except 1 and 13) refer to hospitals, schools, universities, police station, fire station, cemetery and sport facilities. They shall have the landscape with both functional and aesthetic resources. The planting within public amenities shall be a combination of Ethno-botanic and ornamental species.

- The planting shall integrate the institutional developments with their surrounding and diminish the institutional appearance.
- Mixed and dominant species shall be used at the planting at educational establishment.

- Buffer zone shall be provided for the police station.
- Aesthetically pleasing large umbrella shaped trees shall be provided for sport facilities.

Strategies

Similar to the strategies proposed to the Taman, the long term planning of Urban Parks, Civic areas and City and Local Parks shall take into consideration that only shrubs will be irrigated continuously. Trees, palms and grass will not be irrigated upon their establishment and shall depend on rainfall.

Factor of drought tolerance of plant species shall be considered when designing the areas. This is for the purpose of saving water or dealing with water shortage and dry seasons if any of them occur.

The drought tolerant species that have been selected from the UDG plant list for residential areas are as follows:

- i) *Cassia fistula*
- ii) *Cinnamomum iners*
- iii) *Samanea saman*
- iv) *Delonix regia*
- v) *Lagerstroemia speciosa*
- vi) *Michelia alba*
- vii) *Casuarina sumatrana*

The list of drought tolerant plant in Table S1 (Executive Summary) can be used as reference.

4.3.5 Public Utilities

The public utilities refer to reservoirs, sewage treatment plant, water treatment plant, electrical sub-station, electricity pylons, gas station, radio tower and public NGV. The landscape shall provide visual screens and additional security zones between the utilities and other land uses.

- Small spreading trees and palms shall be planted for the small utility facilities.
- Dense trees and shrubs shall be planted for the large utility facilities.
- Tall dense trees shall be planted for “mega-structures”.

Strategies

The long term planning of Public Utilities shall take into consideration that only shrubs will be irrigated continuously. Tree, palms and grass will not be irrigated upon their establishment and shall depend on rainfall.

Any strategies that will be implemented shall be based on the characters of the public utilities. Drought tolerant species should be considered in designing public utilities. Its purpose is to provide less water for the plants and thus, reduce the cost for maintaining the landscape areas.

The drought tolerant species that have been selected from the UDG plant list for residential areas are as follow:

- i) *Cinnamomum iners*
- ii) *Erythrina variegata*
- iii) *Lagerstroemia speciosa*
- iv) *Michelia alba*

The list of drought tolerant plant in Table S1 (Executive Summary) can be used as reference.

The areas include:

- i) Completed public utilities that fall within the no dig policy. Thus, no change shall be made on the landscape. JBA water are suggested to be used as irrigation water – Precinct 1, 8, 9, 10, 16. However, for water conservation and reduce maintenance cost, these areas should plant drought tolerant plants in future replanting exercise.

Public utilities that are still in preliminary stage or planning progress are recommended to be planted with drought tolerant species. Irrigation water will be tapped from nearby water sources. -- Precinct 4, 5 & 6, 11, 12, 14, 17, 18, 19, 20

4.3.6 Road Side and Buffer Zone

Roadside landscape and buffer zone are to contribute to a reduction in adverse environmental impacts created by roads, such as noise and air quality.

- The vegetation shall reflect a distinct character for each of the roads, which depends on the road hierarchy.
- Road corridor can be created as an ideal habitat for wildlife, especially along primary distributor road where human access is not actively promoted and reserves are wide enough to allow substantial belts of structure planting.
- Indigenous species shall be selected in associations that replicate natural habitats.
- Bio-diversity of indigenous species shall be promoted.

Strategies

Horticultural and landscape strategies for roadside and buffer zone shall be based on the above characters. These strategies shall be considered in relation with the irrigation strategies. Similar to the strategies for other public areas, only the watering needs of shrubs will be considered in the long run.

Basically, to reduce cost and time for transporting irrigation water, drought tolerant plants should be considered in the landscape design of roadside and buffer zone. After analyzing the plant list as indicated in the UDG, the following plants are recommended to be used as a guide when developing the planting plan:

- i) *Cinnamomum iners*
- ii) *Erythrina variegata*
- iii) *Gardenia carinata*
- iv) *Lagerstroemia speciosa*
- v) *Michelia alba*
- vi) *Tabebuia pallida*
- vii) *Delonix regia*
- viii) *Samanea saman*

However, this list is not exhaustive because to further assist the designers, the list of drought tolerant plant in Table S1 (Executive Summary) can be used as reference.

The road side and buffer zone includes:

- i) Road reserves that are completed or almost completed in construction. Owing to no dig policy, landscape design is suggested to remain and irrigation will be done by trucking – Precinct 16. To reduce cost for trucking, drought tolerant plant should be

considered in future replanting exercise or reduce planting as what currently practise for the oval road in Precinct 1.

- ii) Road reserves that are partly completed and constrained by no dig policy. Since it is partly completed, landscape designers are recommended to utilise drought tolerant plants in their design. Irrigation will be sourced from the pipeline with pipe - jacking where necessary to cross paved roads. – Precinct 1, 7, 8, 9, 10 & 13
- iii) Road reserves that are still in the progress of planning. Drought tolerant species are suggested to be planted in order to conserve water. Lake or rainwater harvesting will be the resources for irrigation purpose – Precinct 5 & 6, 11
- iv) Road reserves that are adjacent to lake or supply main and where the CUT is still under design stage. Pipe for irrigation purpose will be proposed beside or in the CUT. Irrigation water will be tapped from the lake. To conserve irrigation water for new development area, drought tolerant plants are recommended for – Precinct 2, 3, 4, 18
- v) Road reserves that are in the stage of preliminary planning. Since they are nearby to the irrigation main line, it is suggested that irrigation water will be tapped from supply main. Drought tolerant plants are recommended for – Precinct 12, 17, 14 & 15, 19, 20.

4.3.7 Nurseries

The land use plan has allocated a nursery in each precinct as requested by Perbadanan Putrajaya. It is however noted that in some of the precincts no dig policy is in place, and these precincts have inadequate water resources. For this reason, irrigation has to rely on JBA supply, which may not be reliable in time of drought. It is therefore proposed that nurseries in Precinct 3, 7, 9, 10, 11 and 16 be relocated to other precincts where sources of water is reliable such as near to the Sewage Treatment Plant, or near to retention ponds.

4.4 Private Realm

According to the Use Class Order, the open spaces belonging to the private realm are classified as Residential and Commercial areas. The following paragraphs shall explain the proposed strategies according to the use class order.

Residential Landscape

Residential landscape shall comprise of a variety of plant species that reflect and enhance the overall character of each neighbourhood. Each neighbourhood shall have its own distinct planting theme using different plant species, colour or particular maintenance regime.

- The use of variety of indigenous species is encouraged.
- All roads shall have indigenous tree planting which consists of appropriate species not prone to causing damage to the roads and paths.
- Neighbourhood entrance shall feature ornamental planting creating a colourful entry statement.
- Planting shall be located at the rear and side boundary of the individual lots.

Strategies

Drought tolerant species shall be considered in designing residential landscape especially in the situation that no irrigation facilities are provided. This is because all residential areas are considered as private area. The purpose of planting drought tolerant species is to reduce the demand for irrigation water to maintain the landscape areas.

To reduce the water demand further, upon establishment of the plant materials that has been planted, only shrubs will be irrigated continuously in line with the long term strategies for the public areas.

The drought tolerant species that have been selected from the UDG plant list for residential areas are as follow:

- i) *Bauhinia pupurea*
- ii) *Ficus benjamina*
- iii) *Plumeria spp*
- iv) *Tabebuia rosea*
- v) *Delonix regia*
- vi) *Erythrina variegata*
- vii) *Samanea saman*

The list of drought tolerant plant in Table S1 (Executive Summary) can be used as reference.

The residential area includes:

- i) Strata-titled property (All Precincts except 1, 2, 3, 4, 18)
- ii) Landed-tilted property (All Precincts except 1, 2, 3, 4, 5 & 6, 20)
- iii) Both of the above areas are private area and no irrigation facilities will be provided. Thus, rainfall harvesting and JBA water is suggested to be used for irrigation water.
- iv) Commercial centres (All precincts)
All commercial centres are private areas and no irrigation system will be installed. Rainfall harvesting in conjunction with JBA water are suggested to be used for irrigation water.

Drought tolerant plants are recommended to be planted.

Neighbourhood Centre

The neighbourhood centre (Precinct 8) shall function as a central meeting space for the residents, and shall encourage interaction with nature on a local scale.

- The vegetation of neighbourhood centre shall be a combination of ornamental flowering plants with emphasis on fragrant flowers, mix forest tree and colourful shrubs.
- Ornamental colourful planting shall be provided at the entrance. Each entrance shall have a distinct different landscape approach or character design around a dominant species or colour.

Strategies

Since it is a private area, irrigation water will not be provided from the main irrigation pipe. However, water demand for the area has been calculated and JBA water will be used for plant irrigation purpose. Drought tolerant species are recommended to be used to reduce the irrigation demand from JBA. Again, only shrubs will be irrigated upon establishment of the soft landscape for purpose of long term water conservation measures. The list of plant species listed is extracted from UDG, which was categorised as drought tolerant species. However, the list of drought tolerant species in Table S1 (Executive Summary) can be used as reference.

- i) *Bauhinia pupurea*
- ii) *Ficus benjamina*

- iii) *Plumeria spp*
- iv) *Tabebuia rosea*
- v) *Delonix regia*
- vi) *Erythrina variegata*
- vii) *Michelia alba*
- viii) *Michelia chempaka*
- ix) *Samanea saman*
- x) *Peltophorum pterocarpum*

4.5 Water Conservation In Horticultural Practice

*Mulching Mat From Oil Palm Empty Fruit Bunches**

Introduction

Mulching with oil palm empty fruit bunches (EFB) in newly established plantations (mainly oil palm trees) is a common practice in Malaysia. It serves as a cost saving waste disposing method that benefits the plantations. EFB has good nutrient content and is able to improve the properties of the soil and is biodegradable.

The common practice in the fields is to lay or stack the EFB around the young plants. However, the main problem with this practice is in the physical characteristics of the material. It is the thorny, heavy, bulky and slippery and requires intensive labour for this activity. If it is not laid properly, weeds will be able to grow and thus compete for fertiliser with the young oil palms. Parts of the soil not totally covered will dry up during the dry season, hence watering needs to be carried out.

In order to overcome these drawbacks and to promote the utilisation of this waste universally in all types of plantations, estates and gardens, the Forest Research Institute of Malaysia in collaboration with a local company has successfully produced a mat from EFB, which proves to be very practical for use as mulching material.

Material and Methods

The production of this mulching mat involves various stages of mechanical processing of EFB either whole or dewatered by screw press in the mill. The EFB are shredded into semi-

fibrous form with a fractionator. The material is then air dried to a moisture content of about 10 -15%. Then it is sprayed with a biodegradable binder in a mould that is set between two metal caul plates. The fibres are pre-pressed and released from the mould. The semi-finished mat is then cold pressed under high pressure between 2cm space bars on each side of the mat for four minutes after which the pressure is released and the metal plates are clamped together in order to reduce bounce -back of fibre. It is then left overnight for the binder to set. The clamps are then released and the mat is left to dry. The mat is then baled and packed out for transportation to or application in the fields. The mat produced is of dimensions 100cm x 50cm x 4cm. A semi circular hole is made in the middle of one side so as to slot in the stem of the tree. Two mats are applied to each tree.

Application And Functions

The mulching mat from oil palms empty fruit bunches (EFB) generally functions as:

- Water absorption material, one of the most important element for plant growth.
- Protection for the soil surface from being eroded by water or wind and gives the space for important soil growth micro - organism to live and multiply.
- To reduce labour for maintenance works in the form of weeding and fertilising and avoiding the tree stem from being injured by blade from grass-cutter.
- Reduce the application of fertilisers because fertilisers applied around the tree stem are not wash away by watering or evaporation.

* *Extracted from text prepared by Wan Asma Ibrahim, Wan Rasidah Kadir*

5 IRRIGATION WATER DEMAND

5.1 Objectives

The horticultural and landscaping objectives of this study are identified as the assessment of total irrigation demand for plants in Putrajaya and the recommendation on landscape strategy and how these issues will affect the outcome of this study.

5.2 Scope of Work

The scope of work for the study of horticultural aspects of the irrigation master plan is concentrated mainly on the calculation of total irrigation water demand. To achieve that, it is pertinent that the water demand of plant group is established first. This study shall explain the basis for the plant water demand and factors such as the soil series, plant root depth zone and most importantly, the evapotranspiration rate of plants will be studied and explained.

Once the plant water demand has been established, the calculation of total irrigation water demand can be obtained by multiplying the plant water demand against the quantity of plant materials derived from plans and drawings submitted to Perbadanan Putrajaya.

5.3 Issues and Constraints

To assess the total water demand, it is pertinent that the plants in these areas are to be divided into four major plant groups. They are divided into groups of trees, palms, shrubs and ground covers and lawn.

The irrigation demand of each group is determined by considering factors such soil and its available water, evapotranspiration rate of plants, the root zone depth and plant quantity. These factors will be examined to enable us to establish the water demand of each plant group. It is pertinent to note that the calculation was based on FAO (Food and Agriculture Organization, United Nation) method.

5.4 The Soil and Its Water

Referring to the soil map of Putrajaya, it was discovered that the area has 17 types of soil series. However, it is interesting to note that approximately 80 % of the soil series in Putrajaya are made up of the Bungor series as evident from the soil map. (Please refer Figure 5.1). Being the most predominant soil series in Putrajaya, it is therefore, quite relevant to use the characteristics of the Bungor soil series as the basis for the calculation of water demand. Figure 5.2 shows the section of Bungor soil series.

From *Panduan Mengenal Siri-Siri Tanah Utama di Semenanjung Malaysia* by *Jabatan Pertanian Semenanjung Malaysia*, the Bungor soil series is described as having a fine sandy loam texture. Structurally, it is weak to moderate medium and fine subangular blocky. It is also a well-drained soil with a moderately low water retention capacity. The field capacity of Bungor soil series is 216.7 mm/m with a wilting point of 66.7 mm/m. The difference between the field capacity and the wilting point will give the available water of 150 mm/m for this soil series. Please refer Figure 5.3.

Field capacity is the capacity of the soil to retain water against the downward pull of the force of gravity. In atmosphere of tension this is 1/3. Subsequently, *wilting point* is the moisture content of soil at which a plant wilts and is unable to recover. In the atmosphere, this is 15. (Please refer Figure 5.4). *Available water* is the range of soil moisture between the wilting point and the field capacity. For plant growing purposes, that is the most important range of soil moisture. Table 5.1 describes the characteristics of Bungor soil series. In addition to that and for reference purposes, Table 5.2 also shows the different characteristics of other types of soil textures.

Table 5.1 The Characteristics Of Bungor Series

Characteristic	Description
Colour	Brownish yellow to yellowish brown
Texture	Fine sandy loam.
Structure	Weak to moderate medium and fine sub-angular blocky and consistence friable to firm with depth
Drainage	Well drained
Water Retention	Moderate low
Depth	Deep

(Source: *Panduan mengenai siri-siri tanah utama di Semenanjung Malaysia. 1993. Jabatan Pertanian Semenanjung Malaysia.*)

Table 5.2 Wilting Point, Field Capacity and Available Water Based On Soil Texture

Soil Texture	Wilting Point (mm/m)	Field Capacity (mm/m)	Available Water (mm/m)
Medium Sand	25	100	75
Fine Sand	33	125	92
Sandy Loam	50	166.7	116.7
Fine Sandy Loam *	66.7	216.7	150
Loam	100	266.7	166.7
Silt Loam	116.7	291.7	175
Clay Loam	150	316.7	166.7
Clay	216.7	333.3	116.6

(Source: *Soil, their chemistry and fertility in tropical Asia. 1966. Prentice Hall*)

* -- Texture of Bungor Series

5.5 Root Depth Zone

This is also one of the most important factor to determine the plant water demand. However, it has to be noted that due to economic reasons, research materials available to determine the root depth zone are generally concentrated for harvest crops instead of ornamental crops. Nevertheless, the information available from the research papers on harvest crops can be adopted to determine the root depth zone of ornamental crops. For example, from the research paper entitled *Irrigation Practice and Water Management by Food and Agriculture Organization (FAO)* of United Nation, the rooting depth of mature irrigated crops grown in a deep permeable well-drained soil are divided into 3 categories. The categories are described as the shallow rooted, moderately deep rooted and deep rooted. The shallow rooted crops have a range of rooting depth of between 0 to 0.6m while the moderately deep-rooted crops have a range of rooting depth of between 0.5 to 1.2m. Meanwhile, the deep-rooted crops are categorised as having a rooting depth of between 1.0 to 2.0m.

For this study, the root depth zone for plant groups shall be based on the average of the rooting depth of harvest crops mentioned earlier. For example, the rooting depth of shallow rooted harvest crops such as groundnut, onion and turf grasses is between 0.3m to 0.6m. The average root depth of these shallow rooted crops is adopted for the groundcovers and lawn plant grouping. The average rooting depth of bananas (0.5-0.9m), sunflower (0.7-1.2m) and tobacco (0.5-1.0m) which comes under the moderately deep-rooted crops is then adopted as the average for root depth zone for shrubs. Deep rooted harvest crops such as rubber trees, avocado and citrus with their range of rooting depth between 1.0 to 2.0m is used as the basis to get the average root depth zone for trees and palms. The average root zone depth is tabulated in the following Table 5.3.

Table 5.3 The Range and Average Of The Root Zone Depth

Plant Category	Range of Root Zone Depth (m)	Average Root Zone Depth (m)
Tree	1.00 - 2.00	1.50
Shrub	0.50 - 1.20	0.85
Palm	0.70 - 1.30	1.00
Ground Cover and Lawn	0 - 0.60	0.30

(Source: Irrigation practice and water management, 1984, FAO)

Unlike harvest crops where irrigation is a continuous process, it has been established that the initial 3 years period is the most critical period of plant growth especially for ornamental trees and palms. Therefore, in the calculation of water demand, this is an important factor whereby, upon establishment of the trees and palms, the water required for irrigation purposes can be greatly reduced.

5.6 Evapotranspiration Rate

Evapotranspiration is defined as the loss of water by evaporation from soil and vegetative surface and transpiration by plant. It is essentially the water demand of plants. To estimate evapotranspiration rate of tree, shrub, palm and ground cover, several examples of each plant group were selected to obtain an average. It has to be noted that, similar to the root depth zone, the evapotranspiration rate is also based on harvest crops since there are numerous research that has been done on them. Assumption is also made that plants in the same family should have a similar Etcrop. Table 5.4 below shows the average evapotranspiration rate of each category of plants.

Table 5.4 Average Evapotranspiration Rate For Plant Groups

Plants	Etcrop	Average Etcrop
Trees		
Hevea brasiliensis (Rubber tree)	6.32	4.33
Coffea spp (Coffee)	2.74	
Cocoa	2.74	
Persia americana (Avocado)	2.26	
Citrus spp (Citrus)	2.88	
Shrubs		
Musa spp (Banana)	4.66	4.53
Ananas cosmosus (Pinnacle)	2.33	
Helianthus annus (Sunflower)	6.15	
Lycopersicon esculentum (Tomato)	4.76	
Nicotiana tabacum (Tobacco)	4.76	
Palms		
Cyrtostachis renda (Red Palm)	3.56	3.57
Licuala grandis (Fan Plam)	3.58	
Groundcover and Lawn		
Arachis hypogea (Ground nut)	5.85	4.87
Allium cepa (Onion)	3.75	
Various turf grasses	5.00	

(Source : Irrigation practice and water management. 1984.FAO)

5.7 Water Requirement

Using the FAO calculation method and all relevant information that has been gathered, the water requirement for tree, palm, shrub and ground cover can be determined. Among the factors that has been described and was used to obtain the water demand are the soil available water, allowable water deficit, rooting depth, assumed application efficiency, evapotranspiration rate and coverage area. Table 5.5 below shows the average evapotranspiration rate and calculated water requirement for each category of plant.

Table 5.5 Average Evapotranspiration Rate And Calculated Water Requirement For Each Category Of Plant

Plant Type	Average Evapotranspiration Rate	Calculated Water Requirement, L
Tree	4.33 mm / No / day	24 L / No / day
Palm	3.57 mm / No / day	7.1 L / No / day
Shrub	22.65 mm / sq. m. / day	6.3 L / sq. m. / day
Ground Cover and Lawn	121.75 mm / sq. m. / day	3.1 L / sq. m. / day

(Source: Crop water requirement. 1977. FAO)

With the information provided on the basis of plant water demand calculation, it is believed that the total water demand calculation can be obtained.

5.8 Plant Quantity

Plant quantity was obtained by looking into approved landscape plans from PPJ. Plant quantity of unapproved areas will be determined by comparing the approved areas together with information obtained from the land use plan and its use class order.

The irrigation demand of each precinct is determined by considering water demand and quantity of each plant category of all areas inside the precinct. Total irrigation demand is obtain by adding the irrigation of whole 20 precincts in Putrajaya as shown in Appendix SC (in Executive Summary).

5.9 Water Demand Strategy

Based on the water requirement and plant quantity, the total water demand in each precinct is as follows:

	Water Demand (MLD)
Irrigation of shrubs & grass	35.5
Irrigation of shrubs only	16.8

Owing to the tremendous demand it is agreed with PPJ that irrigation of plants should be limited to shrubs only. For trees and palms, water is required generally during the growing stage only and during this period water will be supplied through trucking. As for grass the water demand is high particularly owing to the large area of underground cover. During period of drought grass may become brown and this has to be accepted in order that irrigation water demand and system cost can be reduced. In fact, it was highlighted during a recent meeting with the maintenance team of Taman Wetlands that only the shrubs were watered during the watering rounds.

Adopting the strategy of irrigation shrubs only the water demand in each precinct are as follows:

Precinct	Demand (MLD)
1	0.87
2	1.35
3	0.22
4	0.39
5&6	0.96
7	0.31
8	0.58
9	0.43
10	0.44
11	1.04
12	0.40
13	1.08
14,15&DE	1.06

16	0.43
17	0.37
18	0.59
19	1.11
20	5.16
Total	16.79

5.10 Water Demand By Phases

The delivery of irrigation water is greatly influenced by the development phases, namely,

1. Phase 1A from 1/1999 to 12/2000
2. Phase 1B from 1/2001 to 12/2005 (Fully developed)
3. Phase 2 from 1/2006 onward (Assume full development by 2010)

Another important factor to consider is water requirement in relation to plant growth i.e. tree and palm in fact do not need watering after three (3) years as they have reached their establishment stage.

Taking into account the plant growth requirement, development phasing and source of water supply/ irrigation scenarios (detailed in Chapter 6), the total water demand is calculated and is presented in the form of bar charts (Figure 5.5 - 5.7). The water demand (from Putrajaya Lake and rain harvesting ponds) for the following scenarios have been computed:-

- Option 1 :** All Irrigation needs supplied from the lake.
- Option 1a - Irrigation demand for public and private realms (Table 5.6 and Figure 5.5)
- Option 1b - Irrigation demand for public realm only (Table 5.6 and Figure 5.6)
- Option 2 :** Combination of Various Water Sources i.e. Proposed Option
- Irrigation demand for public realm using Lake Water (Table 5.7 and Figure 5.7)

The water demand for all these options is illustrated in Figure 5.8 and summarised in Table 5.8.

Table 5.8 Various Irrigation Water Demand By Year

	Irrigation Water Demand (Mld)				
<u>Year End</u>	2000	2003	2010	2013	2020
<u>Option 1a</u>	7.11	18.12	23.923	16.849	16.849
<u>Option 1b</u>	5.366	13.74	18.894	13.779	13.779
Option 2 i.e. Proposed Option Using					
Lake Water	5.203	10.627	8.088	5.622	5.622
STP Water	0.000	1.651	8.478	6.983	6.983
<u>Trucking</u>	1.009	2.344	0.192	0.192	0.192
<u>JBA Water*</u>	0.163	1.210	2.082	1.240	1.240

** for Public and Private Realms*

Chapter 6 of this report addresses the Putrajaya Lake drawdown owing to water abstraction from the lake under various irrigation scenarios.

6. WATER RESOURCES

6.1 Introduction

The estimated surface area of Putrajaya Lake 4 km². It is a huge water body and would be the obvious source of water except that the recreational and aesthetic function of the lake does not allow excessive and prolonged drawdown of water below its targeted +21m LSD. Besides the lake there are other potential sources. Our study examines the potential of following sources of water supply.

- Rainwater harvesting/ponds
- Ground water
- Treated sewage water
- Augmentation from Sungai Langat
- Putrajaya Lake
- JBA water supply
- Augmentation from Sungai Gajah
- Mining pond (in Precinct 20)

In matching irrigated areas with designated water sources, the problems with delivery and distribution of water would have to be looked into. A practical irrigation system would probably abstract from various water sources depending on the proximity of the area to be irrigated to the source of water, the reliability of the water source and the irrigation priority accorded to various areas.

6.2 Rainwater Harvesting

Rainwater harvesting can be accomplished in two ways: (1) via open ponds and (2) via underground storages. Open ponds could be developed in parks and garden to catch stormwater. The amount that could be irrigated from ponds would depend on the size of ponds and the acceptable drawdown of pond storage. Initial computations indicate that for a pond covering 5 % of the irrigated area and an acceptable drawdown of 1.5m, the area that could be irrigated is 30% assuming a 2 year drought event. For built up areas, tanks could be installed to store rainwater for irrigation and other uses.

Besides irrigation, ponds and tanks also have a flood mitigation function. Currently, JPS is encouraging the use of such methods as a means to reduce the stormwater runoff at source and the cumulative effect of many such installations is that stormwater runoff downstream could be substantially reduced.

Problem with ponds and tank storages is their potential of being mosquito breeding areas. Ponds in park areas will receive water from the adjacent park areas. As such the water would contain a high concentration of nutrients from fertilizers. This could lead to algae bloom in ponds.

6.2.1 Ponds

Besides rainfall harvesting ponds could also be designed as temporary storages for water pumped from the lakes or wetland and to be used to irrigate plants in the vicinity of the ponds. Having a temporary storage would buffer the pumping requirements during peak irrigation periods. An irrigation watering window of 8 hours a day would require a certain pumping rate to supply the water required during the 8 hours if pumped directly from the lake. But, with the presence of a temporary storage pond, pumping from the lake to the pond can be carried out over 24 hours. This would require only one third (1/3) the original pumping rate.

At the masterplan stage, pond design can only be addressed conceptually. As far as irrigation requirements are concerned, this study would identify the size of ponds required and consequently what size of irrigation area the pond could serve. With rainfall harvesting alone the ponds could only serve a limited area but if the ponds are designed with pumping from the lake to supplement the water if drawdown is excessive, the area served could be much more.

Detailed design of the ponds would have to be carried out by the individual landscape architect have considered the aesthetics and blending of water features with the landscape. The pond will definite have a dead storage (permanent storage) volume as to maintain the aesthetic function of the pond, there must be a minimum water depth for fishes and plant live to thrive. Fishes are necessary to prevent mosquito breeding. The active storage depth is the depth of storage important for irrigation and is assumed to be 1.5 m. This depth is considered reasonable, but actual depth of active storage would depend on the terrain and proposed landscaping works. Reduction in active storage depth must be compensated by larger pond areas. Typical inlet and outlet structure for these ponds can be obtained from various references and some will be selected to be incorporated as examples for landscape designers. The hydraulics of pond outlet structures will have to be checked against a standard design flood to ensure damage due to overspilling during a flood is minimized.

Ponds require large areas and there are already areas identified to be developed as stormwater detention ponds which we hope could also be used for harvesting rainwater for irrigation. Besides storm water detention ponds, other ponds could be developed within the parks to

harvest rainwater. Looking at the terrain we have identified some ponds but actual shape and final location of the ponds will have to be decided by the designers of the parks taking into account other factors such as aesthetics, safety and recreation.

Three flood retention ponds were identified as potential water source for irrigation (see Map 2 in Executive Summary). The catchment areas of these ponds were estimated from PPJ's Drainage Masterplan Report. The pond area was estimated and assuming an active storage of 1m, the pond storages were computed. These were then checked against required pond storages for various sizes of irrigated areas. The results are presented in Table 6.1.

Retention Pond 3 (RP 3) in Precinct 14 has sufficient storage to cater for an irrigation demand of 0.2 Mld for a 50-yr design return period. But if we accept a 5 year return period as the design criteria, the pond could cater for a demand of 0.26 Mld.

Basing on the analysis, other than RP 3 the irrigated areas for the other ponds were too small and could not contribute much to irrigation supply.

Table 6.1 Water Availability For Existing Pond During Drought

Pond ID	RP1	RP2	RP3
Precinct	9	11	14
Catchment area (ha)	25	20	60
Pond area (ha)	3.0	0.8	15.0
Active storage depth (m)	1	1	1
Active storage (m3)	30000	8000	150000
Water Availability During Drought:			
5-Year Return period (Mld)	0.100	0.070	0.260
10-Year Return period (Mld)	0.090	0.060	0.240
25-Year Return period (Mld)	0.085	0.055	0.230
50-Year Return period (Mld)	0.080	0.050	0.200

RP – denotes Return Period

It is envisaged that the situation will be even worse if we were to locate new ponds in the parks. The three detention ponds are located at strategic low points where catchment contributing the runoff is sizeable and judging from the terrain, it is unlikely that the new ponds located in the parks would not have very large catchment areas unless major works are carried out to reshape the terrain. It is therefore felt that ponds if developed are to supplement supply, the main reliable source of water should come from other sources.

Detention ponds in parks, will also contribute towards improving the quality of runoff reaching the lake. Parks with high fertilizer and pesticide input will contaminate stormwater. A pond will capture the initial storm runoff or the "first flush" of stormwater, which is often the most polluted.

6.2.2 Tanks

The idea of using tanks to store water primarily as a means of reducing storm runoff at source and at the same time harvesting rainwater for washing and watering (non-drinking usage) has been mooted by JPS about 5-years ago. Subsequently, Kementerian Perumahan dan Kerajaan Tempatan (KPKT) had published a guideline for installing rainwater collection and utilization system. The design of the system has been specified in this guideline. The recommended storage capacities of tanks for various types of buildings are as in Table 6.2

Table 6.2 Recommended Tank Storage Capacity For Various Building Types

Building Type	Tank Storage(litres)
Terrace house	1120
Bungalow	1800
Multi Storey Building	Depends on type of building

An issue of concern is mosquito breeding. To prevent breeding of mosquitoes the guideline recommends:

- Use the water regularly to deplete the storage and stagnant water should be drained out.
- If rainwater is to be kept for several days use 'Abate-1-SG' to prevent mosquito breeding
- Cover the tank and even have a net cover over the outlet as mosquitoes can enter the tank through the outlet

Usage of water in tanks, especially if it is in private homes would be difficult to control. We reckon that this method would be a good way to supplement water supply and to reduce the usage of the more expensive drinking water supply for irrigation at times. However, the need to quickly empty water from the tank after the rain to prevent mosquito breeding and to ensure that the system has storage for the next storm clearly conflicts with the need to conserve water for irrigation. In the private homes, stored rainwater if at all used for watering the plants would be a bonus and would reduce the demand of water from other sources.

The recommended storage volume of tanks tabulated above is for the purpose of reducing peak stormwater runoff. If water is required for irrigation larger tanks or separate tanks would have to be provided. Size of storage required for irrigation supply depends on

- the reliability (return period) of irrigation supply imposed
- the size of the catchment area (CA) of the rainfall harvesting tank/pond
- the size of planted area (IA) to be irrigated
- the type of plants

The storage size expressed in terms of cubic metres per square metre of land to be irrigated (using a assumed 5mm/day irrigation requirement) is as tabulated in Table 6.3.

Table 6.3 Storage Requirement For Various Droughts

CA/IA	Storage required (m ³ /m ²)			
	5-yr	10-yr	25-yr	50-yr
2.0	0.18	0.25	0.40	0.60
2.5	0.10	0.15	0.25	0.25
3.0	0.07	0.12	0.18	0.22

In the case of terrace houses, the rain from rooftops could be harvested. In this case the roof is the catchment area (CA). Gardens are the irrigated areas (IA). Garden area is small and the CA/IA is around the order of 3. If we consider a garden size of 50 m² then the size of the active storage should be 0.07 X 50 m³ which is about 3.5 m³ and this storage is required to ensure supply during a 5-year return period drought.

Underground drainage cells

Besides ponds and tanks for rainwater harvesting, there are available new and innovative systems for stormwater retention, which may be worthwhile considering. One such system, involve the installation of underground drainage cell (see Figure 6.1). The drainage cell is a permeable modular tanks designed for storing and transporting groundwater. Essentially, it is a permeable plastic grid. The voids are large to maximize water storage volume. Apparently the plastic grid of a commercially available drainage cell only reduces the tank volume by 4% leaving 96% of the grid volume available for water storage

In rainwater harvesting, these cells could replace the conventional ponds and tanks.

These drainage cells could replace open ponds in the parks. To store water, impermeable linings will have to be installed underground encasing the drainage cells. The advantage is

water is stored underground and therefore evaporation loss is negligible. Without open ponds more space becomes available for other uses.

Even if there are ponds these drainage cells could be used together with other systems to purify water entering the ponds so that the problem of algae bloom in the pond will not become an issue.

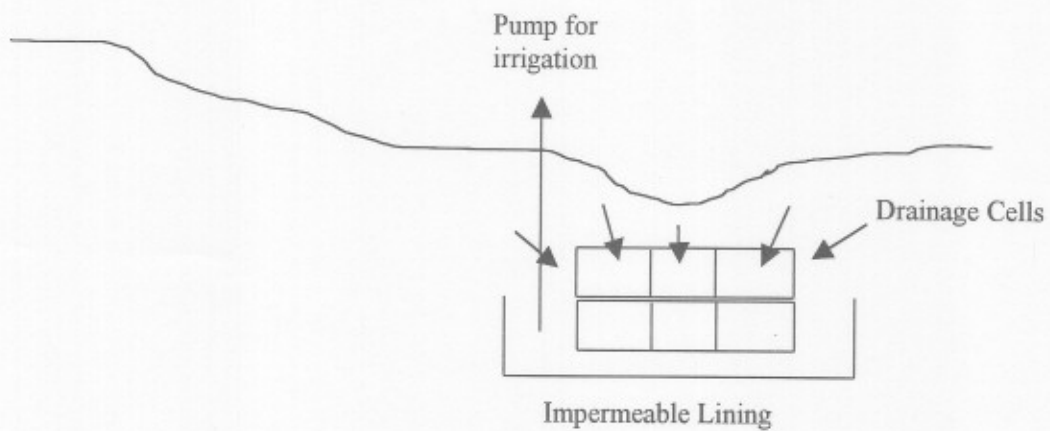


Figure 6.1: Underground Drainage Cell For Rainwater Harvesting

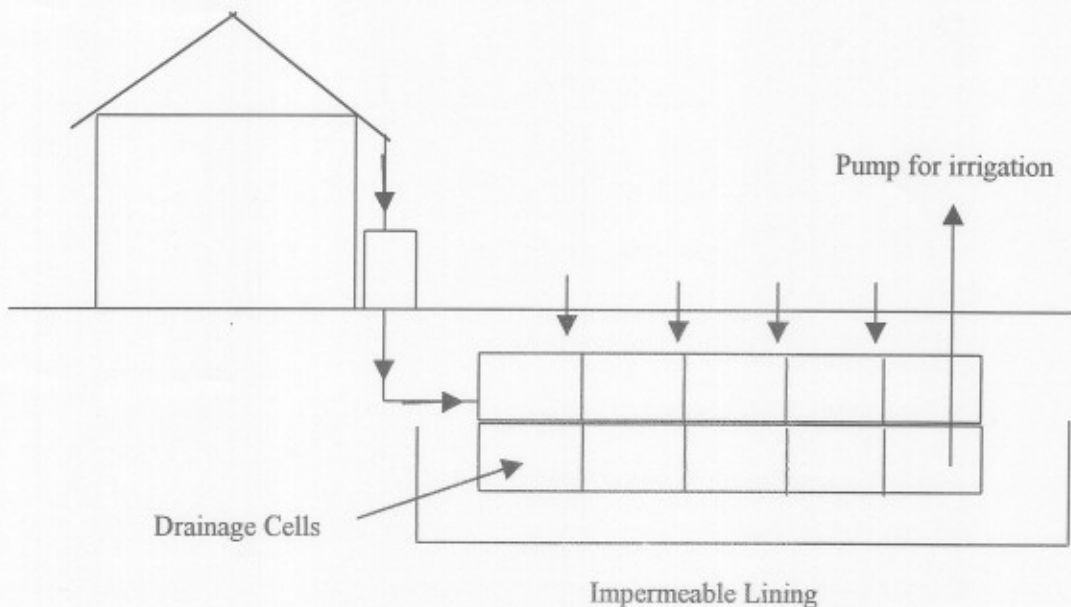


Figure 6.2: Underground Tank Cell For Rainfall Harvesting

For housing estates the provision of such tanks in every house will reduce peak flood discharge and impermeable linings could be installed to store water for irrigation (see Figure 6.2).

This technology is new to the country. JPS is currently testing the use of such drainage cells for stormwater runoff reduction in a project in Tronoh. It is recommended that PPJ implement a pilot project to assess its viability in flood attenuation and also in conserving water for irrigation before extending the concept to other areas. A possible site for this pilot project would be Taman Wawasan which is being developed.

Besides the detention ponds several other potential rainfall harvesting site were identified in the park areas. Rainfall harvesting can be in the form of pond, underground tanks or drainage cells. The development of these rainfall harvesting site will serve several functions i.e. irrigation supply, flood peak attenuation and water quality improvement.

6.2.3 Policy on Rainwater Harvesting for Irrigation

Rainwater harvesting is encouraged by JPS to attenuate stormwater runoff at source. However, the flood mitigation/attenuation function is already taken care of in Putrajaya with the presence of the Putrajaya Lake. Thus the implementation of rainwater harvesting for flood attenuation will not be made mandatory in Putrajaya but it can be selected as an option for purpose of irrigation.

6.2.4 Guidelines on Rainwater Harvesting

It is recommended that the new development especially in the private realm which are beyond the control of PPJ in terms of the day to day operation of irrigation system and government buildings, rainwater harvesting should be encouraged. Guidelines for development of rainwater harvesting are detailed in Appendix A.

6.3 Ground water

Based on the "Catchment Development and Management Plan for Putrajaya Lake Report (Draft Final), abstraction of groundwater for irrigation purposes can be done by building a well field consisting of 6 wells from the alluvium downstream of the lake so as to avoid disturbing the hydrological regime of the lake. The designed yield amounts to 0.5 cusec (10,000 gallons/hour) only, this amount is too small to be useful. Appendix B gives a detailed assessment of the ground water.

6.4 Treated Sewage Water

Under Phase 1 development, the PE (population equivalent) for Putrajaya is 100,000. Based on 100 L/day/PE, the net available water after treatment from STP1 is 10 Mld.

It is not practical to pipe sewage water to remote areas. It is envisaged that the most practical approach would be to use treated sewage water for precincts near to the treatment plant.

Treated water from the sewage water treatment plant (STP 1) in Precinct 14 (available water of 10Mld) could probably be used for irrigating the surrounding areas in Precincts 14 and 15 and DE (total irrigation demand of 0.70 Mld). The water from the sewage plant (STP 2) in Precinct 20 (available water of 60 Mld) could be used for nearby areas in Precincts 5, 6 19 and 20 (total irrigation demand of 6.27 Mld). Applying water to the land for irrigation is in fact further treating the quality of the sewage water which would otherwise be released directly to the drainage system. Treated sewage water will be evaporated away and if leached into the ground will be filtered when it emerges into the drainage system.

Usage of sewage water may be sensitive in places of worship and religious significance. Therefore watering using sewage water in these areas is not recommended for instance the cemetery area in Precinct 20.

The phasing of Sewage Treatment Plant STP2 in Precinct 20 is as follows:

Stage 1	-Complete by year 2003	for 300,000 population
Stage 2	-Complete by year 2006	for 300,000 population

6.5 Augmentation from Sungai Langat

Sungai Langat is a large river nearby where external water supply could be sourced. The catchment of Sungai Langat near to Putrajaya is about 1200 km². This is 250 times larger than the catchment of Putrajaya Lake and as such the flow in Sungai Langat is relatively large. However, Sungai Langat water is currently being tapped for water supply at the Langat mile 10 intake, the Cheras mile 11 intake and the Semenyih Intake. The Langat and Semenyih dams constructed upstream regulate the flow into Sungai Langat during dry weather and the impose

d compensation release past the Semenyih Intake is 90 Mld. Three major water users downstream of the Semenyih Intake are as below.

Table 6.4 Committed Abstraction Along Sungai Langat Downstream Of Putrajaya

Main water users along Sungai Langat downstream of Sungai Chuau	Abstraction (Mld)
Bukit Tampoi water supply intake	34
Genting Sanyen	14
Mega Steel	15
Total	63

All together the major downstream water users require 63 MLD of water which gives a balance of $90-63 = 27$ Mld. Taking into account the riparian needs downstream there is very little water left for Putrajaya Irrigation needs.

Pumping from Sungai Langat would entail the construction of intake, and installation of pipelines to bring water from Sungai Langat to Putrajaya. Owing to this, other Potential sources of water for the southern area such as the sewage treatment plant STP2, the Lake or development of rainfall harvesting ponds should be considered.

6.6 Putrajaya Lake And Impact Due To Irrigation Abstraction

6.6.1 Water Balance Analysis

The Putrajaya Lake and the wetlands are the biggest and most conspicuous water bodies in the area and would be an obvious source of water. Already several areas are pumping water from the lake for irrigation and for practical reasons some areas near to the lake would need to source water from the lake and probably from the wetlands if necessary. As mentioned above, there are constraints to sourcing water from the lake as the lake performs an important aesthetic and recreational function and any adverse impact on this function due to water abstraction for irrigation would not be acceptable.

To complicate matters, the lake is developed in two stages. Stage one of the lake development is already completed and impoundment started. Under Phase 1A, the total area of the lake is estimated to be 110 ha.

The Lake will be developed to its final designed size of 400 ha under Phase 1B.

The longitudinal section of the lake and the wetlands were taken from PPJ's Drainage Master Plan (see Figure 6.3). The lake level is to be maintained at +21 M LSD. The terrain in

Putrajaya is steep. Wetlands levels are stepped up through a series of weirs to raise the water level as high as +31.65 m LSD (at wetland UN8) – an average gradient of about 1:500.

At this stage of the study we have not considered using the wetland, which covers a total area of 120ha., as a source of supply but have not ruled it out completely. Bringing water from the main lake to land of higher elevations would require some form of temporary storage at the location to be irrigated. Having some form of temporary water storage would reduce peak pumping rates. This temporary storage could be in the form of additional ponds in parks as discussed in section 6.2 above or the wetland could be used as the temporary storage. Issues with using the wetland as temporary storage would have to be identified and resolved.

Daily water balance studies were carried out to determine the draw down of the lake. A schematic of the water balance analysis is illustrated in the Figure 6.4.

6.6.2 Sensitivity of Lake Drawdown

The estimated total irrigation requirement from both the public and private realm is 16.8 MLD. The source of water for irrigation could be 100% from the lake or partly from the lake and part from other sources such as ponds and sewage water. Analysis was carried to determine the impact of water abstraction from the lake for various irrigation scenarios. The resulted maximum lake drawdown based on 800mm and 300mm annual runoff model respectively are tabulated in Table 6.5.

Table 6.5 Maximum Lake Drawdown For Various Irrigation Options

Option	Areas irrigated with Lake water		Irrigation Demand (MLD)	Maximum Lake Drawdown (mm)	
	Precincts	Realm		800 arm ¹	300 arm ¹
1a	All Precincts	Public and private	16.8	125	420
1b	All Precincts	Public realm only	13.7	75	370
2	Selected areas as in APPENDIX SC	Public realm only	5.62	25	75

¹ arm denotes mm annual runoff model

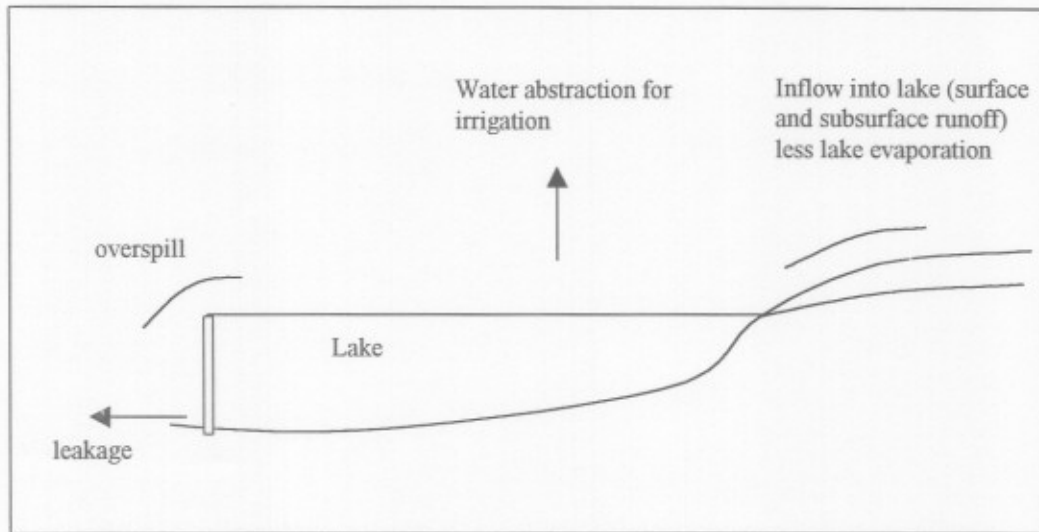
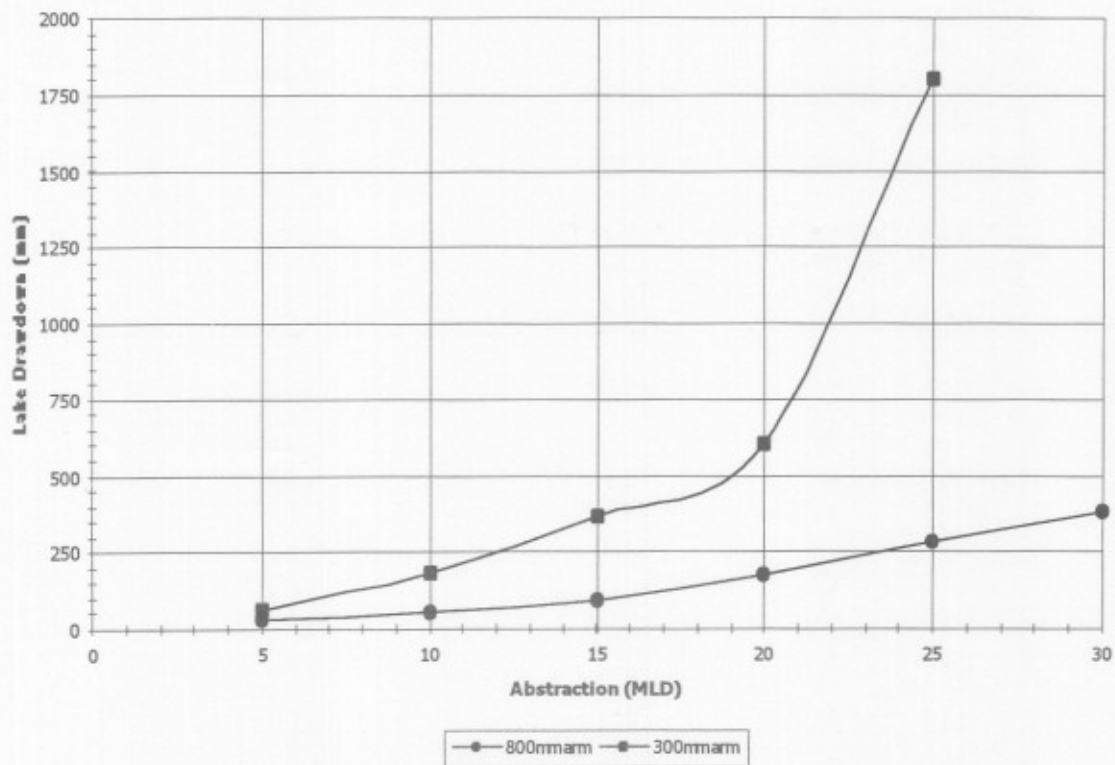


Figure 6.4 : Components of Lake Water Balance Computations

The lake drawdown due to water abstraction for 800mm and 300mm annual runoff model is presented in Figure 6.5.



arm denotes annual runoff model

Figure 6.5 Putrajaya Lake Drawdown Chart

i) *Results of 800mm Annual Runoff Model*

Option 1a water balance study

Under Option 1a all irrigation requirements from the public and private realm will come from the lake. The total irrigation demand during a dry day is 17 Mld. Theoretically when it rains, irrigation will be reduced or cut off completely. But to allow for inefficiencies we have assumed that irrigation will be completely cut off only when rain exceeds 10mm. If rain is less than 10mm we have assumed that the full amount of irrigation will be supplied. Water balance computation was carried out using the 51 years (1947 to 1998) of generated inflow data. The maximum drawdown is 125 mm.

Option 1b water balance study

Under Option 1b the total amount to be abstracted for irrigation in a dry day is 14 Mld. With less abstraction the drawdown is lesser than that of Option 1a. The maximum drawdown is 75 mm.

Option 2 water balance study

Under Option 2 the total amount to be abstracted for irrigation in a dry day is 5.6 Mld. The maximum drawdown is 25 mm.

Sensitivity Analysis

The reliability of the computations above depends to a great extent the accuracy of estimation of inflows into the lake. It was pointed out that the observed inflow at Prang Besar seems rather low compared to the flows in rivers nearby. Therefore we have adopted a model that gave a higher annual runoff of 800mm rather than the model that gave an annual runoff of 300mm. Suppose, for reasons unknown, the annual runoff in this river is actually that low then our estimation of lake drawdown would be underestimated. The lower runoff model was therefore reevaluated and its results incorporated in our water balance study. Comparison of the two runoff models is tabulated in Table 6.5.

ii) *Result of 300mm Annual Runoff Model*

Option 1a, 1b And 2

Results show that the drawdown is 420 mm and 370mm for Option 1a and 1b respectively. For Option 2, the drawdown is about 75mm but with conservation measures this drawdown can be reduced.

Conclusions

The lake drawdown scenario can be quite sensitive to the model adopted (see Table 6.5). To plan for the conservative case we would recommend that Option 2 irrigation water allocation using the lower flow model be adopted.

Finally there will be pocket areas where development of water resources especially for irrigation may not be cost effective. These areas are small isolated areas located far away from the water source and therefore to develop a irrigation water distribution system to convey water to this area will be expensive. Isolated private properties and small remote parks will fit into this category.

6.6.3 *Impact Due To Lake Drawdown*

The obvious source of irrigation water for Putrajaya would be from Putrajaya Lake. This lake has an inundated area of about 4 km² and is replenished by stormwater runoff from a catchment of about 60 km². However, the lake performs an important aesthetic function and excessive draw down would expose the sides of the lake. Informal discussions with Putrajaya indicate that the allowable draw down is about 1 metre. The depth of draw down depends on:

- The amount of water required for irrigation and this is directly proportional with the area to be irrigated. The gross area to be irrigated in Putrajaya is 38 km² of which 26 km² is in the Public Realm and 12 km² is in the Private Realm.
- The severity of a drought event occurring in Putrajaya and its Lake catchment.

Water balance studies indicate that the draw down is approximately 420mm (adopting the observed model at Prang Besar) if all the irrigation water needs (shrubs only) are obtained from the Lake. This is within the acceptable lake draw down limit of PPJ. However, it is not possible to source all the irrigation supply from the Lake as the economics and practicality of the delivery system as well as the 'no dig policy' are factors that need to be considered in the selection of water sources. Lake water in conjunction with other sources and water conservation measures are recommended in order to achieve the most cost effective irrigation option.

6.7 **Augmentation From Sungai Gajah**

Sungai Gajah which flows through the fringe of Precinct 11 has an approximate catchment area of 2 km² and based on its estimated low flow of 0.16 MLD, it can only irrigate about 3 ha of planted area by direct pumping and piping. However, it is observed that during normal

time, the flow in Sungai Gajah is quite substantial. During periods of normal flow arrangements can be made to truck water from Sungai Gajah rather than from the Lake which is much further away. Ideally the educational use class parcel located beside Sungai Gajah should tap water from this river using pump, this option is however no longer applicable as Sg Gajah will become a covered concrete channel.

6.8 Mining Pond in Precinct 20

The mining pond area of about 8 ha is located in precinct 20 is a potential source of irrigation water for the precinct. So far no survey has been conducted for the pond. Nevertheless, the catchment area from which this pond gets its source of water is estimated to be about 25 ha.

From analysis, this pond could in the long term sustain irrigation requirement of approximately 0.3 Mld only. This is sufficient for the cemetery (demand of 0.2 Mld) but insufficient for the nursery (demand of 4.8 Mld) in precinct 20.

7. WATER QUALITY

7.1 Putrajaya Lake

The averaged water quality index (WQI) for seven subcatchments in the Putrajaya Lake (Phase IA) has indicated the lake water to be within Class II, whose quality is higher than the Class IV standard specified for irrigation under the Proposed Interim National Water Quality Standards (INWQS) (see Table C1 and C2 in Appendix C). Hence, water from the Putrajaya Lake is suitable to be used for irrigation.

The monitoring results have shown that the present water quality in the lake generally complies with the limits stipulated in the Putrajaya Lake Ambient Water Quality Standard except for ammoniacal nitrogen and *E. coli*. The water should be treated using standard disinfection techniques prior to being used for irrigation. In view of this, it is recommended PPJ shall continuously monitor the *E. coli* content in the Lake to reconfirm the necessity of disinfection.

7.2 Other Water Resources

7.2.1 Ground Water

Based on previous studies conducted by the Geological Survey Department (1994), the ground water within Putrajaya was observed to range from being slightly acidic to neutral. The concentrations of nitrate, sulphate and ammonia have been found to be below their respective detection limits in all boreholes. The groundwater samples also registered trace amounts of heavy metals. It is recommended that sampling of the groundwater be carried out to determine the present groundwater quality prior to being used for irrigation.

7.2.2 Treated Sewage Effluent

Effluent that is being discharged from the sewage treatment plant near to the Gate 1 of the Federal Administrative Center of Putrajaya complies with Standard A of the Environmental Quality (Sewage and Industrial Effluent) Regulations, 1979 (see Table C3 and C4 in Appendix C). It is proposed that the effluent be disinfected to minimise the risk of disease transmission during spraying.

7.2.3 *Sungai Langat*

The water quality at station no. 2917608 which is located at the upper reaches of Sg. Chuau was found to be within Class II in 1995. As the river goes into the lake and flows downstream, water quality of Class II category was observed at station no. 2916603. However, at the confluence of Sg. Chuau with Sg. Langat, the water quality deteriorated to Class III standard.

A grab sample was taken at the main river of Sg. Langat near Kg. Simpang Empat, approximately 3.4 km upstream of the confluence between Sg. Langat and Sg. Chuau. Results of the water quality analysis should that the concentration of iron, total coliform and *E. coli* have surpassed their respective Class IV limits (see Table C5). Hence, it is recommended that the river water be disinfected to minimise the risk of disease transmission during irrigation.

7.2.4 *Mining Pond*

Grab samples were taken from an ex-mining pond in Precinct 20, near to the Taman Selatan in Dengkil for water quality analysis. The water was found to be highly acidic with pH of 2.5. The concentrations of iron and manganese were found to be higher than Class IV limits (see Table C6). Hence, water from the ex-mining pond is considered to be unsuitable for irrigation.

8. IRRIGATION STRATEGIES

8.1 Introduction

As control and management of irrigation water in the public and in the private realm is very different, the irrigation strategies adopted in these two realms would necessarily be different.

It is proposed that PPJ will directly control and manage the irrigation of planted areas in the public realm. Consequently the approach in water resources development, the delivery of irrigation water and the operation of the system can be planned in greater detail.

On the other hand, the day to day operation of irrigation systems in the private realm i.e. gardens in private homes are beyond the control of PPJ. Therefore it would not be realistic to combine both systems. Guidelines will be provided for irrigation water source development within private properties to irrigate their planted areas.

8.2 Public Realm Irrigation Strategies (Source Development)

In the public realm the various potential sources of irrigation water have been examined which include:

- Rainwater harvesting tanks/ponds
- Groundwater
- Treated sewage water
- Augmentation from Sungai Langat
- Putrajaya Lake
- JBA water supply
- Sungai Gajah
- Disused mining pond in Precinct 20

It is proposed that the public realm will obtain water mainly from:

- Putrajaya Lake and
- Sewage treatment plants (STP1 and STP2)

The lake is the obvious source for water and many areas close to the lake will take water from the lake. For areas far away from the lake, delivery of water will be a problem that has to be resolved. It is convenient and neat to deliver water from the lake to the plants via pipes. But several factors have rendered this approach unacceptable. One factor of constraint is Putrajaya's 'no dig policy'. In developed areas such as in Precincts 9 and 11 irrigation pipelines could not be installed because possible pipe routes are already paved and laying of pipes will require digging. The other factor is the cost effectiveness of delivering water to isolated small irrigation areas. For these areas, although water may still come from the lake, the mode of delivery of water could be by tankers. For isolated pockets of irrigated areas located far from the lake, it will be more practical to use JBA water for irrigation.

Sewage Treatment Plants, STP1 and STP2 could theoretically supply about 70 Mld of irrigation water. This is a large source of water and it is proposed that some of this water be used to irrigate area in their vicinity so that the reliance on lake water could be reduced since Lake drawdown is a major concern. Again the delivery of water is via pipelines, which would be a practical and more effective arrangement, and by tankers if the situation and the 'no dig policy' do not allow the construction of pipelines. The proposed irrigation water demand from the sewage plants are as below.

- STP1 to supply water (0.7 Mld) to Precincts 14, 15 and Diplomatic Enclave (DE).
- STP2 to supply water (6.3 Mld) to Precincts 5, 6, 19 and 20 (excluding promenade and cemetery).

Disinfection is required for sewage water effluent to reduce the risk of disease for recreational users of surface waters and to minimise contamination downstream. Due to the presence of impurities in water, continuous chlorinating treatment is proposed as subsequent phase of treatment for sewage water effluent. Chlorination will also retard the possible growth of algae to prevent clogging of irrigation application system. Disinfection facility shall be designed to be able to supply dosages of disinfectant at least 100% higher than normal doses in order to provide disinfection in case of emergencies such as construction for expansion. The treatment system shall provide a chlorine residual concentration of 1.5-2 mg/L in the water before discharging to the storage pond.

The other Precincts will generally source irrigation water from the Lake and JBA water for certain area. Simulation studies were carried out using approximately 51 years of daily rainfall data and it was found that the drawdown is around 60 mm (see Figure 6.5) based on 300mm annual runoff model. In the simulation studies the effect of urbanization, and the need

to provide for compensation flow (taken as 10% of annual average flow) and the return flow due to irrigation were considered.

To supplement irrigation water it is recommended that ponds be developed for harvesting rainwater. However, for the pond or any rainwater harvesting proposal to be effective, the catchment area contributing to the pond, the size of the pond and the weather pattern would have to be assessed. If the catchment is small, a larger pond size will not help very much as not much water could be harvested. If the weather pattern is such that there is a prolonged dry season, then a larger storage would be required to sustain the drawdown during a prolonged dry season.

There are a number of hilltop parks in Putrajaya and within these parks. However, there is not much catchment area for rainfall harvesting to be effective. Moreover siting a pond in a hilltop area creates a potential risk to slope stability and other hazards associated with overtopping of ponds and increasing of pore water pressure in hill slopes. It is difficult and costly to irrigate parks on hill, it has been proposed that (Chapter 4) parks shall be maintained natural and to adopt the reforestation concept thus obviating the need of a permanent irrigation system.

8.3 Public Realm Irrigation Strategies (Delivery)

Delivery of water to the planted area is complicated by the fact that irrigation pipelines were not considered when utility trenches were constructed for some of the existing areas. This coupled with the no-dig policy of Putrajaya makes it necessary to consider other ways to deliver irrigation water.

For areas where installation of pipelines is not possible or practical, water could be delivered by trucks to irrigate the roadside plants.

Even though delivery of water could be carried out by using trucks, these trucks could only access the roads in the area and irrigate only the road side plants. To water the interior of parks a system of pipelines within the park is still necessary. Without pipes and sprinkler systems, the interior of parks not accessible by water trucks will not be irrigated. However these areas could strategically be cultivated with for instance cow grass, which is reputed to be hardy and be able to regenerate itself when rain finally falls after a prolonged drought.

For areas yet to be developed, the new utility trenches laid will have to allow space for the irrigation pipelines so that water can be delivered directly to the irrigated areas.

8.4 Private Realm Irrigation Strategies

In the private realm, attempts have been made to develop guidelines for developing rainfall harvesting tanks or ponds. However, owing to practicality in long term maintenance and problem in bearing the cost, this shall be adopted with care.

Size of storage required depends on

- the reliability (return period) of irrigation supply imposed
- the size of the catchment area (CA) of the rainfall harvesting tank/pond
- the size of planted area (IA) to be irrigated
- the type of plants

The storage size expressed in terms of cubic metres per square metre of land to be irrigated (using a assumed 5mm/day irrigation requirement) is as tabulated below:

Table 8.1 Storage Requirement for Rainfall Harvesting Tank/ Pond

CA/IA	Storage required (m ³ /m ²)			
	5-yr	10-yr	25-yr	50-yr
2.0	0.18	0.25	0.40	0.60
2.5	0.10	0.15	0.25	0.25
3.0	0.07	0.12	0.18	0.22

In the case of commercial buildings, the rain from rooftops could be harvested. In this case the roof is the catchment area (CA). Gardens are the irrigated areas (IA). Garden area is small and the CA/IA is in the order of 3. If a garden size of 50 m² is considered then the size of the active storage should be 0.07 x 50 m³ which is about 3.5 m³ which would be able to see through the irrigation needs during a 5-year drought event. To cater for a drought event of 50-years then the size of ponds or tanks will have to be much bigger.

Tanks are also recommended for reducing storm runoff at source. However the storm reduction function conflicts with the water harvesting function of the tank. Water stored for irrigation purposes will occupy space meant for storm water attenuation. If space permits, ponds could be constructed for water harvesting.

Conditions vary from project to project and it is not possible in this masterplan to standardise the size of tanks or ponds for the developers of private areas except to provide a chart as shown above on how various sizes of storage provide could supplement water for irrigation depending on the size of the catchment of the rainwater harvesting facility and the size of the area to be irrigated.

8.5 Proposed Irrigation Strategies in Each Precinct

Precinct 1

Within this precinct, irrigation main supply has been designed for several areas and in some areas the system have been installed. The areas are:

- Taman Botani including a plant nursery (from existing intake, E4),
- Taman Putra Perdana (from existing intake, E5),
- Dataran Putra & Perdana Walk (from existing intake, E7),
- Linear Parks 1 to 5 (from existing intake, E3),
- Promenade (from existing intake, E3),
- Governments offices in Parcels A to G (from existing intake, E3),
- Putra Bridge (from existing intake, E7),
- Bridge 10 (from existing intake, E6), and
- Masjid Putra (from JBA water)

All these areas take water from the Lake. The capacity of the systems is adequate for the type of planting intended for these areas.

Some areas requiring irrigation are located in the high grounds far away from the Lake.

- VIP Hotel
- Istana Hinggap
- Government Reserve 1

However, the irrigation pumps for Taman Putra Perdana have already accounted for the needs of Istana Hinggap and the government reserve 1.

For the VIP Hotel, rainwater harvesting facilities should be provided to store storm water runoff from rooftops and the garden for irrigation. The catchment area is limited and it would not be advisable to construct large ponds in the highland as it may undermine the soil stability of slopes. Rainwater harvested will be rather limited and irrigation would have to be supplemented using JBA supply. As water is scarce it is also recommended that this area be planted with drought resistant species.

The Public Utilities areas in this precinct are:

- DCC
- Telekom HQ
- Substation
- Bus Depot

These areas have been constructed and irrigation has not been designed for. These are small areas and it is recommended that water for irrigation in these areas be from the JBA supply.

There are about 6.1 km of road reserves and the plants require irrigation which has not been designed for. Although the roads have been constructed, it has been decided that irrigation water would have to be delivered by pipeline taking the water from the Lake.

Precinct 2

In this precinct, irrigation for Taman Wawasan, Persisiran Wawasan, Waterfront, Dataran Wawasan and the Boulevard North have been designed by various consultants to take water from the Lake (via E10 and E11). For the isolated government parcels, tapping from JBA is more practical as the development is currently ongoing (phase 1B). For the road system, pipe reticulation from pump house (PH1 at precinct 18) is proposed.

Precincts 3 and 4

In these 2 Precincts, water for the public realm areas will be obtained from Putrajaya Lake via pipe from pump house PH1 and PH2 (located at Precinct 18 and 4 respectively) and the proposed main irrigation line.

Precincts 5 and 6

Water for the parks, government reserves and road reserves in these areas will be mainly obtained from STP2 (located at Precinct 1⁹). However for the promenade, which is next to the lake and religious areas, water will be from the lake pumped via Pump House PH5 at Precinct 6.

Precinct 7

This Precinct is partly developed and with the constraint of the 'no dig Policy' delivery of water from the nearest source i.e. the Lake would have to be by pipeline where possible from proposed pump house PH4 (located at Precinct 8). Putrajaya Lake water supply delivered using pipeline is proposed for the road reserves and JBA water for ERL station reserve. The government reserve, city parks and the neighbourhood parks (which would be about 10% of the residential land area) will have to be irrigated using JBA supply.

It should be observed that in order to avoid digging up the paved roads for irrigation pipe laying, pipe-jacking is warranted in certain locations which will be determined during construction stage.

Precinct 8

The Lake Valley Park, and the promenade which is located next to the lake will obtain water from the Lake via pipelines or trucking (if more practical) from pump house PH4.

The surroundings of the community and neighbourhood park area are currently under construction and JBA water has been recommended as the source of water for irrigation.

Likewise the source of water for irrigating the plants in the already constructed Government institutional areas will be from rainwater harvesting or JBA supply.

Water for irrigating the plants along the road reserve will be from the lake delivered using pipeline. The irrigation requirement of the road reserves is not large. As the precinct is under construction, pipe-jacking may be required at certain paved locations that will be determined during construction stage.

Precinct 9

Taman Rimba Desa is the main park area. It is located at the hilltop and water supply is a problem. Delivery of water to this area is also a problem due to Putrajaya's 'no dig policy'. As such water, if required, have to be pumped from the lake into trucks and conveyed to this

park using trucks. Due to difficulties in conveying water to the hill park, it is proposed that it should be reforested and relies on rainfall.

There is a flood retention pond RP1 which could be used for irrigating the community and neighbourhood park. However due to the scattered nature of the parks, JBA water is recommended.

Government institutional reserve, ERL and LRT will have to be irrigated by JBA water and road reserves by pipeline from the Lake.

Development of precinct is currently in progress as such laying of irrigation pipe will be difficult, pipe-jacking may be warranted in certain locations. These locations will be determined during construction stage.

Precinct 10

An irrigation system has been installed in PMR tapping water from the Lake from existing intake, E9. Water for irrigating the promenade could be taken from the lake from the pump house PH4 (located at Precinct 8). JBA water will be used to irrigate small areas in the kindergarten, surau and TNB substation and Telekom area. Water for irrigating the road reserve will have to be supplied by pipeline from the Lake.

As the precinct is already fully developed, in order to avoid digging up the paved roads for irrigation pipe laying, pipe-jacking is required at certain locations as required by PPJ.

Precinct 11

A large metropolitan park Taman Saujana Hijau with a land area of 42 ha sits on a ridge. The area is located far from the Lake and water cannot be piped to the area under the 'no dig policy'. It is proposed that this park adopt the reforestation concept so that permanent irrigation is not required.

Although there is a retention pond RP2, however due to the community and neighbourhood parks being scattered and the no dig policy, it will be necessary to obtain irrigation water through JBA water supply. Sg Gajah is no longer a suitable source as it has been planned to be converted into a covered channel.

The rest of the irrigated areas including, government reserves and the road reserves will have to rely on water from JBA water or the Lake water delivered via trucks.

Precinct 12

Parks located next to the wetland will tap water from the wetland via pump house PH6. Currently there are two water circulation pipes from the Wetland Main Pumping Station (to Upper East Wetland and Lower East Wetland) pumping water from the Lake to the wetland using the wetland to further improve the water quality. The proposed pump house PH6 is located at the downstream of the Lower East Wetland. The parks and other public areas in this Precinct will use water from PH6 for irrigation.

Precinct 13

Precinct 13 is essentially Taman Wetland. The plant species selected for both the wetland zone and the zone of intermittent inundation is able to self-sustain and perpetuate themselves after a period of drought. Hence, no irrigation system is proposed. However, for the shrubs in Taman Wetland (namely, Wetland Park) PPJ has been irrigating the shrub using truck. A more permanent system can be implemented by extending a pipe from the proposed pump PH7.

The existing plant nursery is currently tapping from the Wetland's cell through a temporary pump set. It is proposed that the pump house PH7 be located nearby the nursery and pump from the nearby Upper West Wetland.

Although the area is already developed, it is recommended that irrigation pipeline be laid to water the primary distributor road reserve areas as watering by truck in high speed roads is not practical.

Precincts 14, 15 & DE

In this area, the largest park area is Taman Rimba Alam which is to be developed as a natural park. The two large retention ponds (named as RP3) in the area with an approximate surface area of 15 ha and a combined catchment area of 60 ha. Water in these ponds can provide only 0.2 Mld of irrigation water while the combined demand for these three precincts is 0.7 Mld.

STP1 is proposed as an irrigation source for three precincts for the parks, government reserves and road reserve areas since RP3 could not meet the demand of these three precincts.

Precinct 16

The largest park area in this precinct, Taman Warisan Pertanian already has an irrigation system designed from gravity line from elevated storage tank, ST1 that is pumped by pump

E8 from intake pond IP (see Map2 of Executive Summary). Since the storage tank has a capacity of 3-month water demand, it will be self - sufficient.

The promenade will take water from the lake via E3 (for northern area of DPM) or PH3 (located at Precinct 19 for southern area of DPM).

The DPM residence's irrigation requirements have already been designed to tap water from the lake i.e. via existing intake E3.

Due to the 'no dig policy', the other government institutional reserve and the road reserve areas will be irrigated by JBA water or from the lake delivered using trucks.

Precinct 17

A pump house PH3 (located at Precinct 19) is proposed to pump water from the lake and to distribute water to the various parks, government institutional reserves and road reserves via pipelines.

Precinct 18

It is proposed that water for irrigation be pumped from pumping station PH1 located at Precinct 18 and to distribute water to the various parks, government institutional reserves and road reserves via pipelines.

The park, Taman Puncak Banjaran is located on hilly area. It is therefore preferred that the park be reforested such that permanent irrigation facilities are not required. However recently PPJ has decided to landscape the park. Owing to this strategy, irrigation facilities will therefore be required.

Precinct 19

The promenade in this precinct is next to the lake and will therefore obtain its irrigation water from the lake. The other areas i.e. the parks, government institutional reserve and road reserve will obtain their irrigation water from STP2 with proper pipe reticulation system, except religious areas which will obtain water from rainfall harvesting supplemented by JBA.

The park, Taman Lindungan is on hilly area. It is preferred that this park be reforested so that no permanent irrigation system is required. However, recently PPJ has decided to landscape the park with palms and bamboo. Owing to this, irrigation facilities will therefore be required.

Precinct 20

The park, Taman Selatan is on hilly area of the precinct. For economical reasons, it is proposed that this park be maintained natural so that no permanent irrigation system is required.

Water from STP2 (located at Precinct 19) will be used to supply water for irrigating Nursery Putrajaya and the road reserve areas. The water requirement for Nursery Putrajaya has been proposed to tap from an 'Irrigation Pond/mining pond' by the designer for the nursery. This can be used during normal period but as the contributing catchment to this pond is not big enough to withstand a prolong severe drought of 1 in 50 years return unless it is very wide which is not an economical size.

Religious areas and the cemetery will be irrigated with water from the lake (via PH 5 located at Precinct 6) as religious sensitivities may not permit the use of STP2 water for irrigation. There were suggestions to look into the possibility of using water spilled from the lake for irrigation. This source of water would not be very reliable and effective as spilling only occurs during the rainy season when water requirements are low. During the drought season when water requirement is high, over spilled water is not available.

9. IRRIGATION SYSTEM AND COST ESTIMATES

9.1 Irrigation Options Considerations

Various alternative systems have been evaluated and details are presented in Appendix J.

The recommended systems are described below.

9.2 Proposed Irrigation System

The proposed systems comprise of one or combination of the following sources/system:

- a) Source from Putrajaya Lake (by pipe reticulation)
- b) Source from Sewage Treatment Plant (by pipe reticulation)
- c) Source from JBA (by tapping off from nearby JBA main)
- d) Trucking (from Putrajaya Lake)

9.2.1 Irrigation Zone

A total of nine (9) irrigation zones have been proposed (Map 3 in Executive Summary Report). Each zone will be served by intake either from Lake or sewage treatment plant, or combination of both sources. Isolated pockets of irrigation areas which are far from water source or where 'no dig Policy' is in place, JBA water and trucking are proposed.

The summary of irrigation zones served by Putrajaya Lake, JBA water and trucking respectively are shown in table below.

Table 9.1 Irrigation Zoning And The Water Demand (Public Realm Only)

a) From Lake

Zone	Intake	Source	Precinct	Water Demand (m ³ /day)
I	PH1	Lake	2, 3 & 18	457
II	PH2	Lake	3 & 4	457
III	PH3	Lake	16, 17 & 19	443
IV	PH4	Lake	7, 8, 9 & 10	355
V	PH5	Lake	5, 6 & 20	611
VI	PH6	Lake	12	237
VII	PH7	Lake	13	1029

Table 9.1 Irrigation Zoning And The Water Demand (Public Realm Only)
(con't...)

b) From Sewage Treatment Plant

Zone	Intake	Source	Precinct	Water Demand (m ³ /day)
IX	SP1	STP1	14, 15 & DE	695
X	SP2	STP2	5, 19 & 20	6269

c) From JBA Water Main

Zone	Intake	Source	Precinct	Water Demand (m ³ /day)
		JBA Main	All precincts Except 3, 4, 12, 13, 17, 18 & 20	924

d) Trucking (From Lake)

Zone	Intake	Source	Precinct	Water Demand (m ³ /day)
		Lake	11 & 16	95

Detailed water source / demand for each landuse area is given in Appendix SC of the Executive Summary.

9.2.2 Mechanical And Electrical Consideration

The number and capacity of pumps has been selected to provide a minimum standby capacity of 50 %. Pump house can be of either concealed type (underground) or exposed type (above ground). The exposed type is proposed based on the following reasons:

- a) Above ground pump house provides better access for installation, operation and maintenance works.
- b) There is no chance of the electrical switchboards and pump motors being flooded.
- c) Artificial rocks and vegetation can be used to camouflage the pump houses.

The intake design criteria are given in Appendix D and the pump capacity required for each intake is tabulated in Table 9.3.

9.2.3 *Pipe Reticulation Consideration*

The pipe reticulation is proposed based on the following design criteria and assumptions:

- a) The pipe sizing is based on a 8-hours watering window (areas that required less watering window will have to be irrigated in a staggered order);
- b) The velocity in pipe is limited to 1.5 m/s; and
- c) The pipe is proposed to be of high density polyethelene (HDPE for pipe less than 300mm diameter) or mild steel concrete lined (MSCL for bigger size); and
- d) Pipe - jacking is warranted at certain locations to avoid digging up paved roads for irrigation pipe laying.

The proposed pipe route and the pipe sizes are indicated in Map 2 and Map 2a – 2h (Executive Summary). The pipe sizes vary from 110mm to 350mm diameter.

Typical pipe location along road, common utility trench (CUT) and promenade are shown in Figure 9.1a – 9.1c, Figure 9.2a – 9.2c and Figure 9.3 respectively.

9.2.4 *Storage Pond for Treated Sewage Water Consideration*

After the effluent from the sewage treatment plant has been treated, it will have to be stored before applying to the irrigation system as timing of inflow into the plant may not coincide with the irrigation window. Hence additional storage pond has to be provided and the design consideration is based on the following criteria:

- a) Storage capacity of 1 day demand;
- b) Storage pond depth of 3m with a free board of 0.6m; and
- c) Storage pond side slope of 1(V) : 2 (H).

9.2.5 *Trucking Consideration*

For areas that have already been developed, being developed or substantially completed (in Precincts 11 & 16) or surrounded by developed areas (e.g. Precinct 11) where 'no dig policy' is a constraint, irrigation by means of trucking have been proposed. The design consideration is based on the following assumption;

- a) Average truck capacity of 3 m³ per truck; (the truck can be either 1m³ or 10m³ truck pending on road traffic constraint)

- b) Truck trip of 6 times per day;
- c) Normal working hour of 12 hour per day;
- d) Truck kiosk of 8 truck capacity for water refilling;

Based on the precinct boundary and the total number of trucks required, two (2) trucking zones have been proposed as below. The layout plan of the truck depot and kiosk is shown in Figure 9.4 and 9.5 respectively.

Table 9.2 Proposed Grouping of Trucking Zone

Group	Precinct	Requirement of Truck			
		Number	Depot & Kiosk Location	Depot	Water Refilling Kiosk
1	16	1	Prec. 12*, 13* & 15	2 No. (25m x 25m)	2 No. (20m x 40m)
2	11	4	Prec. 7 & 8	1 No. (35m x 35m)	1 No. (20m x 40m)

*Note: * The kiosk & depot as proposed in Precinct 12 & 13 respectively is provisional only and will be utilised in the event that the kiosk or depot location in precinct 15 cannot be made available.*

9.2.6 Locational And Design Criteria For Irrigation Facilities

Site identification and selection for pump houses/intakes, truck depots (for overnight parking and repairs), water filling stations (for trucks) and ponds for storage and disinfection (of treated water from the sewage treatment plants) are to be undertaken by the respective planners or designers for the precinct. The locational and design criteria as given in Appendix E are to be used as guidelines in site selection and planning and design of these facilities

9.2.7 Cost Estimates and Area Required For Irrigation Facilities

The cost estimate for capital cost as well as operation and maintenance (O&M) cost per annum are generated and tabulated in Table 9.3. The summarised estimates represented in Table 9.4 below.

For O&M cost, the irrigation frequency is based on 260 day per year assuming irrigation is required for day that rainfall is less than 5mm (from Chapter 2).

Table 9.4 Grand Summary Of Cost Estimate For Proposed Irrigation System

	Capital Cost	Annual O & M
	RM	RM
<u>Pipe System</u>		
Intake & Pump (at Lake & STP)	7,560,000	607,593
Pipe Reticulation	13,650,900	273,018
Watering System	4,589,052	229,454
Intake Pond Excavation at STP	683,664	13,673
Disinfection for STP	150,000	86,792
Sub-total	26,633,616	1,210,530
Committed Costs		
Truck	650,000	353,600
JBA Water	1,000,000*	1,453,563
<u>Operation , Maintenance & Management</u>		
Tools & Equipment	200,000	10,000
Integrated Irrigation Management (IIMS)-soft & hardware	1,000,000	50,000
Subtotal	1,200,000	60,000
GRAND TOTAL	36,020,177	3,077,693

** Allow Cost for tapping from existing JBA pipe

9.3 Irrigation Application System, Scheduling Concept And Centralised Control System

The commonly used watering system which are Spray System and Drip System as well the basic concepts of irrigation scheduling concept comprising of Block System, Valve-In-Head System and Quick Coupling System and the proposed irrigation centralised control system for PPJ are described in details in Appendix F.

10 INTEGRATED IRRIGATION MANAGEMENT SYSTEM

10.1 Objectives

The main objective of the Irrigation Irrigation Management System (IIMS) is to enable systematic irrigation management, improve efficiency of water allocation and optimised management of water resources. Irrigation is mainly targeted at maintaining the soil moisture in the planted areas to an optimum level that satisfy the water requirements for plant survival and growth and at the same time do not promote water wastage. Knowledge of the status of soil moisture is thus the key to systematic irrigation management and soil moisture can be monitored by direct measurement of soil moisture using tensiometers or indirectly by monitoring rainfall and evaporation. Besides, the overall irrigation system in Putrajaya is complex. Eventually, there may be more than 100-pumps (mainly booster pumps to supply pressurized water to the sprinklers and driplines). In certain areas water is supplied by truck. Source of water comes mainly from the Putrajaya Lake, supplemented by water from sewerage treatment plants. There is a need to monitor and manage this system.

With modern electronics and communications technology, it is now possible have remotely located sensors recording rainfall, water level, evaporation and soil moisture and automatically sending the data to the irrigation control center which could be in PPJ headquarters. Similarly, the pumps in the irrigation system and their status can be monitored. Real-time data provides the irrigation manager with knowledge of the current status of the irrigation areas with which he can use to better manage the irrigation system.

The most direct indicator of irrigation requirement is soil moisture and if the soil moisture of various areas can be monitored then the irrigation manager or an automated system can be programmed to supply the irrigation water.

Indirectly, soil moisture can also be estimated by monitoring other contributing factors to soil moisture, such as rainfall. For instance, if it is already raining heavily in certain Precincts, then irrigation in that Precinct can be cut down thus saving water.

Besides the day to day allocation of irrigation water the irrigation manager also needs to monitor his water supply status and to implement water conservation if it is found that the supply has drop below critical limits. If the drawdown of Putrajaya Lake, which is the main source of irrigation water supply drops below a predefined critical level then its time to implement water conservation measures.

A decision support system (DSS) is proposed to assist Putrajaya's irrigation manager in the operation of the irrigation system. The conceptual design of the DSS will be developed in this study outlining the various methods whereby water requirements of various irrigated areas could be estimated and how this could lead to a decision on how much and when to supply irrigation. Eventually the DSS will be in the form of a computer software residing in the irrigation central control center with real-time hydrological and climatic data will be available at this control center via a SCADA system. The development of the software for the DSS and the SCADA system is beyond the scope of this study and will not be attempted.

10.2 Remote Data Acquisition For Irrigation Management

To be able to manage the system remotely, real-time data on the status of water and catchment conditions must be available. This would require the setting up of a network of hydrological stations with telemetric links to the Irrigation Control Centre (ICC).

NAHRIM (1999) had proposed a hydrological network comprising, 5 rainfall stations, 7 streamflow stations and 5 water level stations. These stations could be used for the purpose of real-time hydrological monitoring and remote automation of irrigation. The locations of these stations are as shown in Figure 10.1.

NAHRIM's proposed water level station at PWL5 would be adequate for monitoring the Putrajaya Lake level but additional water level stations will be required for ponds and wetlands which are meant for irrigation water supply and where drawdown of water from these water sources would be of concern to Putrajaya's irrigation manager. The exact locations of these water level stations could be specified as and when pond locations are confirmed.

Evaporation does not vary very drastically with location. The average pan evaporation in Putrajaya is about 4.5 mm/day and this value can be used if evaporation data from the proposed Automatic Weather Station in Putrajaya are not available.

The most important parameter as far as irrigation is concerned is soil moisture. It is therefore proposed that a network of soil moisture monitoring stations be set up. However, soil moisture is a relatively variable characteristic compared to evaporation and even rainfall, as soil moisture is affected by changes in rainfall, soil type, terrain, plant species and also the depth at which it is being measured.

10.3 Irrigation Control

There are two major types of irrigation system:

- Pipe irrigation
- Trucking

10.3.1 Pipeline Irrigation Control

Fig. 10.2(a) shows a schematic of a typical pipe irrigation network. Water is pumped by the main pump from the water source e.g. Putrajaya Lake or STP2 pond and is conveyed via pipelines to various target irrigation zones. At the various zones there are booster pumps to supply pressurized water to the various areas where there are satellite controls which further allocates water to individual distributor lines that service the various irrigated sub-areas. The satellite controls allocate water to individual distributor lines according to preprogrammed time schedules. Each line finally delivers water to the plant either through drip lines or sprinklers.

Drip lines and sprinklers have a predesigned rate of water delivery. They are therefore preset at the time of installation and during the operational phase, the rate of delivery cannot be changed. The satellite controls can be programmed to open the valves of individual lines at user selected time schedules and time intervals. Therefore the lowest level of irrigation control would be at the satellite level. If more water is required the satellite control can be programmed to irrigate more frequently or for a longer period of time. If satellites are linked to a soil-moisture meter (such as tensiometers, gypsum blocks) local control would be possible as soil moisture would be the most accurate indicator of need to irrigate. Each satellite normally control between 16 to 32 sprinklers and driplines. However, based on experience in some of the already developed irrigation areas in Precinct 1, it is estimated that the number of satellites would be in the order of 2500. Remote and automated control at the level of satellites would be expensive at the rate of RM 5000 per control. Moreover, the measurement of soil-moisture has reliability problems. Manual control would require substantial manpower and is not recommended for day-to-day operations. Occasional adjustment to control e.g. during a drought may be possible.

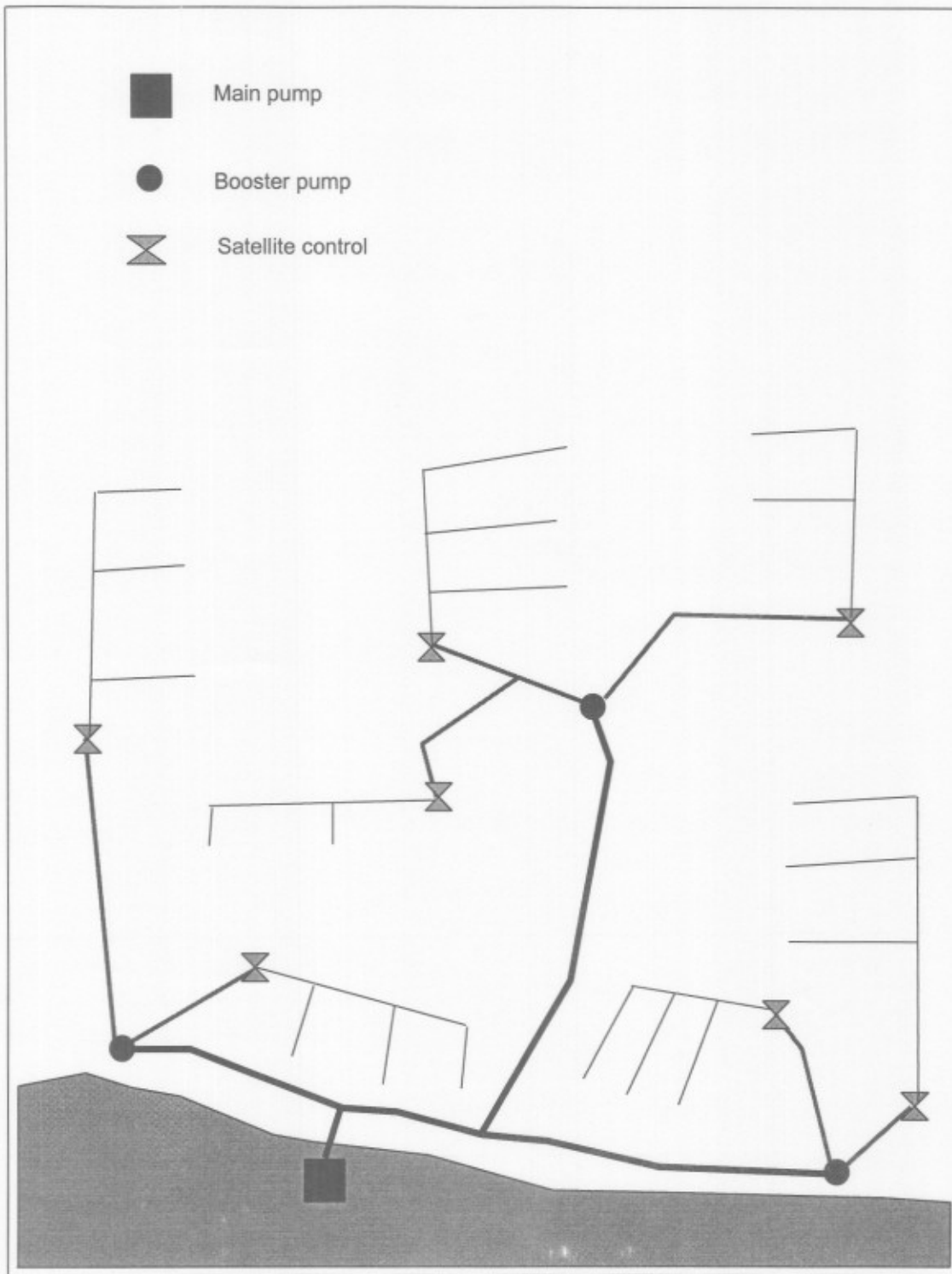


Fig. 10.2(a): Schematic of a Typical Pipeline Irrigation System

The next level of control would be at the level of booster pumps. If booster pumps are not activated then irrigation would not occur even if the satellites trigger valves to open for irrigation. The number of booster pumps is much lesser, of the order of 70 to 100. The level of control is at zone level. It is envisaged that there will be a need to under irrigate certain less important areas when water resources availability is critical. By under irrigation, the system should be able to supply, say, half, one-third or quarter the normal supply. To accomplish this, the satellites must be programmed to irrigate in short time intervals several times per day instead of a single application per day. The level of control at booster pump level is recommended.

10.3.2 Trucking irrigation control

In areas irrigated by trucking, water allocation is also dependent of soil moisture and water availability. Irrigation involves transporting water to the area and spraying water on the plants via a hose. Process is very much man-power dependent and efficiency and evenness of water application is lower.

The overall irrigation of Putrajaya within the Public Realm involves two major types of system. A system for determining the need for irrigation that caters for both systems is required. Since direct measurement of soil-moisture is not an easy task for a big area like Putrajaya, it is proposed that indirect methods to monitor soil moisture be adopted. The water balance approach to compute soil-moisture coupled with some measurement so of soil moisture for the purpose of validation is proposed and described below.

10.4 DATA FOR WATER BALANCE ANALYSIS

A decision support system (DSS) based on an irrigation water balance model is proposed. The aim of water balance computations is to indirectly estimate the soil moisture and provide a basis for activating pumps in areas where irrigation is delivered via pipelines and activate trucking of irrigation water where irrigation is to be supplied via trucks. The concept behind the water balance model will be developed under this study. It is envisaged that the water balance model will be updated regularly using real time information from the proposed monitoring network. The data requirements of the DSS are as described below.

Rainfall

Rainfall would be the single most important parameter in the water balance equation. The amount of water contributed by rainfall is substantial. Another characteristic of rainfall is that it varies significantly from area to area and fluctuates significantly with time. This is especially so in west peninsular Malaysia as the rainfall here is localised compared to monsoon rains, which are often widespread. Duration of rainstorm is often short (often lasting 1-3 hours) and the rainfall intensity can be high.

Rainfall in the west coast of Peninsular Malaysia is dominated by localized intense thunderstorms. The rainfall can be very intense (intensities of 20-30 mm/hr) are common. Such rainfall would have more than replenish the water requirement in the planted areas and irrigation would not be required. As such it may be necessary to check rainfall as frequently as every hour so that timely action could be taken to adjust the supply.

Evaporation

Pan evaporation is about 4.8mm/day and does not vary very much with area. Pan evaporation data could be recorded and sent daily to the ICC as an input to the water balance analysis. The water balance equations would require potential evapotranspiration (E_o) values. E_{pan} values will be converted to its equivalent E_o by multiplying E_{pan} with an appropriate pan coefficient K_p before being used for water balance analysis. Pan evaporation data as it is collected currently by JPS and Jabatan Perkhidmatan Kajicuaca (JPK) is a manual process and which could not be automated for remote monitoring.

Soil Moisture Characteristics

The most important parameter for irrigation is soil moisture. There are instruments for monitoring soil moisture such as tensiometers, gypsum blocks, moisture meters. The reliability and representativeness of readings varies.

Indirect methods of estimating soil moisture and hence when to irrigate

Several properties of soils are important for estimation of irrigation requirements. The properties include:

Field capacity (FC) determines how much water the soil can retain against gravity. Obviously clayey soil will have a higher FC than sandy soil.

Wilting point (WP) is the moisture level below which the plant will wilt and die.

The total available soil moisture (TAM) is therefore equal to:

$$TAM = FC - WP \quad \dots\dots\dots (10.1)$$

The readily available soil moisture (RAM) is a fraction of TAM i.e.:

$$RAM = p \cdot TAM \quad \dots\dots\dots (10.2)$$

Where p is a fraction depending on type of plant

Typical p values ranges from 0.3 to 0.7

Indicative values of FC, WP for various soil types are given below:

Soil Type	FC (%)	WP (%)
Sand	4.79	3.17
Fine sand	3.29	1.33
Sandy loam	9.69	4.17
Fine sandy loam	16.80	8.93
Silt loam	23.36	6.12
Silt clay loam	21.70	5.02
Clay loam	24.15	11.55
Clay	31.12	25.70
Loam	37.90	19.03

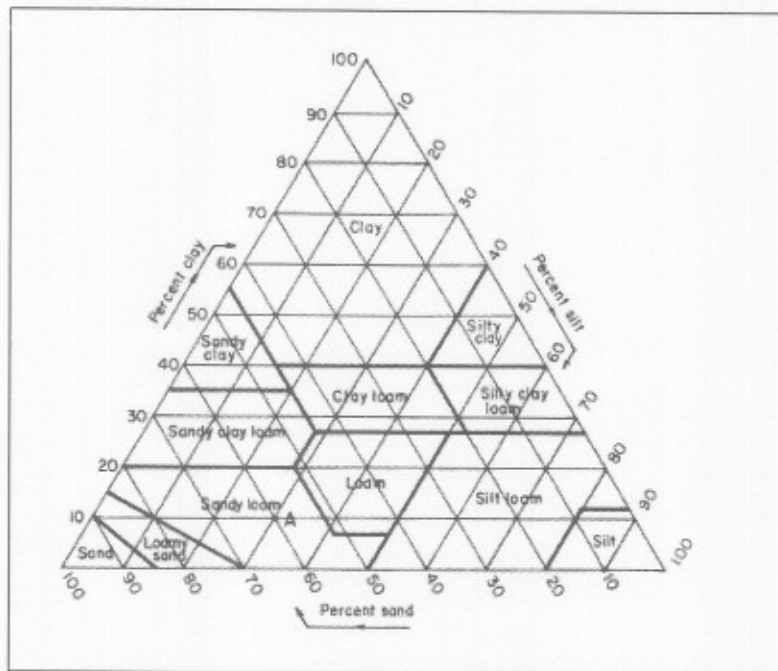


Figure 10.3 (a): Classification of Soil Types

10.5 PROPOSED TELEMETRIC SYSTEM

Under the City Control Center (CCC), there will be a network of telemetric rainfall, water level and an automatic weather station in Putrajaya (See Figures 10.1 and 10.2)

These data are monitored on a real-time basis, by the Parks and Environmental Management System (PEMS) Module of the CCC. Tensiometers could be installed at some sites and data transmitted to PEMS.

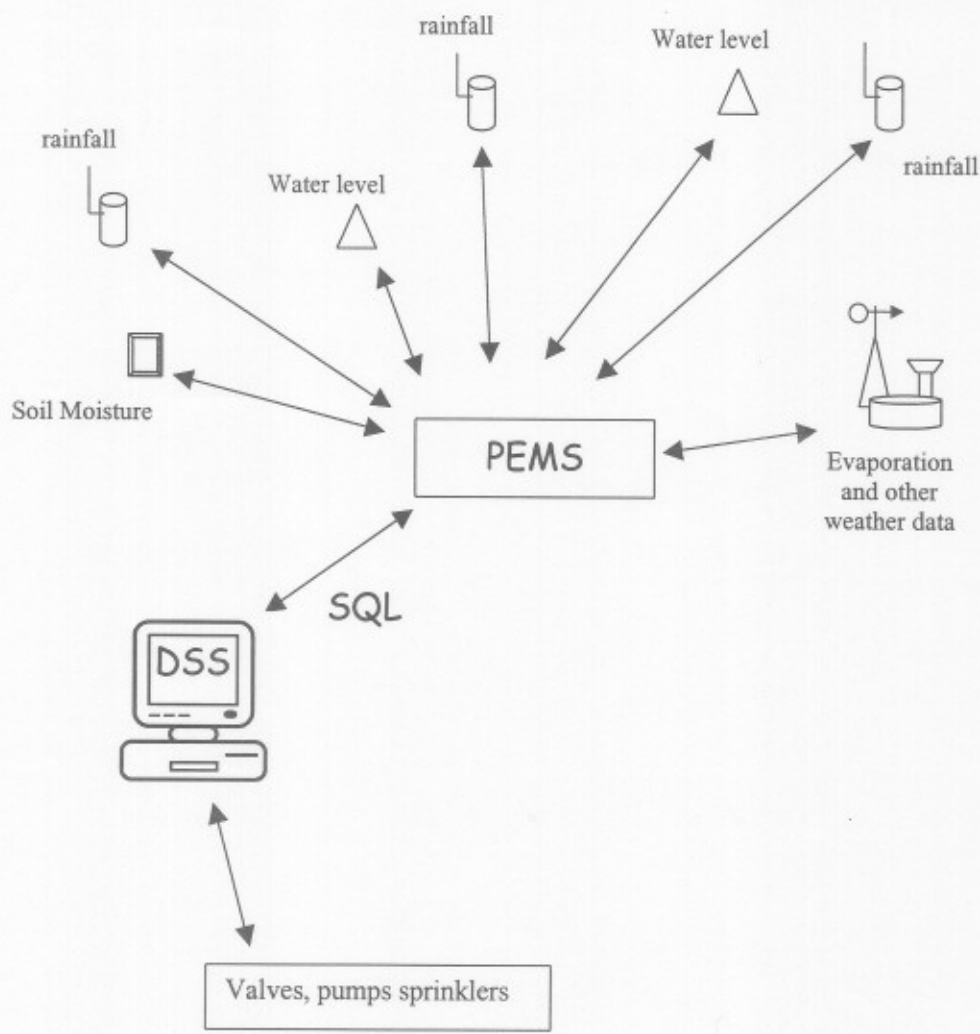
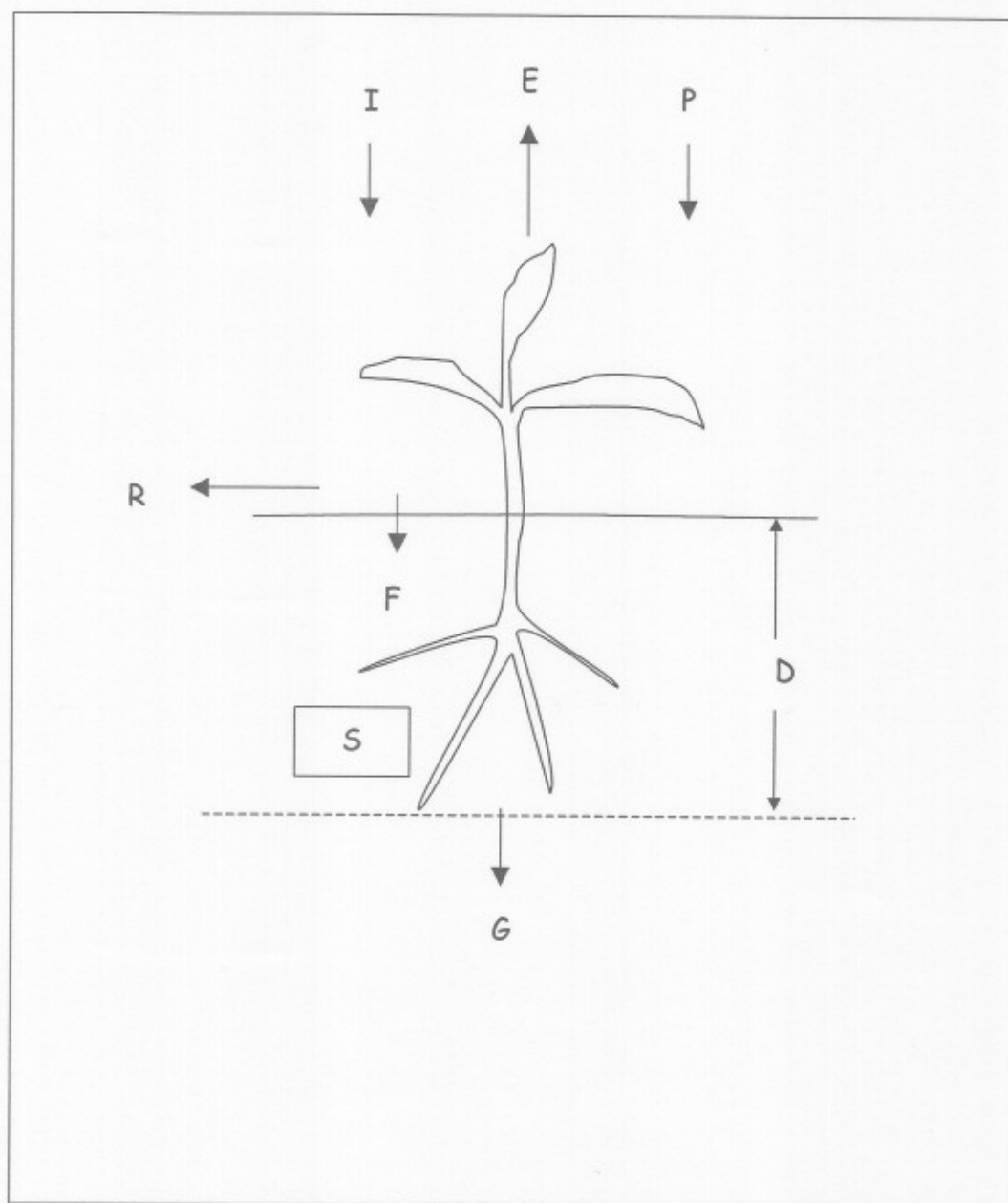


Figure 10.3 : Remote Hydrological Stations

10.6 SOIL MOISTURE WATER BALANCE MODEL

The soil-plant-water relationship for an irrigation unit is as follows:



I	Irrigation	S	Soil moisture
P	Precipitation	G	Percolation to groundwater
E	Evapotranspiration	D	Root depth
R	Surface runoff	F	infiltration

Fig 10.4. Soil-Plant-Water Relationship

The figure above shows the various components of the soil moisture water balance model at time period I and the general water balance equation is as follows:

$$S_i = S_{i-1} + F_i - E_i - G_i \quad \dots\dots\dots (10.3)$$

The unit time period commonly adopted is one day.

The infiltration F_i is given by:

$$F_i = P_i + I_i$$

If $F_i > F_{max}$ then $F_i = F_{max}$ (10.4)

The surface runoff is therefore:

$$R_i = P_i + I_i - F_i \quad \dots\dots\dots (10.5)$$

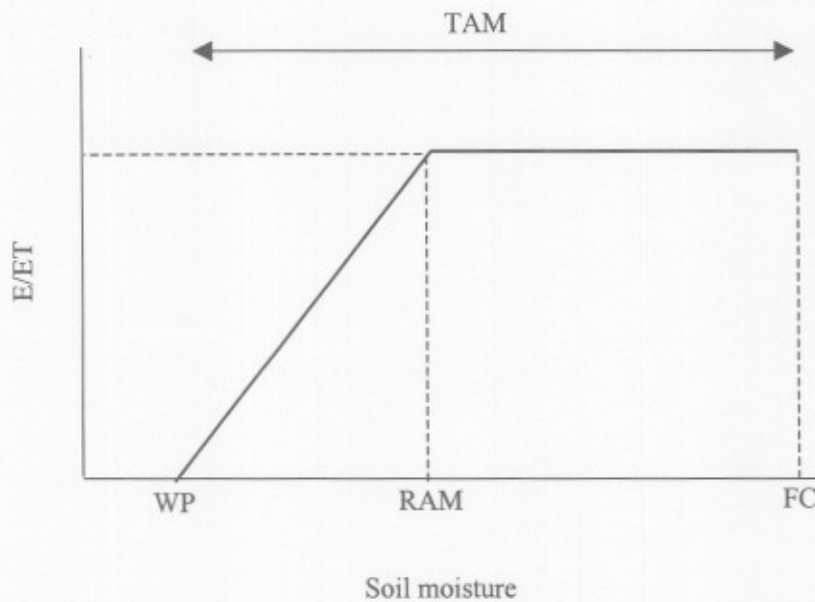
G_i the percolation into the groundwater is computed by:

$$G_i = S_{i-1} + F_i - E_i - FC$$

If $G_i < 0$ then $G_i = 0$ (10.6)

E_i the evapotranspiration depends on several factors namely:

- The type of plant and its stage of growth and correspondingly its crop coefficient K_c
 - The reference crop evapotranspiration E_{to} which has to be computed from climate data or obtained by multiplying the pan evaporation by a factor.
 - The soil moisture availability.
- If $S_{i-1} > RAM$ (readily available soil moisture) then
- $$E_i = K_c \times E_{to}$$



Where E = actual evapotranspiration and
 $ET = K_c \times E_{to}$

Fig 10.5 : Actual Evaporation – Soil Moisture Relation

Actual planting schedule and crop variety

The consumptive use of water depends on the crop coefficient K_c which varies according to the type of plants and the stage of plant growth. The stage of plant growth would vary from place to place. To be able to compute consumptive use of water at each irrigation area, it would be necessary to know the planting schedule and the area planted. K_c of trees, palms and ground covers would be stabilized after a few years when the plants matured. K_c will continue to vary for annuals, but if the proportion of such plants are small, it may be more practical to assign a higher fixed K_c values for annuals.

10.7 IRRIGATION DECISION SUPPORT SYSTEM

The DSS will comprise soil water balance models configured for various irrigated public realm areas in Putrajaya. Water balance computations will indicate the water requirements of the various areas and accordingly the water supply required. With a properly configured DSS irrigation will be to a large extent demand driven and water allocation can be optimized. It is envisaged that optimal management of water supply could only be arrived at after various trial runs of the decision support system as there are many parameters in the system that could not be accurately estimated in the proposed model. The model will eventually be more

realistic as feedback from SCADA system is compared to model output and parameters adjusted accordingly.

A soil-plant-water model such as described above will be conceptualized for water balance modelling. Irrigation will be controlled by the activation of pumps. Therefore irrigated areas modeled will be divided according to areas under the command of each pump. There is a need to cater for areal variation of rainfall, areal variation of plant types, soil type, etc.

At the master station in PPJ, the irrigation manager can query each telemetric rainfall stations to obtain rainfall that occurred since the last query. The rainfall over each area will be computed based on the Thiessen polygon method.

Supply of irrigation water to each area will be computed from real-time monitoring of discharge through metered pipelines

The DSS will have a graphical user interface that supports point and click functions making it easy for the user to navigate through the data entry, water balance modelling and model updating processes. The various steps in the DSS can be presented in the form of tables and flow charts.

For water balance computations the scheme will be divided into target irrigated areas. For each target irrigated areas there will be a need to specify the parameters tabulated below:

Target Irrigated Area		Area (m ²)	Plant		Soil				Irrigation		
			Kc	RD mm	FC mm/m	TAM mm/m	RAM mm/m	FM mm/hr	Priority	IR mm/hr	Ef
p1-1a	Taman Botani	31,175	1.1	500	230	140	70	5	1	3	0.8
p1-1b	Oval Road	270	1.1	500	230	140	70	5		3	0.8
p1-2	Taman Putra Perdana	34,036	1.1	500	230	140	70	5	1	3	0.8
p1-3a	Dataran Putra	2,362	1.1	500	230	140	70	5	1	3	0.8

p1-3b	Perdana Walk	1,218	1.1	500	230	140	70	5	1	3	0.8
p1-3c	Promenade	8,894	1.1	500	230	140	70	5	1	3	0.8
p1-3d	Putra Bridge	960	1.1	500	230	140	70	5	1	3	0.8
p1-3e	Linear Park 1	4,300	1.1	500	230	140	70	5	1	3	0.8
p1-4a	Linear Park 2	4,500	1.1	500	230	140	70	5	1	3	0.8
p1-4b	Parcel A, B	22,000	1.1	500	230	140	70	5	1	3	0.8
p1-4c	Oval Road	180	1.1	500	230	140	70	5	1	3	0.8
p1-5a	Linear Park 3,4	9,072	1.1	500	230	140	70	5	1	3	0.8
p1-5b	Parcel C,D	20,000	1.1	500	230	140	70	5	1	3	0.8
p1-5c	Oval Road	200	1.1	500	230	140	70	5	1	3	0.8
p1-6a	Linear Park 5	4,536	1.1	500	230	140	70	5	1	3	0.8
p1-6b	Parcel E,F,G	29,000	1.1	500	230	140	70	5	1	3	0.8
p1-6c	Oval Road	160	1.1	500	230	140	70	5	1	3	0.8
p1-7	Plant nursery	669	1.1	500	230	140	70	5	1	3	0.8
p1-8	Istana Hinggap	7,448	1.1	500	230	140	70	5	1	3	0.8
p1-9	Government Reserve 1	2,947	1.1	500	230	140	70	5	2	3	0.8
p1-10	Local Distributor D2	3240	1.1	500	230	140	70	5	2	3	0.8
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p7-1	Promenade	1046.4	1.1	500	230	140	70	5	2	3	0.8
t7-1	Primary distributor D3	1701	1.1	500	230	140	70	5	3	3	0.8
t7-2	Secondary distributor D3	2727	1.1	500	230	140	70	5	3	3	0.8
t7-3	Local distributor D3	756	1.1	500	230	140	70	5	3	3	0.8
t7-4	U2 spine road	3240	1.1	500	230	140	70	5	3	3	0.8
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p19-1	Taman Lindungan	9,974	1.1	500	230	140	70	5	2	3	0.8
p19-2	Buffers	3,120	1.1	500	230	140	70	5	3	3	0.8
p19-3	Neighborhood Park	41	1.1	500	230	140	70	5	3	3	0.8
p19-4	Promenade	7,416	1.1	500	230	140	70	5	2	3	0.8
p19-5a	Educational facility	5,041	1.1	500	230	140	70	5	2	3	0.8
p19-5b	Health	955	1.1	500	230	140	70	5	2	3	0.8
p19-5c	Public amenity facilities	1,447	1.1	500	230	140	70	5	2	3	0.8
p19-5d	Public utility facilities	43,176	1.1	500	230	140	70	5	2	3	0.8

p19-6	Plant nursery (allocation)	669	1.1	500	230	140	70	5	1	3	0.8
p19-7	Primary distributor Jln Lingkaran Bandar	2,592	1.1	500	230	140	70	5	2	3	0.8
p19-8	Secondary distributor D3 road	8,208	1.1	500	230	140	70	5	3	3	0.8

Where

Kc Crop coefficient

WP Wilting point

RD Root depth

L1 Soil moisture limit, triggering irrigation

Ef Irrigation efficiency

TAM Total available moisture

RAM Readily available moisture

FM Infiltration rate

L2 Irrigate to this level of soil moisture

IR Irrigation rate

The SCADA system will receive rainfall data regularly at preset intervals from the proposed telemetric rainfall stations. These data will need to be converted to areal rainfall for each of the Precincts..

To convert observed point rainfall to areal rainfall a matrix of Thiessen weights will have to be set up.

Matrix of Thiessen Wts

Rain Stn \ Area	Precinct							
	1	2	20
PR1								
PR2								
PR3								
PR4								
PR5								

Areal rainfall {AR1, AR2, AR3,.....AR20} is computed by multiplying the recorded rainfall {PR1, PR2,..... PR5} with the matrix of Thiessen weights as shown below.

$$\begin{pmatrix} AR1 \\ AR2 \\ AR3 \\ . \\ . \\ . \\ AR20 \end{pmatrix} = \begin{pmatrix} 0.0 & 0.0 & 0.3 & \dots & 0.0 \\ 0.0 \\ 0.0 \\ 0.2 & \text{Matrix of} \\ . & \text{Thiessen Wts} \\ . \\ 0.0 \end{pmatrix} \begin{pmatrix} PR1 \\ PR2 \\ . \\ . \\ . \\ PR5 \end{pmatrix} \quad \dots (10.8)$$

Evaporation values will be obtained from Putrajaya's Automatic weather station and will be converted to reference crop evapotranspiration Eto by multiplying with an appropriate factor. For pan evaporation (Epan) the conversion factor is 0.75 i.e.

$$Eto = 0.75 \times Epan \quad \dots (10.9)$$

Evapotranspiration loss E from each irrigated area will be computed using the following equation:

$$E = Kc \times Eto \quad \dots (10.10)$$

If soil moisture is low, actual evapotranspiration will be less than that shown in Eqn 10.10. The method for estimating evapotranspiration under water stressed condition presented in Eqn 10.7 above.

To cater for varying K_c values within a sub area, the average crop coefficient A_{Kc} will have to be computed for each sub-block and for each day.

$$A_{Kc} = \frac{K_{c1} \cdot A_1 + K_{c2} \cdot A_2 + \dots + K_{cN} \cdot A_N}{\sum A_i} \quad \dots (10.11)$$

To avoid missing evaporation values from affecting water balance computations, it is proposed that default values of daily evaporation be stored in the system and these default values could be used if necessary. The default evaporation values are long term average evaporation.

Month	daily evaporation (mm/day)
Jan	3.5
Feb	3.9
Mar	4.0
Apr	4.0
May	3.8
Jun	3.6
Jul	3.7
Aug	3.7
Sep	3.6
Oct	3.6
Nov	3.3
Dec	3.7

The water balance computations is expected to estimate the following:

- Effective rainfall
- Surface runoff
- Losses
- Irrigation water requirement
- Water depth in the field

Water supply to the various sub areas will have to account for irrigation efficiency. If irrigation efficiency is low, it has to be compensated by a higher rate of irrigation I_a .

i.e. $I_a = (I \div E_f) * 100 \dots\dots\dots(10.12)$

To be useful, attempts must be made to translate water balance results to water management decisions. For a start water balance will estimate the soil moisture depletion. The amount of irrigation required and whether to initiate irrigation or not will depend on the degree of soil moisture depletion.

For systematic decision making, irrigation managers will have to set various target or threshold levels to describe soil moisture depletion and consequently, the decisions that would have to be made once the water levels reaches these threshold levels. For simplicity, it is proposed that 4 soil moisture deficit levels be set i.e. SM1, SM2, SM3 and SM4. As a start it is proposed that the soil moisture deficit levels be set as follows:

- SM1 – at this level soil moisture is at or higher than field capacity and therefore no irrigation is required.
- SM2 – at this level soil moisture is at 60% RAM, irrigation is given depending on the priority of the area and abundance of water source
- SM3 – at this level soil moisture is at 30% RAM, irrigation is given depending on the priority of the area and abundance of water source
- SM4 – at this level soil moisture is at 10% RAM, irrigation is critical but if water source is scarce the area may not be irrigated unless it is high priority area.

To simplify operations it is felt that the amount of irrigation to be applied in each irrigation application should be standardized. In the case of sprinklers and dripper line irrigation the amount of water applied for each irrigation application is determined by the sprinkler and dripper line which sets the irrigation rate and the irrigation satellite which governs the duration of irrigation application. For sprinklers and dripper lines, daily irrigation application is the norm and it is recommended that each irrigation application be set to 5mm. This amount of irrigation is just sufficient to satisfy evapotranspiration needs. In the case of trucking, 5mm per irrigation application is also recommended. Attempt should be made to improve efficiency of irrigation application by trucking. Water manually applied by hose on

the plants will not be efficiently distributed and a lower irrigation efficiency rate should be assigned.

However, soil moisture is not the only criteria for the determination of irrigation supply to the field. There is a need to examine the depletion level of the various sources of water. The Lake level for instance is an important consideration and when drawdown reaches critical levels, decision will have to be made to cut down irrigation to conserve water. Deficit irrigation will have to be practiced in some less important planted areas, while the more important areas such as the promenade will continue to receive optimum irrigation (100% I) while in less critical areas the irrigation can be reduced to (50% I) The deficit irrigation strategy for the Lake could be as follows:

Lake drawdown (mm)	Irrigation criteria (% I)								
	Priority 1			Priority 2			Priority 3		
	SM4	SM3	SM2	SM4	SM3	SM2	SM4	SM3	SM2
50	100	100	75	100	75	50	100	75	50
100	100	100	75	100	75	50	100	75	50
150	100	100	75	100	75	50	100	75	50
200	100	100	75	100	75	50	75	50	25
250	100	100	75	100	75	50	75	50	25
300	100	75	50	75	50	25	75	50	25
350	100	75	50	75	50	25	50	50	25
400	100	75	50	75	50	25	50	25	0
450	100	75	50	75	50	25	50	25	0
500	100	75	50	75	50	25	30	25	0

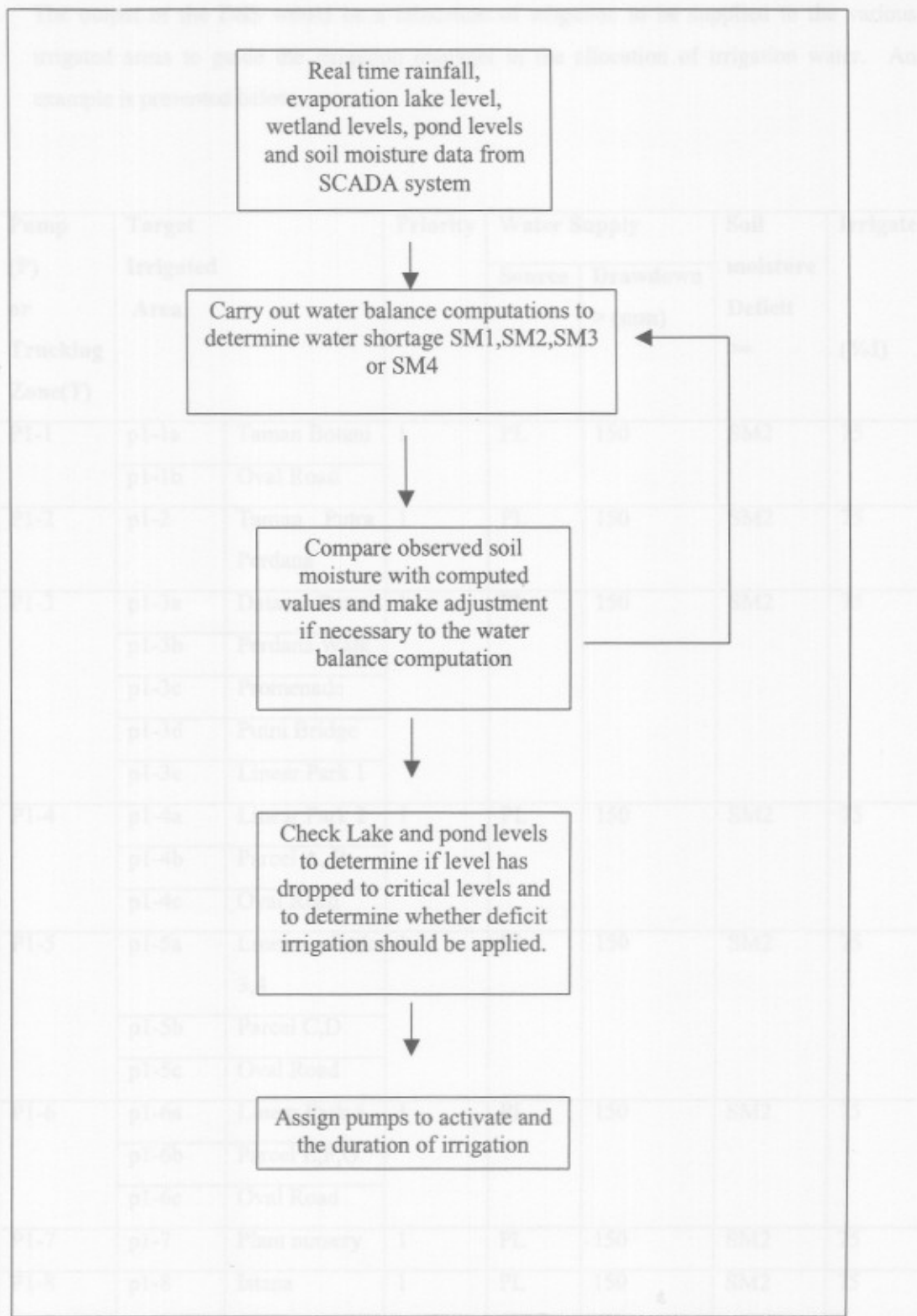


Fig 10.6: Flow Chart of the Irrigation Decision Support System

The output of the DSS would be a tabulation of irrigation to be supplied to the various irrigated areas to guide the irrigation manager in the allocation of irrigation water. An example is presented below.

Pump (P) or Trucking Zone(T)	Target Irrigated Area		Priority	Water Supply		Soil moisture Deficit >=	Irrigate (%I)
				Source	Drawdown > (mm)		
P1-1	p1-1a	Taman Botani	1	PL	150	SM2	75
	p1-1b	Oval Road					
P1-2	p1-2	Taman Putra Perdana	1	PL	150	SM2	75
P1-3	p1-3a	Dataran Putra	1	PL	150	SM2	75
	p1-3b	Perdana Walk					
	p1-3c	Promenade					
	p1-3d	Putra Bridge					
	p1-3e	Linear Park 1					
P1-4	p1-4a	Linear Park 2	1	PL	150	SM2	75
	p1-4b	Parcel A, B					
	p1-4c	Oval Road					
P1-5	p1-5a	Linear Park 3,4	1	PL	150	SM2	75
	p1-5b	Parcel C,D					
	p1-5c	Oval Road					
P1-6	p1-6a	Linear Park 5	1	PL	150	SM2	75
	p1-6b	Parcel E,F,G					
	p1-6c	Oval Road					
P1-7	p1-7	Plant nursery	1	PL	150	SM2	75
P1-8	p1-8	Istana Hinggap	1	PL	150	SM2	75
P1-9	p1-9	Government Reserve 1	2	PL	150	SM2	50
P1-10	p1-10	Local Distributor	2	PL	150	SM2	50

		D2					
.							
.							
.							
P7-1	p7-1	Promenade	2	PL	150	SM2	50
P7-1	t7-1	Primary distributor D3	3	PL	150	SM2	25
T7-2	t7-2	Secondary distributor D3	3	PL	150	SM2	25
T7-3	t7-3	Local distributor D3	3	PL	150	SM2	25
T7-4	t7-4	U2 spine road	3	PL	150	SM2	25
.							
.							
P19-1	p19-1	Taman Lindungan	2	STP2	50	SM2	50
P19-2	p19-2	Buffers	3	STP2	50	SM2	25
P19-3	p19-3	Neighborhood Park	3	STP2	50	SM2	25
P19-4	p19-4	Promenade	2	STP2	50	SM2	50
P19-5	p19-5a	Educational facility	2	STP2	50	SM2	50
	p19-5b	Health	2	STP2	50	SM2	50
	p19-5c	Public amenity facilities	2	STP2	50	SM2	50
	p19-5d	Public utility facilities	2	STP2	50	SM2	50
P19-6	p19-6	Plant nursery (allocation)	1	STP2	50	SM2	75
P19-7	p19-7	Primary distributor Jln Lingkaran Bandar	2	STP2	50	SM2	50

P19-8	p19-8	Secondary distributor D3 road	3	STP2	50	SM2	25
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The decision to activate or not to activate the pump and for how long to activate the pump depends on the computed soil moisture deficit and irrigation priority assigned.

10.8 CONCLUSIONS AND RECOMMENDATIONS

The need to manage the allocation of water for irrigation is important as it could lead to savings in water and in pumping.

For systematic management of irrigation there must be first the ability to monitor the status of irrigation requirements and the status of water availability.

This can be achieved via a real-time monitoring system gathering rainfall, water level, evaporation and soil moisture via a SCADA system.

The irrigation environment is not in a factory like environment and therefore data gathered has errors and inaccuracies and thus the need to simplify decisions based on a range of values.

Automated and remote control of irrigation can be at the level of the irrigation satellites but the sheer number of satellites makes this an expensive approach and increase the system's susceptibility to vandalism.

It is recommended that the day-to-day control of irrigation be made at the level of booster pumps.

A water balance model is described to indicate how rainfall, evaporation and other data can be used to model the soil moisture depletion on a day-to-day basis.

A decision algorithm is recommended based on which the manager can systematically allocate water based on priority of the area, the soil moisture deficit and the status of water availability. The priority settings and the acceptability of drawdown are subjective and can be changed.

To ensure that future irrigation installations are designed for integrated irrigation management operations an important factor to be considered is that irrigation control satellites should only control areas with the same irrigation priority and if possible booster pumps should only control zones with the same irrigation priority.

The overall system is complex and a software needs to be developed to assist the irrigation manager to monitor and manage the system.

Many parameters of the system model such as irrigation efficiencies, field capacity, infiltration rate etc. are unknown and it is expected that with the use of the model, these parameters could be adjusted to fine-tune the model with time.

11. LEGAL REQUIREMENT

11.1 Introduction

One of the main objectives of the Irrigation Master Plan Study is the determination of irrigation water sources and quantities that are available to meet planned irrigation demands. In Selangor, the control of water use, and abstractions is vested with the relevant State Authority. This includes water supplies, irrigation, management of rivers and canals within the State boundaries. The Consultant envisaged that this component of study will involve desk studies on relevant existing Enactment in support of the objectives as stated above.

The desk studies has led to:

- a) recommendations of specific legal requirements that would affect irrigation practices in Putrajaya; and
- b) specific policies and guidelines necessary for the proposed development of irrigation infrastructures.

In the implementation of the Irrigation Master Plan, it is expected that legal aspects on water related issues will be:

- The availability and extraction of water for irrigation development;
- Obtaining permission for purpose of water extraction;
- Water Enactment pertaining to extraction and pollution of water sources.

Irrigation practices involve land and water issues, and there are a number of existing Enactment that govern land, water-use, protection of water quality, and irrigation in Malaysia at both Federal and State levels, operating within the requirements of the Federal Constitution.

11.2 Relevant Legal Enactment

Under the Federal Constitution, the individual State Governments in Malaysia have full jurisdiction over water resources within their boundaries, and are therefore the authority to decide how resources should be developed (for example, whether rights to river water abstractions should be granted, or whether new dams should be constructed).

The main enactment of relevance to Putrajaya Irrigation Master Plan are:

1. The Irrigation Areas Act (Revised 1989)
2. Waters Act, 1920 (Revised 1989)
3. The Land Conservation Act
4. Selangor Water Management Authority Enactment (1999)

11.2.1 *The Irrigation Areas Act (Revised 1989)* where the State Authority is empowered to declare irrigation areas by notification in the state Gazette. The Act stipulates provisions regarding supply of irrigation water for agricultural purposes, and protection of irrigation facilities through enforcement and penalties. The Irrigation Areas Act (Revised 1989) is designed mainly for agriculture and can be extended for landscape irrigation practices.

11.2.2 *Waters Act, 1920 (Revised 1989)* where provisions cover for control of rivers and streams and prohibition of activities affecting rivers, e.g. obstruction of rivers, construction of structures over or beside rivers wider than 6m (20 feet), prohibition of diversion of water from rivers unless licensed, prohibition of pollution of rivers (including subterranean water resources, estuary or sea adjacent to the coast of the State), restriction on the construction of walls and buildings on banks of rivers or within flood channels. Under the Waters Act, 1920 (Revised 1989), the entire property in and control of all rivers in any State is vested solely with the State. One of the principal provisions under the Waters Act is that no person may in any manner obstruct or interfere with any river except under and in all accordance with the terms of a license under this Act. The Waters Act is the fundamental law for river and water management. It has provisions for the proprietary right of rivers, water abstraction, prohibition of diversion of water from rivers except under licence, restriction on construction of walls and buildings on banks of rivers or within flood channels. Refer Appendix G for more details.

11.2.3 *The Land Conservation Act* has provisions for the conservation of hill land, the protection of soil erosion and control of silt. The main purpose of this Act is for the control of unauthorised clearing of hill lands for agriculture. The Act is under the jurisdiction of the Land Office. There are apparent shortcomings in the control and enforcement of the Act. This has led to serious soil erosion, slope failures and land slips, which have caused heavy siltation of rivers, streams and urban drainage systems, especially in hilly areas which are being cleared for housing development.

11.2.4 *Selangor Water Management Authority Enactment 1999 (LUAS Enactment)*

In June 1998, the National Water Resources Council was established to resolve legal, institutional and financial issues and to improve/co-ordinate river basin development and management on a national basis to ensure the long-term sustainability of water supply. Irrigation practices involve land and water, and a review of the water sector in the State indicated the existence of many Agencies involved in the management of water resources. Selangor is the first State in Peninsular Malaysia to form a Water Management Board called Lembaga Urus Air Selangor (LUAS) to manage the State's water resources. One of the key functions is:

- water quality control, monitoring criteria and standards including strategies for protection of watersheds, control of point and non-point pollution, *licensed water abstractions, control of wasteful use*, and a general precautionary approach to the assessment of development externalities.

11.3 Management of Water Sources for Irrigation And Licensed Water Abstraction

It is clear that the LUAS Enactment (1999) shall apply to all rivers wholly within the State of Selangor and to all river basins, catchment areas, wetlands, groundwater, and water bodies within the State of Selangor except those wholly within the Federal Administrative Centre of Putrajaya. However, it is pertinent to note that Putrajaya Lake commands a catchment area of 48 km², out of which approximately 40% or 20 km² falls outside Putrajaya Development area boundary. As the aesthetic and irrigation function of Putrajaya Lake need to be maintained, the water quality and inflow into the lake must be coordinated and properly managed. It is

permission for licensed water abstractions require close interaction between Putrajaya and LUAS to ensure the sustained development of irrigation.

11.4 Irrigation Policy and Management

Whilst this Study is primarily aimed at identifying the irrigation facilities in a form of a Master Plan, and the water resources needed to ensure adequate water supply to meet projected needs, it is clear that policy environment in which these investments are made is of critical relevance. These policies would encompass the following:

- this irrigation Master Plan will form the basis, and future direction pertaining to irrigation development, irrigation water utilisation and management; In the context of Putrajaya, there will be remote pocket areas where development of water resources for irrigation will not be cost effective. The areas are small isolated areas located far away from the water source and to develop an irrigation water distribution system to convey water to the area will be expensive. Isolated private properties and small remote parks will fit into this category.

In this area, landscaping should be designed to minimise water demand i.e. by planting plant species that require less watering such as trees and drought resistant plants. Water supply could be from JBA supply and if large quantities are required water may have to be transported via trucks to these areas.

- a clear policy on extent of irrigation and priority of irrigation in times of drought.

In times of drought, irrigation will have to be progressively cut down to conserve water. This is especially critical if the supply is drawn from Putrajaya Lake. Alarm levels are to be set for the Lake, and when the lake drawdown hits an alarm level, the irrigation supply would have to be cut down in certain areas. In this respect, there is a need to priorities the irrigated areas so that in the event of a drought the areas which will be under-irrigated will be known and the irrigation manager can then allocate water accordingly. The IWMS software should have this feature built-in to assist the irrigation manager in drought management.

- a clear irrigation policy on public and private facilities;

In the public sector a centralised irrigation system will be provided. This system will be controlled by PPJ so that management of water supply in the event of a drought is under control. For the private sector, however, irrigation is left to the individual owners. Developers of the private properties, however, would have to conform to guidelines on irrigation water source development as set out in this master plan. The Master Plan provides guidelines on the size of water harvesting facilities required. In many cases, however, the water harvesting facilities will not provide sufficient water for the planted areas in an extreme drought. But with the presence of these water harvesting facilities, the usage of JBA supply could be reduced.

- type of recommended plants, zoning of landscape areas and private and public domains; emphasis should be placed on growing landscape trees and plants that will not require any irrigation after the first 3 years of growth. The choice of grass ground covers that can withstand drought situations. In this respect, cow grass is a suitable choice as it is able to regenerate itself after a drought and would probably withstand low level irrigation better than many other ground covers.
- a clear policy on source management in the need for conservation of water and on water quality control, monitoring criteria and standards including strategies for protection of watersheds, control of point and non-point pollution; One of the recommendations is to adopt water conservation strategies once the draw down in the Putrajaya lake reaches a predefined critical level. In times of drought, under irrigation of crops is permitted to conserve water. Certain priority areas will continue to receive full irrigation while irrigation supply to less important irrigated areas will be reduced.
- licensed quantities of water abstractions with guidelines consistent with the Irrigation Master Plan. Developers of irrigation infrastructures should seek the State Authority for license to abstract water. The water abstraction may incur payment in respect of every license under the Waters Act in form of an annual fee as may be imposed by the State Authority. As discussed in the Master Plan, the plant groupings are divided into 4 major categories namely trees, palms, shrubs and ground covers and lawn. The irrigation demand of each group is determined by considering factors such as soil and

its available water, evapotranspiration rate of plants, the root zone depth and plant quantity.

The quantity of water abstracted from the Lake by the various proposed pumps are as tabulated in Appendix SC (Executive Summary Report).

- policy on irrigation coverage and control of wasteful use; the extent to which irrigation water supply is provided in various precincts is shown in Appendix SB (Executive Summary Report).
- a clear cut policy on demand management such as rainwater harvesting, use of drainage water and minimising water usage by recycling of water; demand management is concerned with finding an appropriate balance between the benefits of using irrigation water and the cost of supply. Demand management concerns issues relating to ways to promote more desirable levels and patterns of use. With increasing costs of new source works and supplies, demand management can be an alternative that can be considered in future, in the context of reducing irrigation water consumption. Demand management techniques include water conservation; reducing water consumption, and using rainwater harvesting. The Consultant is of the opinion that demand management policies and strategies if implemented can contribute to a reduction in the overall irrigation water consumption.
- policy for private sector/households involvement in the provision and use of irrigation water.
- In individual households or in any privately owned properties, which could be office or commercial complexes, it is difficult to impose upon the owners the source of water to be used.

11.5 Guidelines on Irrigation Development

11.5.1 Introduction

The guideline sets out conditions/requirements for irrigation development in the Putrajaya. Putrajaya Corporation is the controlling Agency, and prior approval (with the exception of individual household irrigation) for all large irrigation development is necessary. To ensure speedy processing, irrigation development applications shall be subjected to the following requirements.

11.5.2 Irrigation Development

In preparing proposals for irrigation, reference should be made to the Putrajaya irrigation Master Plan which shall form the basis, and future direction pertaining to irrigation development, water utilisation, management and operation of facilities.

11.5.2.1 Information And Details To Be Submitted

- Background information;
- Type of irrigation development;
- Implementation Schedule;
- Copy of Land Title;
- Name of Consultant and letter of Appointment;
- Profile of Consultant;
- A Key plan with a scale of 1 : 25000 or 1 : 50 000 showing the location;
- Site plan both hard copy and digital format to a scale of 1 in 1000 showing the following:
 - Information of existing infrastructure at the proposed irrigation site;
 - Relevant details such as lot boundaries, structures, ground levels within 300 m of the site;
 - Details of relevant revenue sheets, district name, and north point are to be shown in the site plan;
 - Type of plants and landscape proposals, irrigation system layout plans and details;
 - Location point of water extraction (To state whether proposals comply with the Putrajaya Irrigation Master Plan)
- Design drawings and layout plans for the water control structures, irrigation pipelines and pumping systems;
- Irrigation and drainage:

- Proposals for water extraction and method of irrigation;
 - Mode of operation and maintenance after completion;
 - Analysis of irrigation water requirement;
 - Permission from State Authority for extracting water from rivers and natural streams;
 - Water quality assessment in terms of suitability for specified irrigation development;
 - Quantity of water extraction/diversion; duration of extraction
 - Location plan of river and point of water extraction
- Spot levels at 20 meters intervals including contour lines at 0.5 meter intervals to be plotted on the site/layout plan; All levels are to be based on Land Survey Datum
 - Details of construction methods to ensure that the existing infrastructure works are not affected, and that excavation works shall not endanger any adjacent properties, structures or buildings.

11.5.2.2 Design Calculation and Plan

All design works shall be carried out by Professional Engineers registered with the Board of Engineers Malaysia. Details of calculation and design drawings to suitable metric scales for all irrigation works, sprinklers, pipelines, pumping stations, retention ponds, etc. are required to be submitted.

11.5.2.3 Water Quality Requirements

The guidelines are spelt out in EIA Order of 1987. Industrial estate development for medium and heavy industries covering an area of 50 hectares or more is a prescribe activity under item 9 (b) of the Schedule of the EIA order 1987. Section 34 A of the Environmental Quality Act (EQA) 1974, requires the submission of an EIA report prior to granting approval by the relevant approval Authority. According to the guidelines set by the DOE the target for water quality suitable for irrigation is Class IV. Detailed design drawings including computations, to suitable scales for the water quality control and enhancements measures are required to be submitted.

11.5.2.4 Reporting and Documentation

A report on the proposed irrigation development encompassing the above requirements is to be submitted. The formats for report submissions are as follows:

Size of Report	: A4
Plan in report	: A3
Construction drawings	: A1

11.6 Checklist for Irrigation Development

This Study has formulated a Checklist for Irrigation Development. The checklist as set out in Appendix H (Main Report) is prepared to:

- (a) ensure that proposed irrigation projects are developed in harmony with total development infrastructures; and
- (b) assist the Local Authority in the processing of applications.

The guideline is prepared to serve as an aid to Planners, Developers and Consultants that are involved in irrigation development. In this aspect, the relevant PPJ's Checklist such as Form SA, PB and PBS are expanded and updated to incorporate the above additional data as follows,

- (a) Form SA amended to Form SA (Pindaan 1)
Senarai Semakan Permohonan untuk Permohonan Kebenaran Merancang Bagi Kelulusan Susun Atur (Seksyen 21, Akta Perancangan Bandar dan Desa, 1976)
- (b) Form SA1 amended to Form SA1 (Pindaan 1)
Senarai Semakan Permohonan untuk Permohonan Kebenaran Merancang Bagi Kelulusan Susun Atur (Seksyen 21, Akta Perancangan Bandar dan Desa, 1976)
- Kandungan Laporan Cadangan Pemajuan
- (c) Form PB amended to Form PB (Pindaan 1)
Senarai Semakan Permohonan untuk Permohonan Kebenaran Merancang Bagi Pendirian Bangunan (Seksyen 21(3) Mengenai Pendirian Bangunan, Akta Perancangan Bandar dan Desa, 1976)

- (d) Form PB1 amended to Form PB1 (Pindaan 1)
Senarai Semakan Permohonan untuk Permohonan Kebenaran Merancang Bagi Pendirian Bangunan (Seksyen 21(3) Mengenai Pendirian Bangunan, Akta Perancangan Bandar dan Desa, 1976)
- Kandungan Laporan Ringkas Cadangan Pemajuan
- (e) Form PBS1 amended to Form PBS1 (Pindaan 1)
Senarai Semakan Permohonan untuk Permohonan Kebenaran Merancang Bagi Pendirian Bangunan Sementara (Seksyen 21(3) Mengenai Pendirian Bangunan, Akta Perancangan Bandar dan Desa, 1976)
- (f) Lampiran B(i) amended to Lampiran B(i) (Pindaan 1)
Senarai Semakan Teknikal untuk Permohonan Kebenaran Merancang Bagi Pelan Susun Atur (Seksyen 21, Akta Perancangan Bandar dan Desa, 1976)
- Laporan Sokongan LCP Termasuk Pelan/Gambarajah/Model
- (g) Lampiran B(i) amended to Lampiran B(i) (Pindaan 1)
Senarai Semakan Teknikal untuk Permohonan Kebenaran Merancang Bagi Pendirian Bangunan (Seksyen 21(3) Mengenai Pendirian Bangunan, Akta Perancangan Bandar dan Desa, 1976)
- Laporan Ringkasan Cadangan Pemajuan dan Pelan – pelan Sokongan Lain
- (h) Form PH remains
Senarai Semakan Permohonan untuk Permohonan Pelan Pra-Hitungan

The amended checklists are given in Appendix H.

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Table 2.1 Existing Rainfall Station Around Putrajaya

JPS Station number	Location	Average Annual Rainfall
2917001	Stor JPS Kajang	2036 mm
2917106	Ladang West Country	2319 mm
2916001	Prang Besar	2148 mm
2816112	Ladang Galloway	2087 mm

Table 2.2 Zero Rain Analysis At Ladang West Country (Nos: 2917160)

Year	Consecutive Day	Starting Date
1948	13	15, Aug, 1948
1949	13	05, Jan, 1949
1950	20	03, Sep, 1950
1951	11	06, Aug, 1951
1952	19	10, Jan, 1952
1953	13	07, Aug, 1953
1954	15	05, Aug, 1954
1955	15	21, May, 1955
1956	11	29, May, 1956
1957	14	09, Feb, 1957
1958	18	30, Jun, 1958
1959	15	24, May, 1959
1960	11	23, May, 1960
1961	9	21, Jan, 1961
1962	15	28, Jan, 1962
1963	11	08, Sep, 1963
1964	17	16, May, 1964
1965	13	04, Jan, 1965
1966	12	24, Jun, 1966
1967	10	05, Jul, 1967
1968	11	17, Jun, 1968
1969	12	19, Jul, 1969
1970	16	11, Aug, 1970
1971	10	04, Mar, 1971
1972	12	24, Jun, 1972
1973	13	21, Apr, 1973
1974	13	08, Aug, 1974
1975	12	03, May, 1975
1976	16	20, Jan, 1976
1977	15	08, Sep, 1977
1978	14	16, Jul, 1978
1979	13	14, May, 1979
1980	14	21, Jan, 1980
1981	25	26, Jul, 1981
1982	16	15, Jan, 1982
1983	17	03, Jan, 1983
1984	10	12, Aug, 1984
1985	20	29, Jul, 1985
1986	23	02, Aug, 1986
1987	14	27, Jan, 1987
1988	12	09, Dec, 1988
1989	22	12, Jul, 1989
1990	16	20, May, 1990
1991	17	04, Jun, 1991
1992	22	26, Aug, 1992
1993	23	20, Jan, 1993
1994	24	14, Aug 1994
1995	10	4, Jul 1995
1996	14	17, Jun 1996
1997	11	2, Jan 1997
1998	15	29, Jan 1998

Zero Rain = 0 mm

Table 2.3 Zero Rain Analysis At Ladang Galloway (Nos: 2816112)

Year	Consecutive Day	Starting Date
1939	29	04,Jul,1939
1941	13	27,May,1941
1947	18	13,Jul,1947
1948	19	11,Jul,1948
1949	24	02,Jan,1949
1950	26	14,Jun,1950
1951	22	06,Jun,1951
1952	14	20,Jul,1952
1953	20	10,Aug,1953
1954	14	07,Aug,1954
1955	18	20,May,1955
1956	16	30,Apr,1956
1957	14	09,Feb,1957
1958	17	27,Nov,1958
1959	16	24,May,1959
1960	27	16,May,1960
1961	29	13,Jan,1961
1962	21	22,Jan,1962
1963	21	23,Jan,1963
1964	17	16,May,1964
1965	26	26,May,1965
1966	13	18,Jul,1966
1967	11	03,Jun,1967
1968	20	18,Feb,1968
1969	17	19,Jul,1969
1970	15	14,Jan,1970
1971	15	24,Feb,1971
1972	15	10,Jan,1972
1973	18	27,Jan,1973
1974	26	21,May,1974
1975	17	08,May,1975
1976	19	14,May,1976
1977	16	27,Feb,1977
1978	14	26,Jan,1978
1979	15	10,Jan,1979
1980	18	06,Feb,1980
1981	25	25,Jul,1981
1982	27	18,Jul,1982
1983	17	01,Feb,1983
1984	14	08,Aug,1984
1985	38	31,May,1985
1986	20	18,Jun,1986
1987	9	13,Feb,1987
1988	10	14,May,1988
1989	14	05,Jun,1989
1990	20	05,Feb,1990
1991	28	07,Jul,1991
1992	16	15,Jan,1992
1993	12	28,Jul,1993
1994	14	14,Jan 1994
1995	14	18, Aug 1995
1996	18	27, Jun 1996
1997	15	2, Feb 1997
1998	16	28, Feb 1998

Zero Rain = 0 mm

Table 2.4 Results of No-Rain Analysis

	Average	10-yr	20-yr	50-yr
Number of consecutive days of no rain				
0 mm/day	15	20	22	24
< 5 mm/day	22	31	33	36
< 10 mm/day	29	40	43	47
< 15 mm/day	36	50	55	67
Total days of no rain				
0 mm/day	204	–	–	–
< 5 mm/day	264	–	–	–
< 10 mm/day	290	–	–	–
< 15 mm/day	310	–	–	–

Table 2.5 Evaporation Data

Eto computed From climate data of MMS
mean from 1968-1995 (Kuala Lumpur International Airport)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)	Mean	26.38	26.74	27.04	27.16	27.37	27.28	26.91	26.85	26.68	26.57	26.27	26.26	26.79
	Max	32.04	32.90	33.08	33.02	32.72	32.53	32.15	32.27	31.93	31.95	31.46	31.42	32.29
	Min	22.22	22.49	22.98	23.48	23.70	23.30	22.91	22.89	22.90	23.09	23.08	22.71	22.98
RH (%)	Mean	80.95	80.04	81.07	83.32	82.79	81.30	80.86	80.70	82.48	83.38	85.00	83.70	82.13
	Max	96.68	96.29	96.46	96.73	96.20	95.86	95.71	95.59	96.16	96.46	96.96	96.84	96.33
	Min	54.07	52.11	53.93	58.32	59.63	58.07	57.91	56.88	58.77	59.39	61.82	59.59	57.54
Sunshine hours	Mean	6.18	6.93	6.73	6.59	6.56	6.48	6.54	6.11	5.35	5.49	5.05	5.33	6.11
U2 (m/sec)	Mean	0.22	0.27	0.27	0.27	0.30	0.30	0.35	0.32	0.32	0.30	0.27	0.22	0.29
ETo (mm/day)	mean	3.48	3.93	4.03	3.95	3.77	3.62	3.67	3.71	3.61	3.58	3.29	3.33	3.66

Eto computed From climate data of MMS
mean from 1968-1995 (Petaling Jaya)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)	Mean	26.80	27.17	27.45	27.49	27.78	27.79	27.34	27.38	27.03	27.00	26.61	26.61	27.20
	Max	32.55	33.25	33.53	33.48	33.18	33.07	32.61	32.75	32.48	32.60	32.00	32.06	32.80
	Min	23.05	23.31	23.79	24.11	24.31	24.03	23.64	23.71	23.62	23.62	23.53	23.24	23.66
RH (%)	Mean	77.80	77.54	78.75	80.86	80.30	77.82	78.18	77.32	80.09	80.88	83.09	80.64	79.44
	Max	94.38	94.23	94.63	95.23	94.43	93.39	93.63	92.95	94.29	94.55	95.52	94.88	94.34
	Min	52.48	51.14	53.04	56.57	57.95	56.27	56.79	55.64	57.80	58.27	60.57	57.34	56.15
Sunshine hours	Mean	5.89	6.65	6.34	6.20	6.15	6.09	6.17	5.91	5.22	5.40	4.66	5.13	5.82
U2 (m/sec)	Mean	0.25	0.25	0.25	0.25	0.27	0.27	0.30	0.30	0.27	0.30	0.25	0.22	0.27
Eto (mm/day)	mean	3.48	3.88	3.97	3.88	3.69	3.55	3.60	3.69	3.61	3.59	3.22	3.21	3.61

JPS's Pan Evaporation Data

STN NO	YEAR	JAN	FEB	MAC	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Mean
2916301	1981-90	4.3	5.2	4.9	5.0	4.7	4.8	4.8	4.9	5.0	4.8	5.0	4.4	4.8

Table 2.6 Parameters For 800mm per annum Runoff Model

Parameter	Value	Parameter	Value
SS	3	FC	1.0
FS	1.2	DCS	300
RC	0.3	DCT	360
RS	0	A	0.2
RR	0	GSU	150
RK	0.2	GSP	2
RX	1.2	GDEL	0
RDEL	0		

Table 2.7 Parameters For 300mm per annum Runoff Model

Parameter	Value	Parameter	Value
SS	5	FC	1.5
FS	1.5	DCS	300
RC	0.1	DCT	360
RS	0	A	0.2
RR	0	GSU	600
RK	0.3	GSP	1.5
RX	1.2	GDEL	0
RDEL	0		

Table 3.1 Summary of Land Use Areas for Irrigation

S/N	Land Uses	Gross Land Area (ha)	%
1	Government institutional use	270.67	9.4
2	Public amenity facilities	400.23	13.6
3	Public utility facilities (excl. detention ponds & existing water treatment plant)	71.05	2.4
Sub-total		741.95	31.0
4	Open space (excl. Putrajaya Lake and wetlands)	1133.15	38.5
5	Residential	910.90	31.0
6	Commercial	151.30	5.0
7	Service Industry	4.65	0.1
Total		2941.95	100.0
8	Roadside landscape buffer and street planting reserve (referring to U5, U4, U3 and U2 roads only)	62555m	

Source:

1. Gross land areas extracted from approved layout plans for Precincts 1, 8, 9, 10, 13 and 16; UDG reports for Precincts 5, 6, 7, 11, 14, 15, 17, 19, 20; DUD for Precincts 2,3 and 4; Master Plan Review for Putrajaya and Revised Master Plan, November 1999.
2. Length of major and secondary roadways scaled from Master Plan November 1999.

Table 5.1 The Characteristics of Bungor Series

Characteristic	Description
Colour	Brownish yellow to yellowish brown
Texture	Fine sandy loam.
Structure	Weak to moderate medium and fine sub-angular blocky and consistence friable to firm with depth
Drainage	Well drained
Water Retention	Moderate low
Depth	Deep

(Source: *Panduan mengenai siri-siri tanah utama di Semenanjung Malaysia*, 1993, Jabatan Pertanian Semenanjung Malaysia.)

Table 5.2 Wilting Point, Field Capacity and Available Water Based On Soil Texture.

Soil Texture	Wilting Point (mm/m)	Field Capacity (mm/m)	Available Water (mm/m)
Medium Sand	25	100	75
Fine Sand	33	125	92
Sandy Loam	50	166.7	116.7
Fine Sandy Loam *	66.7	216.7	150
Loam	100	266.7	166.7
Silt Loam	116.7	291.7	175
Clay Loam	150	316.7	166.7
Clay	216.7	333.3	116.6

(Source: *Soil, their chemistry and fertility in tropical Asia*, 1966, Prentice Hall)

* denotes texture of Bungor Series

Table 5.3 The Range and Average Of The Root Zone Depth

Plant Category	Range of Root Zone Depth (m)	Average Root Zone Depth (m)
Tree	1.00 – 2.00	1.50
Shrub	0.50 – 1.20	0.85
Palm	0.70 – 1.30	1.00
Ground Cover and Lawn	0 – 0.60	0.30

(Source: *Irrigation practice and water management*, 1984, FAO)

Table 5.4 Average Evapotranspiration Rate For Plant Groups

Plants	Etcrop	Average Etcrop
Trees		
Hevea brasiliensis (Rubber tree)	6.32	4.33
Coffea spp (Coffee)	2.74	
Cocoa	2.74	
Persia americana (Avocado)	2.26	
Citrus spp (Citrus)	2.88	
Shrubs		
Musa spp (Banana)	4.66	4.53
Ananas cosmosus (Pinapple)	2.33	
Helianthus annus (Sunflower)	6.15	
Lycopersicon esculentum (Tomato)	4.76	
Nicotiana tabacum (Tobacco)	4.76	
Palms		
Cyrtostachis renda (Red Palm)	3.56	3.57
Licuala grandis (Fan Plam)	3.58	
Groundcover and Lawn		
Arachis hypogea (Ground nut)	5.85	4.87
Allium cepa (Onion)	3.75	
Various turf grasses	5.00	

(Source : Irrigation practice and water management. 1984.FAO)

Table 5.5 Average Evapotranspiration Rate and Calculated Water Requirement For Each Category of Plant

Plant Type	Average Evapotranspiration Rate	Calculated Water Requirement, L
Trec	4.33 mm / No / day	24 L / No / day
Palm	3.57 mm / No / day	7.1 L / No / day
Shrub	22.65 mm / sq. m. / day	6.3 L / sq. m. / day
Ground Cover and Lawn	121.75 mm / sq. m. / day	3.1 L / sq. m. / day

(Source: *Crop water requirement*, 1977, FAO)

Table 5.6

OPTION 1 - SUMMARY OF IRRIGATION WATER DEMAND BY PRECINCT FOR ALL PRECINCTS

Water requirement per plant (liter/plant/day for Tree & Palm or litre/m2/day for Shrub & Ground cover & Lawn):

Tree: 24.00 Palm: 7.10 Shrub: 6.30 Ground cover & Lawn (GC & L) : 3.1

Precinct type	Gross land area (ha)	Plant Quantity				Full Irrigation Demand		PHASE 1A				PHASE 1B				PHASE 2			
		Tree (No)	Palm (No)	Shrub (m2)	GC & L (m2)	Public (l / day)	Private (l / day)	Public (l / day)	Private (l / day)	Public (l / day)	Private (l / day)	Public (l / day)	Private (l / day)	Public (l / day)	Private (l / day)	Public (l / day)	Private (l / day)	Public (l / day)	Private (l / day)
Precinct 1	171.24	26,981	7,856	121,560	657,729	3,453,018	97,186	2,905,735	0	579,260	0	255,277	0	255,277	0	292,007	97,186	74,591	37,297
Precinct 2	179.70	37,899	9,206	178,121	830,611	4,671,479	99,189	0	0	0	4,671,479	99,189	1,308,732	38,066	0	0	0	0	0
Precinct 3	55.33	5,694	1,608	25,289	87,872	365,650	84,346	0	0	0	0	0	0	0	0	365,650	84,346	189,599	32,370
Precinct 4	218.19	18,604	4,716	69,204	257,939	851,084	280,368	0	0	0	0	0	0	0	0	851,084	280,368	280,367	107,597
Precinct 5&6	287.82	52,098	9,508	187,340	841,962	2,236,998	1,032,134	0	0	0	0	0	0	0	0	2,236,998	1,032,134	670,460	290,435
Precinct 7	67.64	11,938	2,680	51,294	277,925	750,658	234,869	0	0	0	0	595,430	0	107,265	0	155,228	234,869	134,022	68,959
Precinct 8	148.60	25,564	5,695	121,995	546,227	935,375	1,049,394	76,894	936,304	16,223	258,461	858,482	12,958	258,316	4,973	0	100,131	0	38,427
Precinct 9	188.35	29,297	3,815	89,259	407,471	939,436	683,999	74,574	227,263	19,049	62,735	691,254	444,603	209,784	122,730	173,608	12,133	6,154	4,656
Precinct 10	92.29	16,039	3,014	74,497	395,695	938,659	619,339	759,497	580,326	128,687	160,196	179,162	0	137,587	0	0	39,013	0	10,769
Precinct 11	320.85	56,914	10,046	226,312	960,571	1,747,261	1,927,626	0	0	0	0	1,747,261	1,927,626	499,376	535,854	0	0	0	0
Precinct 12	98.56	19,961	2,870	72,061	387,176	819,249	602,132	0	0	0	0	0	0	0	0	819,249	602,132	236,869	167,167
Precinct 13	360.53	50,387	2,461	54,922	171,262	2,599,765	0	1,550,051	0	867,432	0	598,005	0	129,569	0	451,710	0	86,930	0
Precinct 14, 15 & DE	604.20	99,140	13,222	253,359	901,881	3,563,296	1,271,782	0	0	0	0	3,563,296	1,271,782	701,443	359,524	0	0	0	0
Precinct 16	102.63	19,035	2,965	73,852	344,532	795,877	638,693	0	0	0	0	795,877	638,693	252,804	177,323	0	0	0	0
Precinct 17	98.10	17,484	3,026	64,768	348,582	842,708	417,251	0	0	0	0	0	0	0	0	842,708	417,251	255,684	115,514
Precinct 18	161.45	21,755	3,659	81,819	343,606	864,317	583,214	0	0	0	0	0	0	0	0	864,317	583,214	423,713	162,461
Precinct 19	291.94	44,983	7,239	151,026	679,288	1,939,961	906,278	0	0	0	0	0	0	0	0	1,939,961	906,278	857,819	250,768
Precinct 20	380.53	166,756	8,331	161,877	516,213	7,840,897	226,731	0	0	0	0	0	0	0	0	7,840,897	226,731	5,092,278	63,474
TOTAL	3,827.96	720,528	101,917	2,058,356	8,956,539	36,155,689	10,754,530	5,366,751	1,743,893	1,610,650	481,392	13,955,523	4,394,851	3,860,154	1,238,469	16,833,416	4,615,785	8,308,487	1,349,894

Table 5.7

OPTION 2 - SUMMARY OF IRRIGATION WATER DEMAND BY PRECINCT FOR PROPOSED AREA USING LAKE WATER (PUBLIC REALMS ONLY)

Water requirement per plant (liter/plant/day for Tree & Palm or litre/m2/day for Shrub & Ground cover & Lawn):

Tree: 24.00 Palm: 7.10 Shrub: 6.30 Ground cover & Lawn (GC & L): 3.10

Precinct type	Gross land area (ha)	Plant Quantity				Full Irrigation Demand		PHASE 1A				PHASE 1B				PHASE 2			
		Tree (No)	Palm (No)	Shrub (m2)	GC & L (m2)	Public (l / day)	Private (l / day)	Full Water Demand		Water Demand + 3 years		Full Water Demand		Water Demand + 3 years		Full Water Demand		Water Demand + 3 years	
								Public (l / day)	Private (l / day)	Public (l / day)	Private (l / day)	Public (l / day)	Private (l / day)	Public (l / day)	Private (l / day)	Public (l / day)	Private (l / day)		
Precinct 1	141.07	24,329	6,691	105,228	614,224	3,329,086	0	2,817,429	0	553,702	0	255,277	0	255,277	0	256,380	0	65,490	0
Precinct 2	141.18	34,005	7,470	155,194	755,714	4,354,404	0	0	0	0	0	4,354,404	0	1,227,738	0	0	0	0	0
Precinct 3	41.01	4,706	907	16,726	69,184	365,650	0	0	0	0	0	0	0	0	0	365,650	0	189,599	0
Precinct 4	170.59	15,319	2,384	40,739	195,821	851,084	0	0	0	0	0	0	0	0	0	851,084	0	280,367	0
Precinct 5&6	7.00	966	378	9,156	38,500	121,740	0	0	0	0	0	0	0	0	0	121,740	0	34,610	0
Precinct 7	0.30	2,224	514	9,470	104,462	381,204	0	0	0	0	0	240,839	0	22,290	0	12,727	0	2,769	0
Precinct 8	10.70	7,179	1,821	29,814	217,265	743,212	0	76,894	0	16,223	0	666,318	0	211,732	0	0	0	0	0
Precinct 9	62.58	1,949	239	5,373	91,602	558,014	0	0	0	0	0	430,376	0	48,110	0	0	0	0	0
Precinct 10	19.15	3,300	1,472	26,256	221,198	886,603	0	758,964	0	128,512	0	0	0	0	0	0	0	0	0
Precinct 11	12.50	7,652	1,912	29,818	240,270	644,135	0	0	0	0	0	644,135	0	78,897	0	0	0	0	0
Precinct 12	38.51	11,777	1,450	27,837	219,932	819,249	0	0	0	0	0	0	0	0	0	819,249	0	236,869	0
Precinct 13	360.53	50,387	2,461	54,922	171,262	2,599,765	0	1,550,051	0	867,432	0	598,005	0	129,569	0	451,710	0	86,930	0
Precinct 14, 15 & DE	160.10	39,865	1,601	39,545	20,013	0	0	0	0	0	0	1,279,295	0	0	0	0	0	0	0
Precinct 16	11.93	5,187	784	15,696	134,464	442,568	0	0	0	0	0	570,206	0	202,118	0	0	0	0	0
Precinct 17	56.10	11,800	1,984	34,209	232,754	842,708	0	0	0	0	0	0	0	0	0	842,708	0	255,684	0
Precinct 18	102.67	13,835	2,220	38,840	182,006	864,317	0	0	0	0	0	0	0	0	0	864,317	0	423,713	0
Precinct 19	5.67	782	306	7,416	31,185	98,610	0	0	0	0	0	0	0	0	0	98,610	0	28,034	0
Precinct 20	113.65	15,473	4,601	73,030	423,437	1,306,054	0	0	0	0	0	0	0	0	0	1,306,054	0	276,053	0
TOTAL	1,455.25	250,737	39,192	719,268	3,963,292	19,208,403	0	5,203,338	0	1,565,868	0	9,038,855	0	2,175,732	0	5,990,228	0	1,880,119	0

Table 5.8 Various Irrigation Water Demand By Year

	Irrigation Water Demand (Mld)				
Year End	2000	2003	2010	2013	2020
Option 1a	7.11	18.12	23.923	16.849	16.849
Option 1b	5.366	13.74	18.894	13.779	13.779
Option 2 i.e. Proposed Option Using					
Lake Water	5.203	10.627	8.088	5.622	5.622
STP Water	0.000	1.651	8.478	6.983	6.983
Trucking	1.009	2.344	0.192	0.192	0.192
JBA Water*	0.163	1.210	2.082	1.240	1.240

** for Public and Private Realms*

Table 9.1 Irrigation Zoning And The Water Demand (Public Realm Only)

a) From Lake

Zone	Intake	Source	Precinct	Water Demand (m3/day)
I	PH1	Lake	2, 3 & 18	457
II	PH2	Lake	3 & 4	457
III	PH3	Lake	16, 17 & 19	443
IV	PH4	Lake	7, 8, 9 & 10	355
V	PH5	Lake	5, 6 & 20	611
VI	PH6	Lake	12	237
VII	PH7	Lake	13	1029

b) From Sewage Treatment Plant

Zone	Intake	Source	Precinct	Water Demand (m3/day)
IX	SP1	STP1	14, 15 & DE	695
X	SP2	STP2	5, 6 & 19	6269

c) From JBA Water Main

Zone	Intake	Source	Precinct	Water Demand (m3/day)
		JBA Main	All precincts Except 3, 4, 12, 13, 17, 18 & 20	924

d) Trucking (From Lake)

Zone	Intake	Source	Precinct	Water Demand (m3/day)
		Lake	11 & 16	95

Note : Detailed water source/ demand for each landuse area is given in Appendix SC of the Executive Summary.

Table 9.2 Proposed Grouping of Trucking Zone

Group	Precinct	Requirement of Truck			
		Number	Depot & Kiosk Location	Depot	Water Refilling Kiosk
1	16	1	Prec. 12*, 13* & 15	2 No. (25m x 25m)	2 No. (20m x 40m)
2	11	4	Prec. 7 & 8	1 No. (35m x 35m)	1 No. (20m x 40m)

Note: * The kiosk & depot as proposed in Precinct 12 & 13 respectively is provisional only and will be utilised in the event that the kiosk or depot location in precinct 15 cannot be made available.

TABLE 9.3
COST ESTIMATE AND LAND AREA REQUIRED FOR PROPOSED IRRIGATION SYSTEM

ITEM	Description	ESTIMATED COST		OPERATING & MAINTENANCE COST		Total Cost
		Quantity	Amount (RM)	Rate (RM)	Amount (RM)	
CONCRETE	1000 for Zone 1 (PP 3, 4, 5, 6)	407	27114	142	0.23	21,654.00
	1000 for Zone 2 (PP 7, 8, 9, 10)	497	39113	205	0.23	21,751.50
	2143 for Zone 3 (PP 11, 12, 13, 14, 15)	443	39113	128	0.23	20,616.00
	1000 for Zone 4 (PP 16, 17, 18, 19)	738	39113	240	0.23	21,852.00
	1000 for Zone 5 (PP 20, 21, 22)	611	39113	228	0.23	21,864.00
	1000 for Zone 6 (PP 23, 24)	217	39113	208	0.23	15,978.00
	1000 for Zone 7 (PP 25)	1000	39113	665	0.23	31,962.00
	1000 for Zone 8 (PP 26, 27, 28, 29, 30)	867	39113	544	0.23	25,214.00
	1000 for Zone 9 (PP 31, 32, 33)	620	39113	468	0.23	26,388.00
	1000 for Zone 10 (PP 34, 35, 36, 37)	1000	39113	665	0.23	46,321.50
PIPE INSTALLATION	Zone 1 (PP 3, 4, 5, 6)	1000	134.00	134.00		134.00
	Zone 2 (PP 7, 8, 9, 10)	1000	134.00	134.00		134.00
	Zone 3 (PP 11, 12, 13, 14, 15)	1000	134.00	134.00		134.00
	Zone 4 (PP 16, 17, 18, 19)	1000	134.00	134.00		134.00
	Zone 5 (PP 20, 21, 22)	1000	134.00	134.00		134.00
	Zone 6 (PP 23, 24)	1000	134.00	134.00		134.00
	Zone 7 (PP 25)	1000	134.00	134.00		134.00
	Zone 8 (PP 26, 27, 28, 29, 30)	1000	134.00	134.00		134.00
	Zone 9 (PP 31, 32, 33)	1000	134.00	134.00		134.00
	Zone 10 (PP 34, 35, 36, 37)	1000	134.00	134.00		134.00
ELECTRICAL COSTS	Zone 1 (PP 3, 4, 5, 6)	1000	134.00	134.00		134.00
	Zone 2 (PP 7, 8, 9, 10)	1000	134.00	134.00		134.00
	Zone 3 (PP 11, 12, 13, 14, 15)	1000	134.00	134.00		134.00
	Zone 4 (PP 16, 17, 18, 19)	1000	134.00	134.00		134.00
	Zone 5 (PP 20, 21, 22)	1000	134.00	134.00		134.00
	Zone 6 (PP 23, 24)	1000	134.00	134.00		134.00
	Zone 7 (PP 25)	1000	134.00	134.00		134.00
	Zone 8 (PP 26, 27, 28, 29, 30)	1000	134.00	134.00		134.00
	Zone 9 (PP 31, 32, 33)	1000	134.00	134.00		134.00
	Zone 10 (PP 34, 35, 36, 37)	1000	134.00	134.00		134.00

TABLE 9.3
COST ESTIMATE AND LAND AREA REQUIRED FOR PROPOSED IRRIGATION SYSTEM

	CAPITAL COST			OPERATION & MAINTENANCE COST PER YEAR						LAND AREA (m ²)
	Demand (m ³ /d)	Capacity (kW)	Amount (RM)	Operation Cost			Maintenance Cost		Total Amount (RM)	
				Usage (kW/day)	Rate (RM)	Amount (RM)	% of Capital C	Amount (RM)		
INTAKE										
PH1 for Zone I (PjP 2, 3 & 18)	457	3*13	690,000.00	352	0.23	21,050.00	2.00%	13,800.00	34,850.00	16*12
PH2 for Zone II (PjP 3 & 4)	457	3*13	690,000.00	352	0.23	21,050.00	2.00%	13,800.00	34,850.00	16*12
PH3 for Zone III (PjP 16, 17 & 19)	443	3*12	690,000.00	328	0.23	19,614.00	2.00%	13,800.00	33,414.00	16*12
PH4 for Zone IV (PjP 7, 8, 9 & 10)	738	3*13	690,000.00	352	0.23	21,050.00	2.00%	13,800.00	34,850.00	16*12
PH5 for Zone V (PjP 5, 6 & 20)	611	3*20	700,000.00	520	0.23	31,096.00	2.00%	14,000.00	45,096.00	16*12
PH6 for Zone VI (PjP 12)	237	3*7	570,000.00	208	0.23	12,438.00	2.00%	11,400.00	23,838.00	16*12
PH7 for Zone VII (PjP 13)	1,029	3*22	830,000.00	568	0.23	33,966.00	2.00%	16,600.00	50,566.00	16*12
SP1 for Zone IX (PjP 14, 15 & DE) - pond not inclusive	695	3*21	700,000.00	544	0.23	32,531.00	2.00%	14,000.00	46,531.00	16*12
SP2 for Zone X (PjP 5, 19 & 20) - pond not inclusive	6,269	3*181	2,000,000.00	4,408	0.23	263,598.00	2.00%	40,000.00	303,598.00	18*14
Sub-total	10,936		7,560,000.00			456,393.00		151,200.00	607,593.00	1,788
	Nominal Diameter (mm)	Length (m)	Rate (RM)	Amount (RM)						(m wide)
PIPE RETICULATION										
Zone I (PjP 2, 3 & 18)	110 - 160	4,500	124.00	558,000.00			2.00%	11,160.00	11,160.00	2.00
Zone II (PjP 3 & 4)	110 - 160	4,150	124.00	514,600.00			2.00%	10,292.00	10,292.00	2.00
Zone III (PjP 16, 17 & 19)	110 - 160	7,210	124.00	894,040.00			2.00%	17,880.80	17,880.80	2.00
Zone IV (PjP 7, 8, 9 & 10)	110 - 160	16,000	124.00	3,436,050.00			2.00%	68,721.00	68,721.00	2.00
Zone V (PjP 5, 6 & 20)	110 - 160	8,000	124.00	992,000.00			2.00%	19,840.00	19,840.00	2.00
Zone VI (PjP 12)	110 - 140	5,780	104.00	601,120.00			2.00%	12,022.40	12,022.40	2.00
Zone VII (PjP 13)	110 - 225	1,900	190.00	682,700.00			2.00%	13,654.00	13,654.00	2.00
Zone IX (PjP 14, 15 & DE)	110 - 160	8,360	124.00	1,036,640.00			2.00%	20,732.80	20,732.80	2.00
Zone X (PjP 5 & 19)	110 - 350	14,000	204.00	3,256,350.00			2.00%	65,127.00	65,127.00	2.00
Precinct 1 - Oval Road	110 - 140	4,000	104.00	1,679,400.00			2.00%	33,588.00	33,588.00	
Sub-total		73,900		13,650,900.00				273,018.00	273,018.00	2 m wide
COMMITTED COSTS										
Precinct 2				2,982,201.00						
Precinct 16				3,554,360.00						
				6,536,561.00						

Sheet 1/3

TABLE 9.3
COST ESTIMATE AND LAND AREA REQUIRED FOR PROPOSED IRRIGATION SYSTEM

	CAPITAL COST					OPERATION & MAINTENANCE COST PFR YF AR					LAND AREA (m*m)	
	Park & Nursery		Civic & Road		Amount (RM)	Operation Cost		Maintenance Cost		Total Amount (RM)		
	Area (sq m)	Rate (RM/Ha)	Area (Ha)	Rate (RM/Ha)		% of Capital C	Amount (RM)	% of Capital C	Amount (RM)			
WATERING SYSTEM												
Zone I (PjP 2, 3 & 18)	0.76	52,500.00	5.37	52,500.00	322,085.00	3.00%	9,663.00	2.00%	6,442.00	16,105.00	-	
Zone II (PjP 3 & 4)	1.10	52,500.00	4.83	52,500.00	311,490.00	3.00%	9,345.00	2.00%	6,230.00	15,575.00	-	
Zone III (PjP 16, 17 & 19)	0.38	52,500.00	3.74	52,500.00	215,969.00	3.00%	6,479.00	2.00%	4,319.00	10,798.00	-	
Zone IV (PjP 7, 8, 9 & 10)	0.85	52,500.00	6.15	52,500.00	367,642.00	3.00%	11,029.00	2.00%	7,353.00	18,382.00	-	
Zone V (PjP 5, 6 & 20)	-	-	8.22	52,500.00	431,477.00	3.00%	12,944.00	2.00%	8,630.00	21,574.00	-	
Zone VI (PjP 12)	0.47	52,500.00	2.15	52,500.00	137,923.00	3.00%	4,138.00	2.00%	2,758.00	6,896.00	-	
Zone VII (PjP 13)	3.74	52,500.00	0.87	52,500.00	242,141.00	3.00%	7,264.00	2.00%	4,843.00	12,107.00	-	
Zone IX (PjP 14, 15 & DE)	1.76	52,500.00	12.09	52,500.00	727,456.00	3.00%	21,824.00	2.00%	14,549.00	36,373.00	-	
Zone X (PjP 5 & 19)	5.17	52,500.00	14.36	52,500.00	1,025,288.00	3.00%	30,759.00	2.00%	20,506.00	51,265.00	-	
Precinct 1 - Oval Road	-	-	2.00	52,500.00	105,000.00	3.00%	3,150.00	2.00%	2,100.00	5,250.00	-	
Other public realms by JBA water	0.99	52,500.00	12.39	52,500.00	702,581.00	3.00%	21,077.00	2.00%	14,052.00	35,129.00	-	
Sub-total					4,589,052.00		137,672.00		91,782.00	229,454.00	-	
					Rate (RM)	Amount (RM)	% of Capital C	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	(m*m)
INTEGRATED IRRIGATION MANAGEMENT SYSTEM												
Hardware and Software					Lump Sum	1,000,000.00	3.00%	30,000.00	2.00%	20,000.00	50,000.00	-
Sub-total						1,000,000.00		30,000.00		20,000.00	50,000.00	-
			Number	Rate (RM)	Amount (RM)	Demand (m3/day)	Rate (RM/m3)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	(m*m)
TRUCK												
Lorry (for Precinct 16)	5 trips		1			16	13.00	54,418.00			54,418.00	-
Lorry (for Precinct 11)	26 trips		4			79	13.00	266,682.00			266,682.00	-
Depot (for Precinct 16)			Lump	Sum	50,000.00		3.00%	1,500.00	2.00%	1,000.00	2,500.00	25*25
Depot (for Precinct 11)			Lump	Sum	150,000.00		3.00%	4,500.00	2.00%	3,000.00	7,500.00	35*35
Refilling Kiosk (for Precinct 16)			0	300,000.00	150,000.00		3.00%	4,500.00	2.00%	3,000.00	7,500.00	1*(20*40)
Refilling Kiosk (for Precinct 11)			1	300,000.00	300,000.00		3.00%	9,000.00	2.00%	6,000.00	15,000.00	1*(20*40)
Sub-total					650,000.00			340,600.00		13,000.00	353,600.00	3,450
Cost of trucking if planting reduced by 50 %										2,521,698.00	Sheet 2/3	

TABLE 9.3
COST ESTIMATE AND LAND AREA REQUIRED FOR PROPOSED IRRIGATION SYSTEM

	CAPITAL COST			OPERATION & MAINTENANCE COST PER YEAR					LAND AREA (m ² m)	
	Volume (m3)	Rate (RM)	Amount (RM)	Operation Cost		Maintenance Cost		Total Amount (RM)		
				Demand (m3/day)	Rate (RM)	Amount (RM)	% of Capital C			Amount (RM)
EXCAVATION for Storage Pond at STP										
SP1 at STP1 (PjP 14)	1,030	12.00	12,360.00				2.00%	247.00	247.00	40*40
SP2 at STP2 (PjP 19)	7,192	12.00	86,304.00				2.00%	1,726.00	1,726.00	70*70
LINING OF POND										
SP1 at STP1 (PjP 14)	720	200.00	144,000.00				2.00%	2,880.00	2,880.00	
SP2 at STP2 (PjP 19)	2,205	200.00	441,000.00				2.00%	8,820.00	8,820.00	
Sub-total	11,147		683,664.00					13,673.00	13,673.00	6,500
	Capacity (m3/day)		Amount	Demand (m3/day)	Rate (RM)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	
DISINFECTION using sodium hypochlorite										
STP1 for SP1	695		50,000.00	695	0.006	9,250.00	2.00%	1,000.00	10,250.00	10*15
STP2 for SP2	6,269		100,000.00	6,269	0.006	74,542.00	2.00%	2,000.00	76,542.00	10*15
Sub-total	6,964		150,000.00	6,964		83,792.00		3,000.00	86,792.00	300
				Demand (m3/day)	Rate (RM)	Amount (RM)			Amount (RM)	
JBA WATER										
Public Realms			1,000,000.00	924	1.40	336,172.00			336,172.00	-
Private Realms *				3,070	1.40	1,117,391.00			1,117,391.00	-
Sub-total			1,000,000.00	3,993		1,453,563.00			1,453,563.00	
	Number	Rate (RM)	Amount (RM)	Operator (No.)	Rate (RM)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	
Tools and Equipment	Lump	Sum	200,000.00		3.00%	6,000.00	2.00%	4,000.00	10,000.00	-
Sub-total			200,000.00			6,000.00		4,000.00	10,000.00	
GRAND TOTAL			36,020,177.00			2,508,020.00		569,673.00	3,077,693.00	12,038

Note:

- 1) Watering window =
- 2) Irrigation Frequency =
- 3) Truck capacity =
- 4) Truck trip =

8 hour
260 per day per year
3 cubic meter
6 no. per day

- 5) Intake capacity for trucking =
- 6) Irrigation time for trucking =
- 7) Filling time for trucking =
- 8) Water depth in SP1 & SP2=

4 trucks per time
8 hour
0.5 hour per batch
2.4 m

- 9) Pond Freeboard = 0.6 m
- 10) Pond slope = 2.0 (1 : H)
- 11) Pond Storage = 1.0 day demand
- 12) Watering systems at public realms are excluded.
- 13) All intake pump quantities are based on two duty and one standby.

* Watering systems at private realms estimated to RM 35 million for a total gross area of 167.69 ha are excluded.

Sheet 3/3

Table 9.4 Grand Summary Of Cost Estimate For Proposed Irrigation System

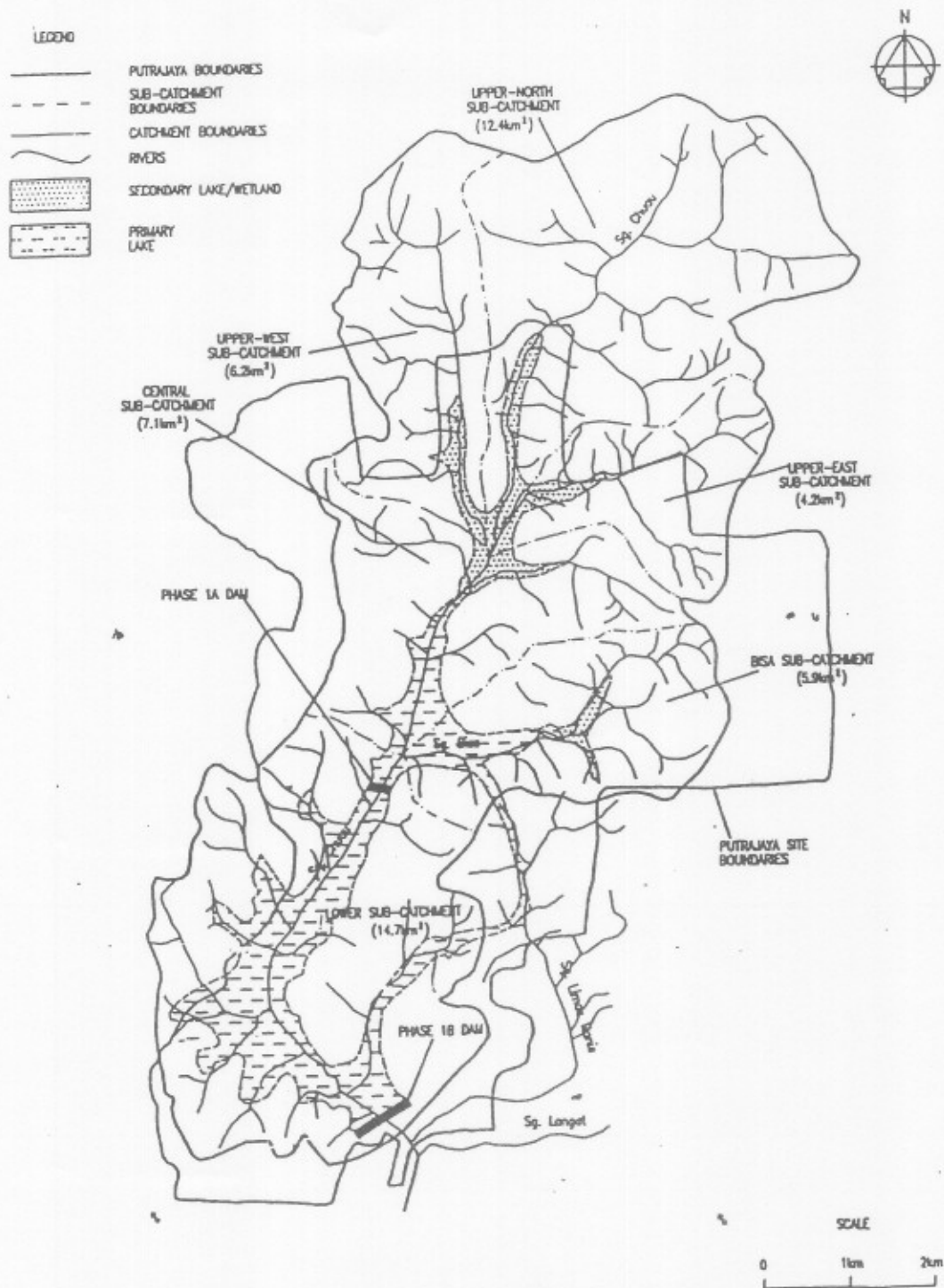
	Capital Cost RM	Annual O & M RM
<u>Pipe System</u>		
Intake & Pump (at Lake & STP)	7,560,000	607,593
Pipe Reticulation	13,650,900	273,018
Watering System	4,589,052	229,454
Intake Pond Excavation at STP	683,664	13,673
Disinfection for STP	150,000	86,792
Sub-total	26,633,616	1,210,530
Committed Costs		
Truck	650,000	353,600
JBA Water	1,000,000*	1,453,563
<u>Operation , Maintenance &</u>		
Tools & Equipment	200,000	10,000
Integrated Irrigation Management (IIMS)-soft & hardware	1,000,000	50,000
Subtotal	1,200,000	60,000
GRAND TOTAL	36,020,177	3,077,693

** Allow Cost for tapping from existing JBA pipe

FIGURE

- Figure 2.1 Catchment Boundary For Putrajaya Lake
- Figure 2.2 Monthly Rainfall Distribution
- Figure 2.3 Stacked Frequency Analysis At Ladang West Country
- Figure 2.4 Stacked Frequency Analysis At Ladang Galloway
- Figure 2.5 Schematic Of Rainfall – Runoff Model
- Figure 2.6 Observed and Simulated Hydrographs at Prang Besar With 800 mm per annum Runoff
- Figure 2.7 Daily Stimulated Runoff (1947 to 1998)
- Figure 2.8 Stacked Frequency Analysis At Prang Besar
- Figure 5.1 Geological Map On Soil Series
- Figure 5.2 Typical Bungor Series
- Figure 5.3 Water Capacity In Relation To Soil Texture And Moisture Constants
- Figure 5.4 Soil Moisture Constant In Term Of Atmosphere Of Tension
- Figure 5.5 Water Demand For Option 1a
- Figure 5.6 Water Demand For Option 1b
- Figure 5.7 Water Demand For Option 2
- Figure 5.8 Water Demand For Various Options Using Lake Water
- Figure 6.1 Underground Drainage Cell For Rainwater Harvesting (See Chapter 6)
- Figure 6.2 Underground Tank Cell For Rainfall Harvesting (See Chapter 6)
- Figure 6.3 Longitudinal Cross Sections Of Lake/Wetland
- Figure 6.4 Components of Lake Balance Computations (See Chapter 6)
- Figure 6.5 Putrajaya Lake Drawdown Chart (See Chapter 6)
- Figure 9.1a Typical Irrigation Pipe Location For 16m Road
- Figure 9.1b Typical Irrigation Pipe Location For 22m Road
- Figure 9.1c Typical Irrigation Pipe Location For 32m Road
- Figure 9.2a Typical Irrigation Pipe Location For Primary 'CUT'
- Figure 9.2b Typical Irrigation Pipe Location For Secondary 'CUT'
- Figure 9.2c Typical Irrigation Pipe Location For Tertiary 'CUT'
- Figure 9.3 Typical Irrigation Pipe Location For Promenade
- Figure 9.4 Truck Depot Layout
- Figure 9.5 Truck Refilling Kiosk Layout
- Figure 10.1 Location of Hydrological Stations
- Figure 10.2 Location of Meteorological Stations
- Figure 10.3 Remote Hydrological Stations (See Chapter 10)
- Figure 10.4 Soil-Plant-Water Relationship (See Chapter 10)
- Figure 10.5 Actual Evaporation – Soil Moisture Relation (See Chapter 10)
- Figure 10.6 Flow Chart of the Irrigation Decision Support System (See Chapter 10)

Figure 2.1



IRRIGATION MASTER PLAN FOR PUTRAJAYA
CATCHMENT BOUNDARY FOR PUTRAJAYA LAKE

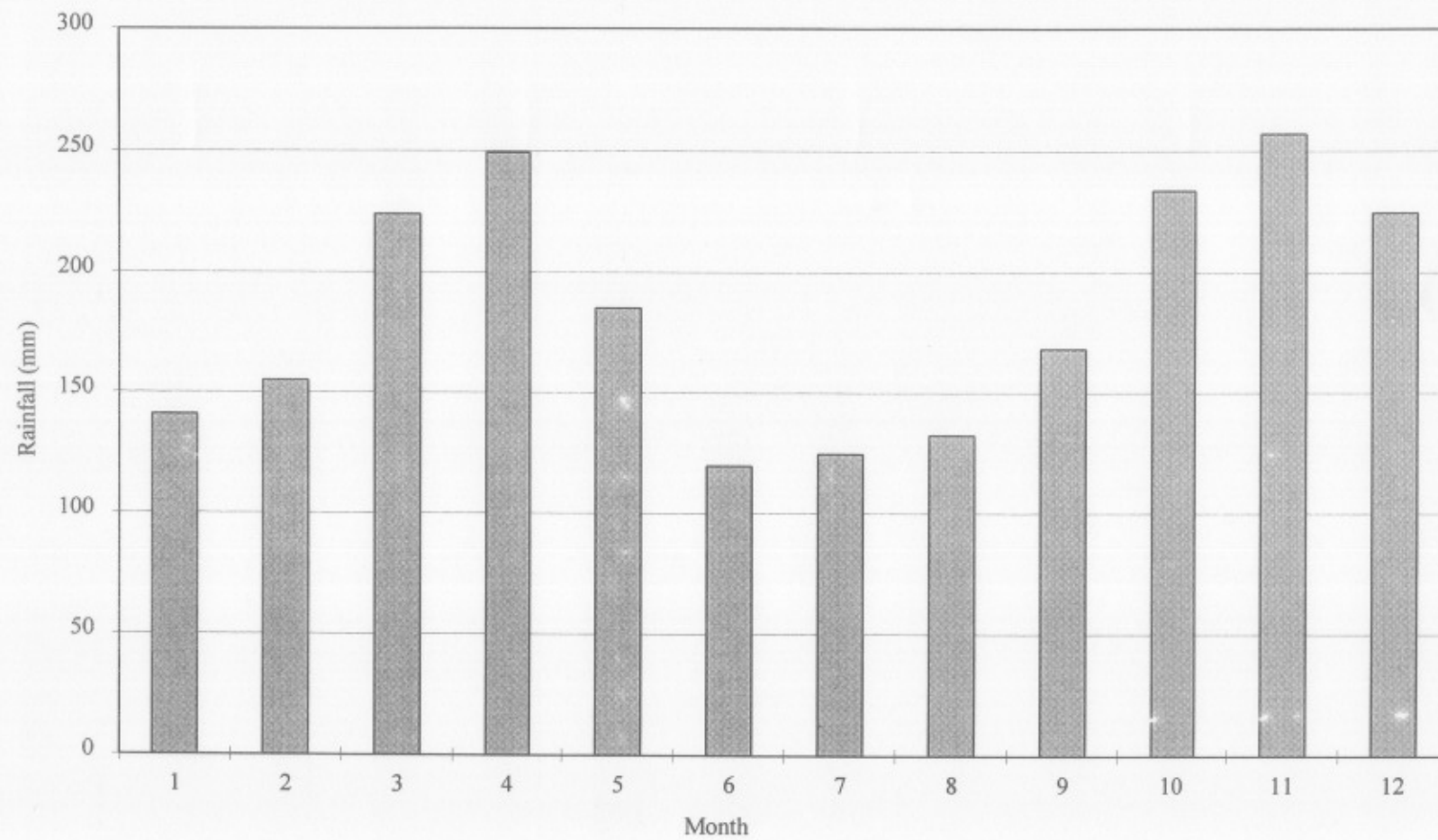


Figure 2.2 : Monthly Rainfall Distribution

Figure 2.3 Stacked Frequency Analysis At Ladang West Country

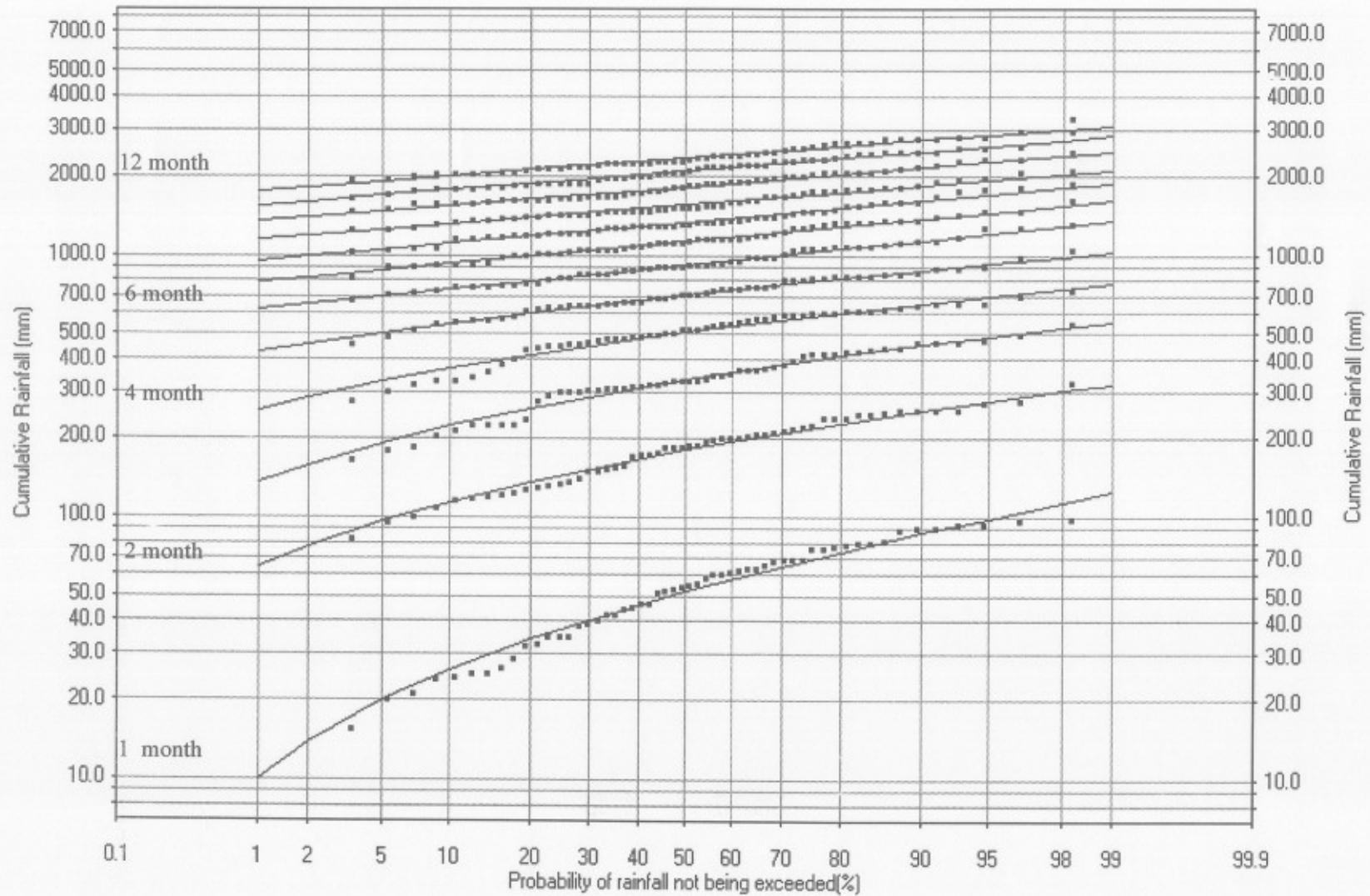


Figure 2.4 Stacked Frequency Analysis At Ladang Galloway

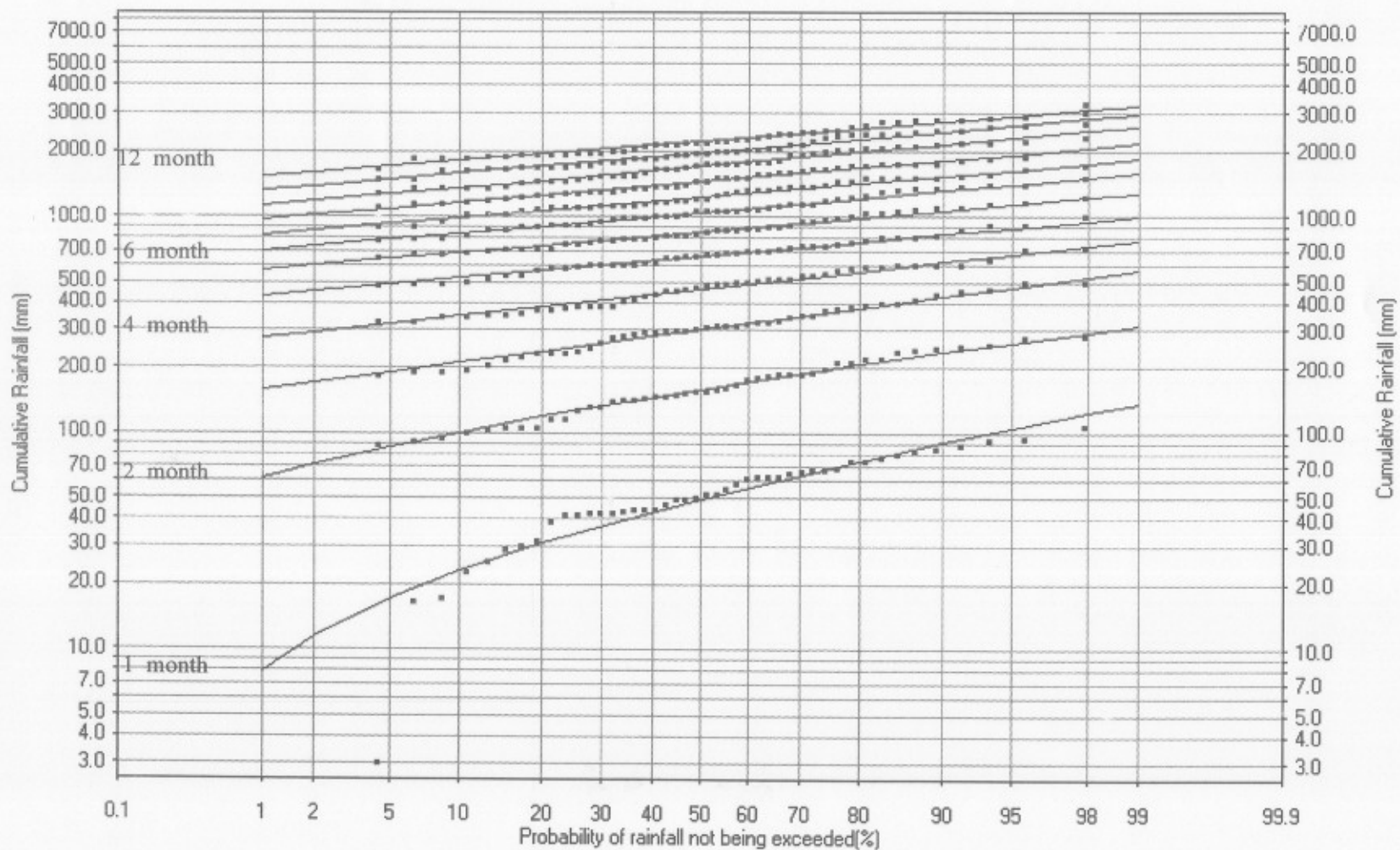
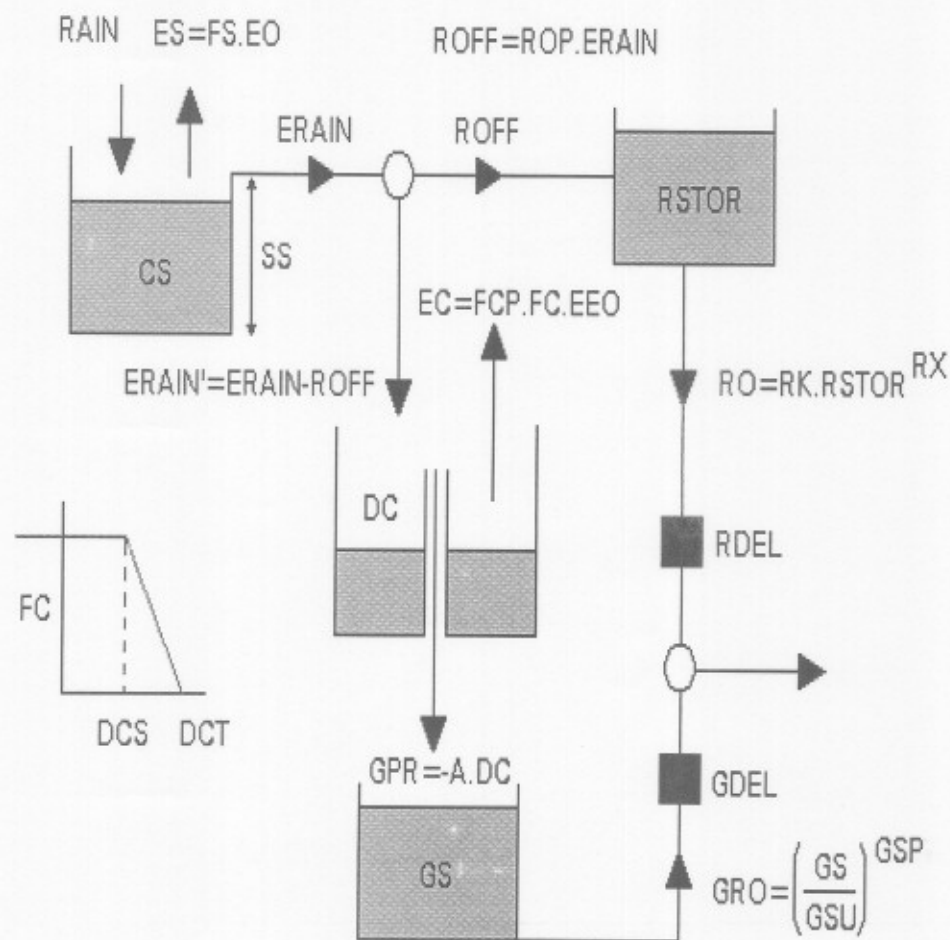


Figure 2.5



$$ROP = RC \cdot \left(e^{-RS \cdot DC} + e^{RR \cdot ERAIN} - 1 \right)$$

$$FCP = \frac{DCT - DC}{DCT - DCS}$$

Schematic Of Rainfall – Runoff Model

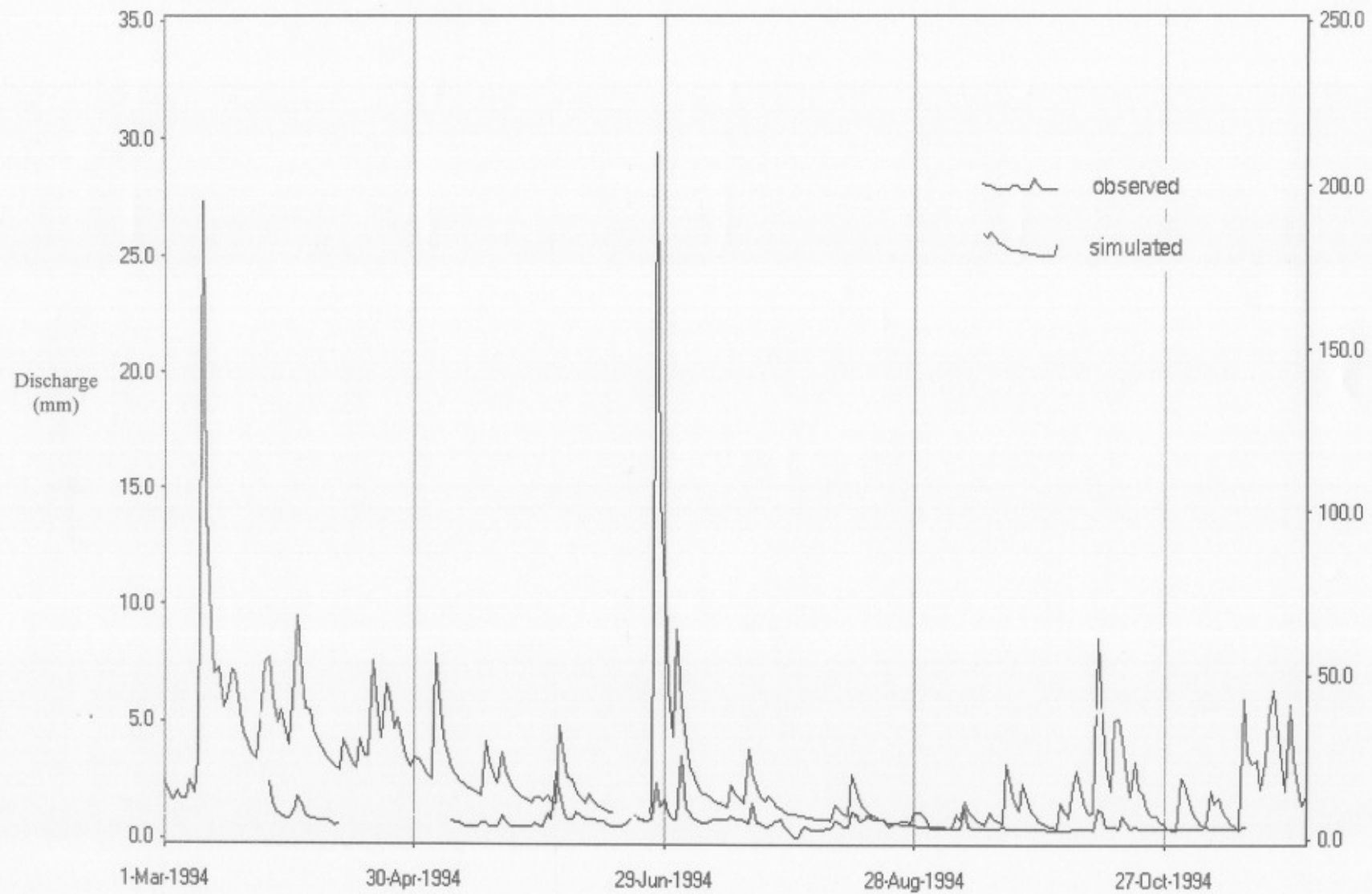


Figure 2.6 Observed and Simulated Hydrographs at Prang Besar With 800mm per annum Runoff

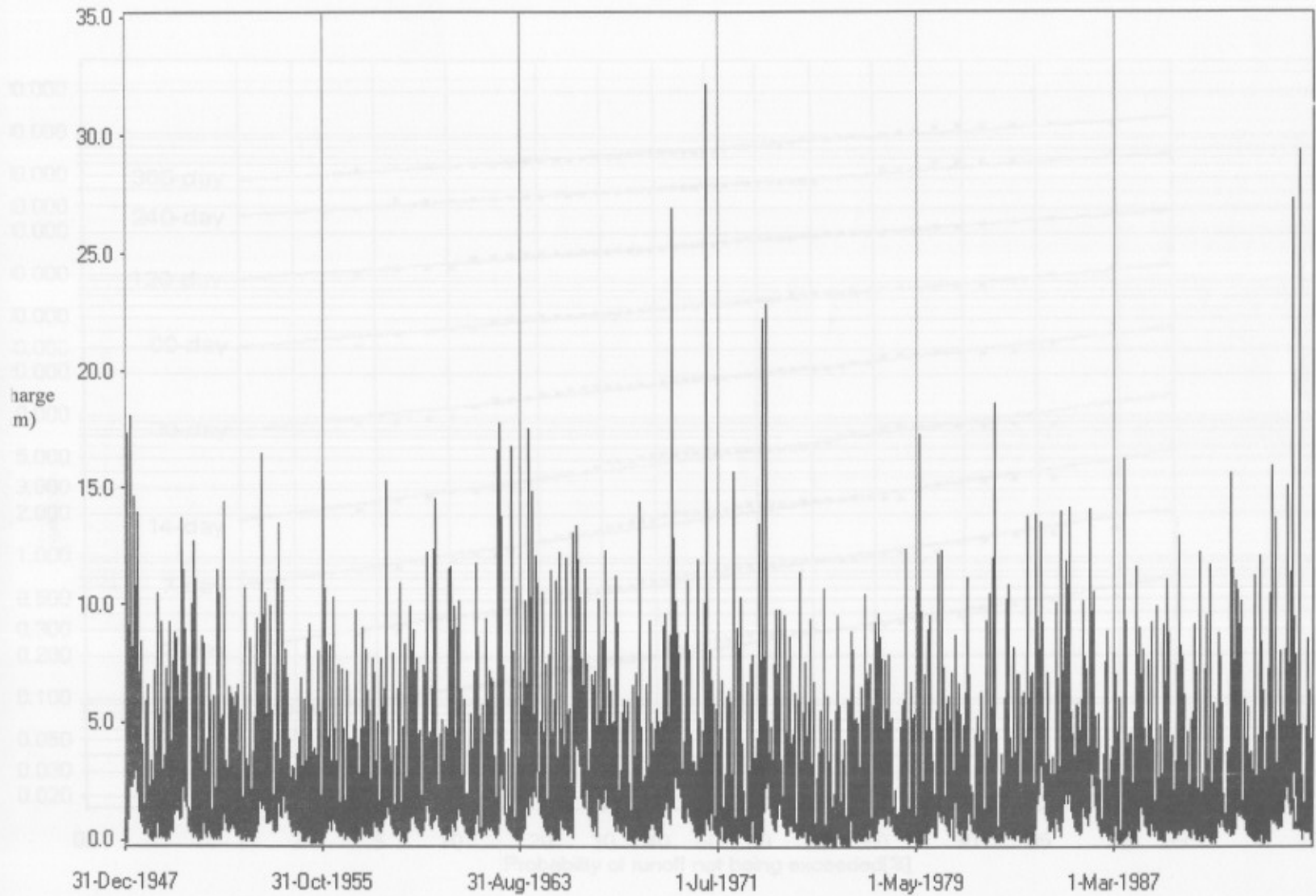


Figure 2.7 Daily Simulated Runoff (1947 to 1998)

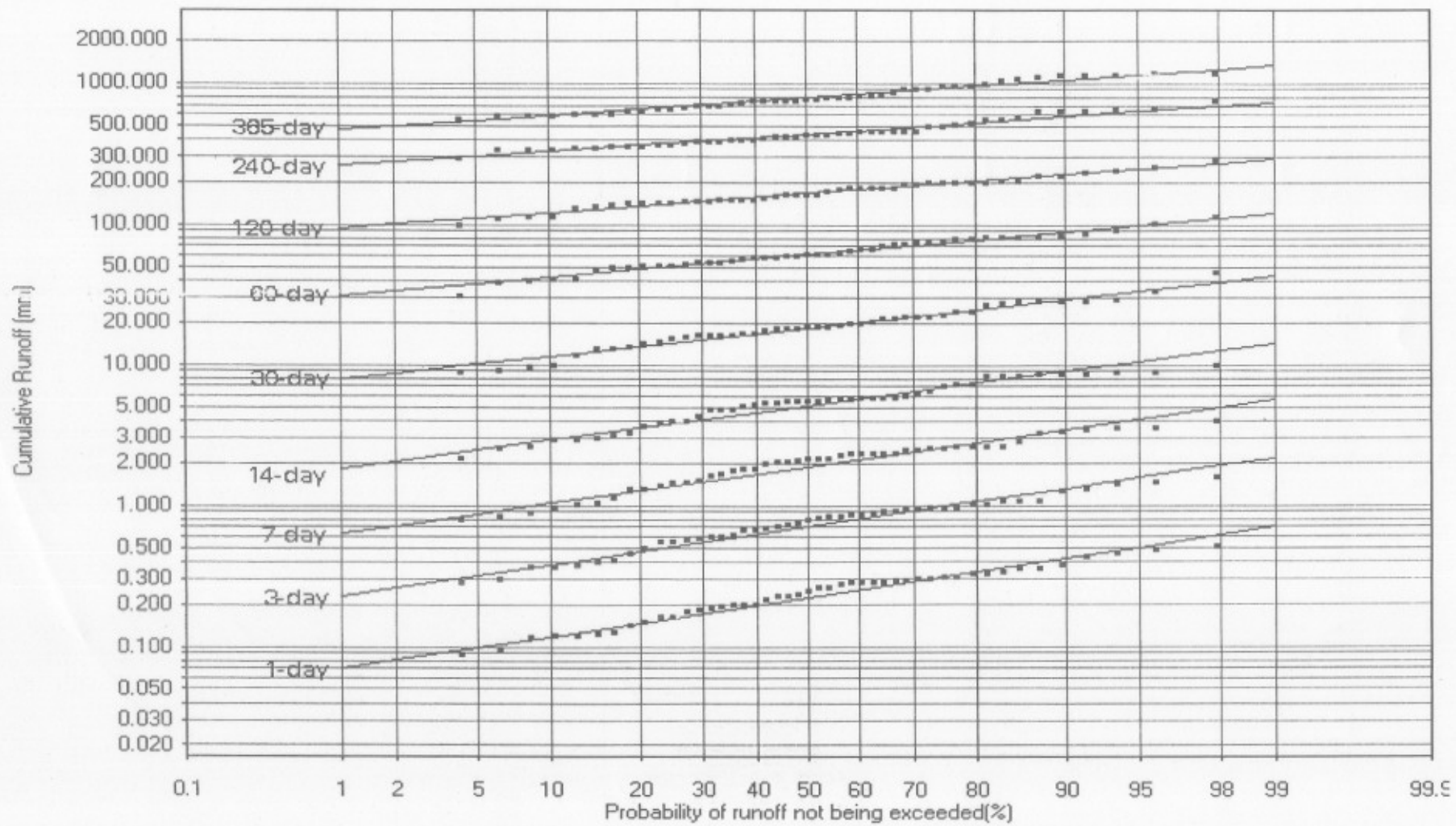
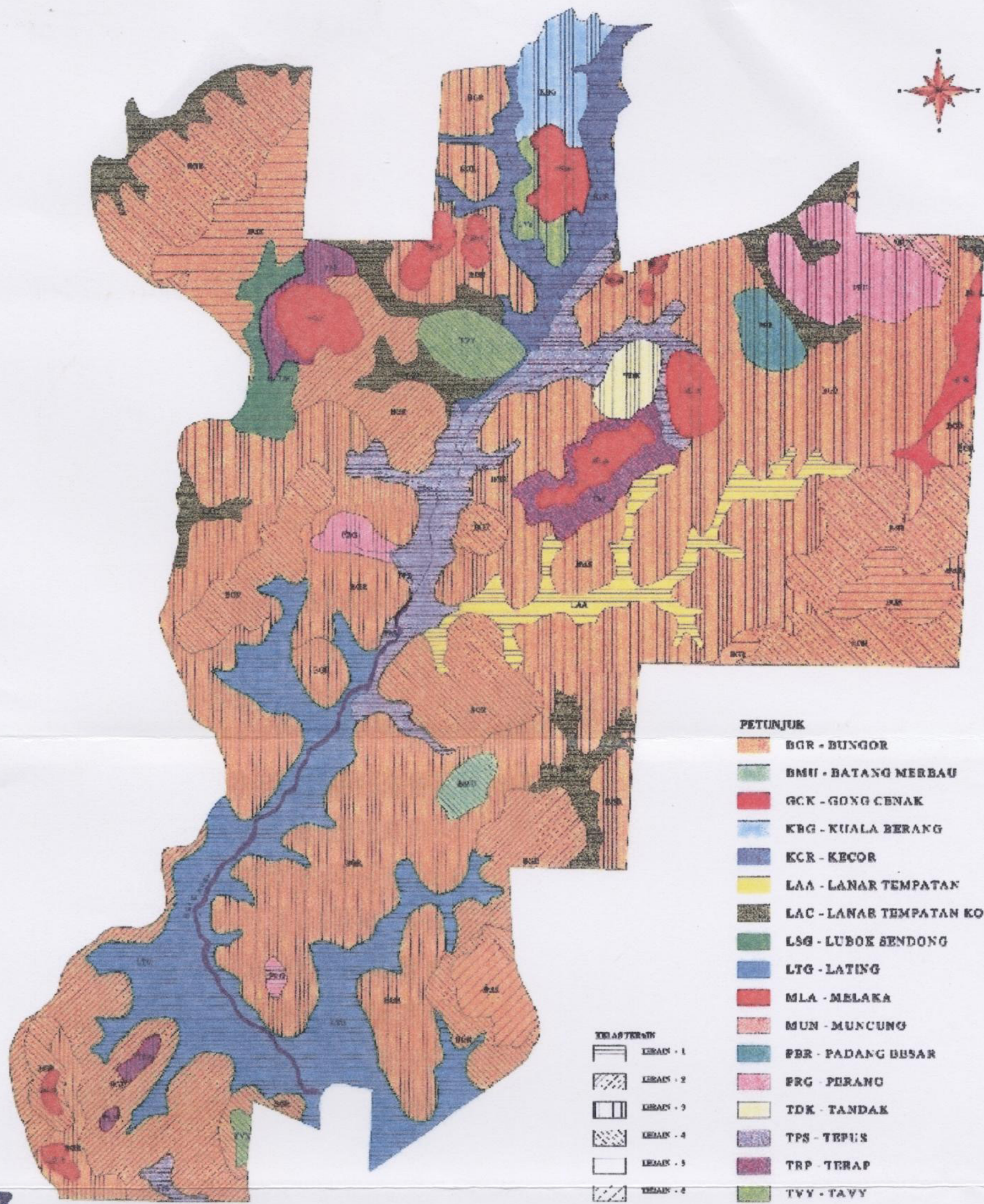


Figure 2.8 Stacked Frequency Analysis At Prang Besar



PETUNJUK

- BGR - BUNGOR
- BMU - BATANG MERBAU
- GCK - GONG CENAK
- KRG - KUALA BERANG
- KCR - KECOR
- LAA - LANAR TEMPATAN
- LAC - LANAR TEMPATAN KOMPLEKS
- LSG - LUBOK SENDONG
- LTG - LATING
- MLA - MELAKA
- MUN - MUNCUNG
- PBR - PADANG BESAR
- PRG - PERANG
- TDK - TANDAK
- TPS - TEPUS
- TRP - TERAP
- TVY - TAVY

KELAS TERENY

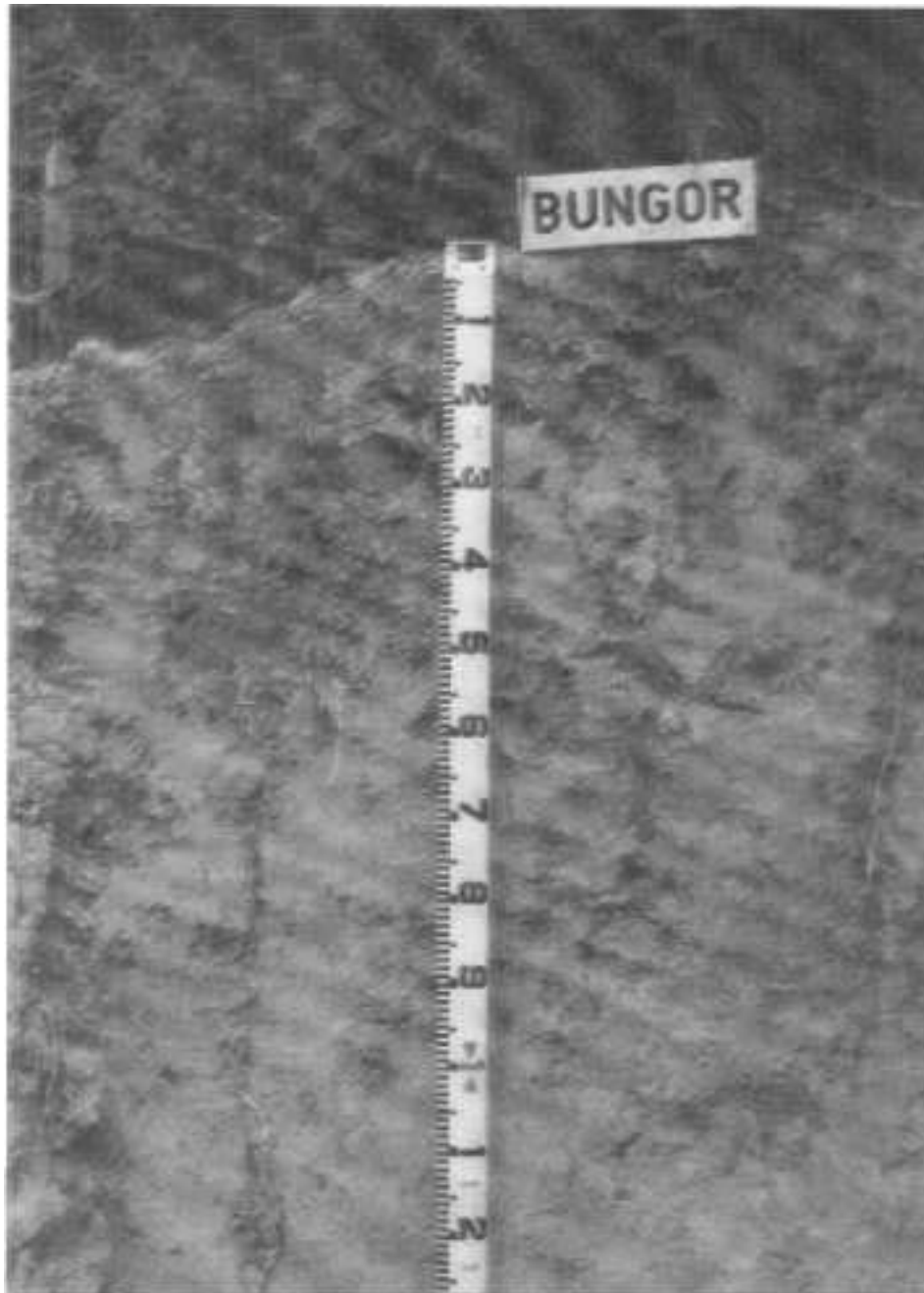
- TERENY - 1
- TERENY - 2
- TERENY - 3
- TERENY - 4
- TERENY - 5
- TERENY - 6



**IRRIGATION MASTER PLAN FOR PUTRAJAYA
GEOLOGICAL MAP ON SOIL SERIES**

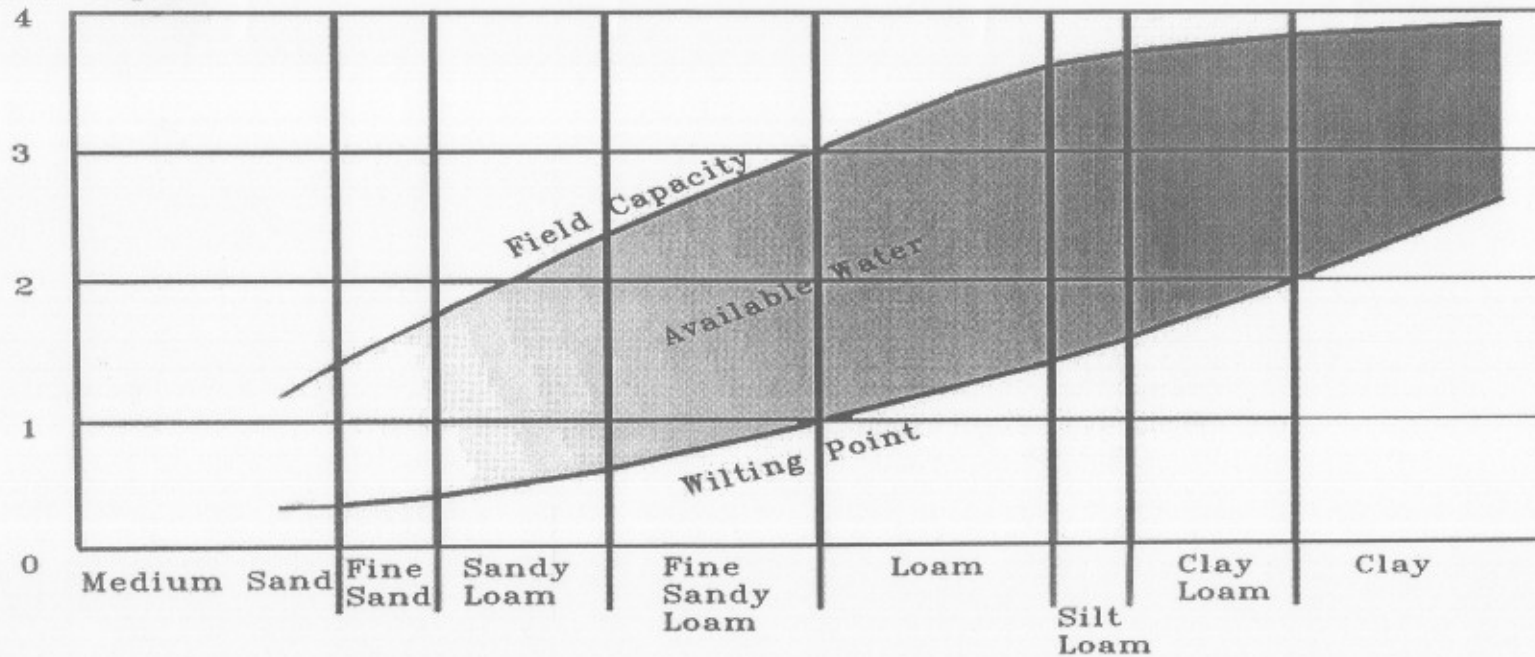
FIGURE 5.1

Figure 5.2



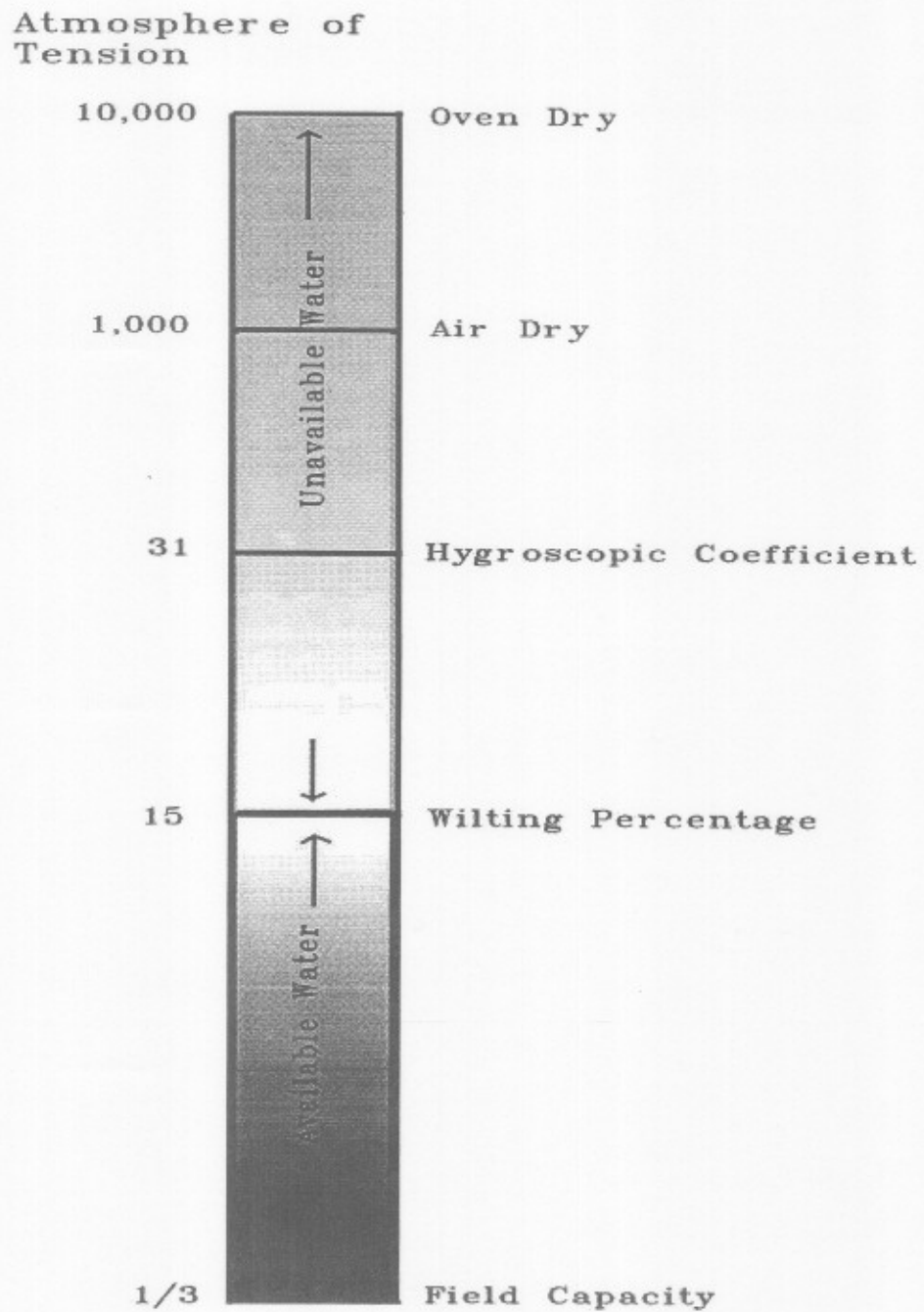
IRRIGATION MASTER PLAN FOR PUTRAJAYA
TYPICAL BUNGOR SERIES

Inches of Water In Each
Foot of Soil Depth



IRRIGATION MASTER PLAN FOR PUTRAJAYA
WATER CAPACITY IN RELATION TO SOIL TEXTURE AND MOISTURE CONSTANTS
 (Source: Soil, their chemistry and fertility in Tropical Asia)

Figure 5.4



IRRIGATION MASTER PLAN FOR PUTRAJAYA
SOIL MOISTURE CONSTANT IN TERM OF ATMOSPHERE OF TENSION
(Source : Soils, their chemistry and fertility in Tropical Asia)

**Figure 5.5 Water Demand For Option 1a
All 20 Precincts For Public and Private Realms**

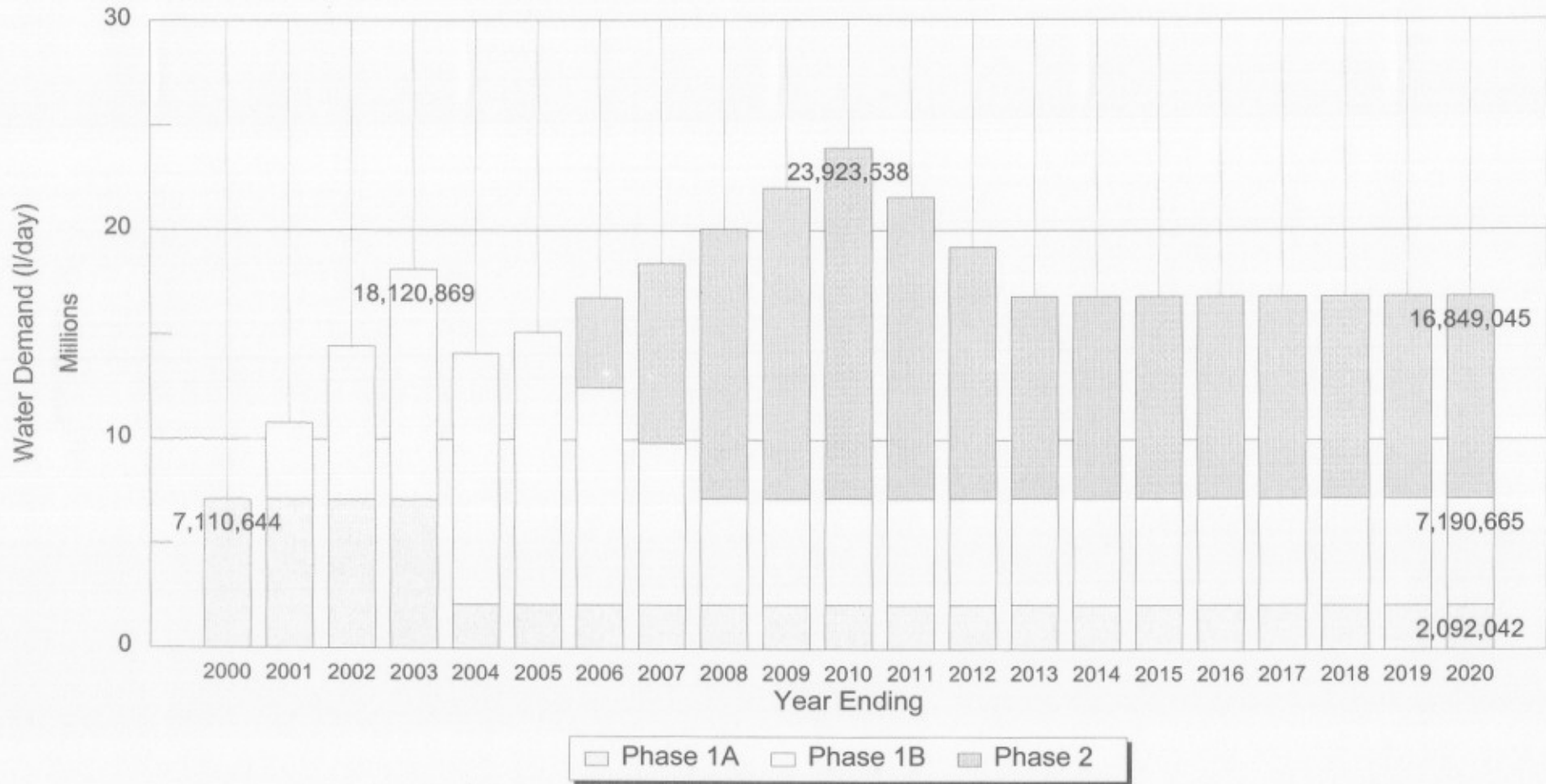
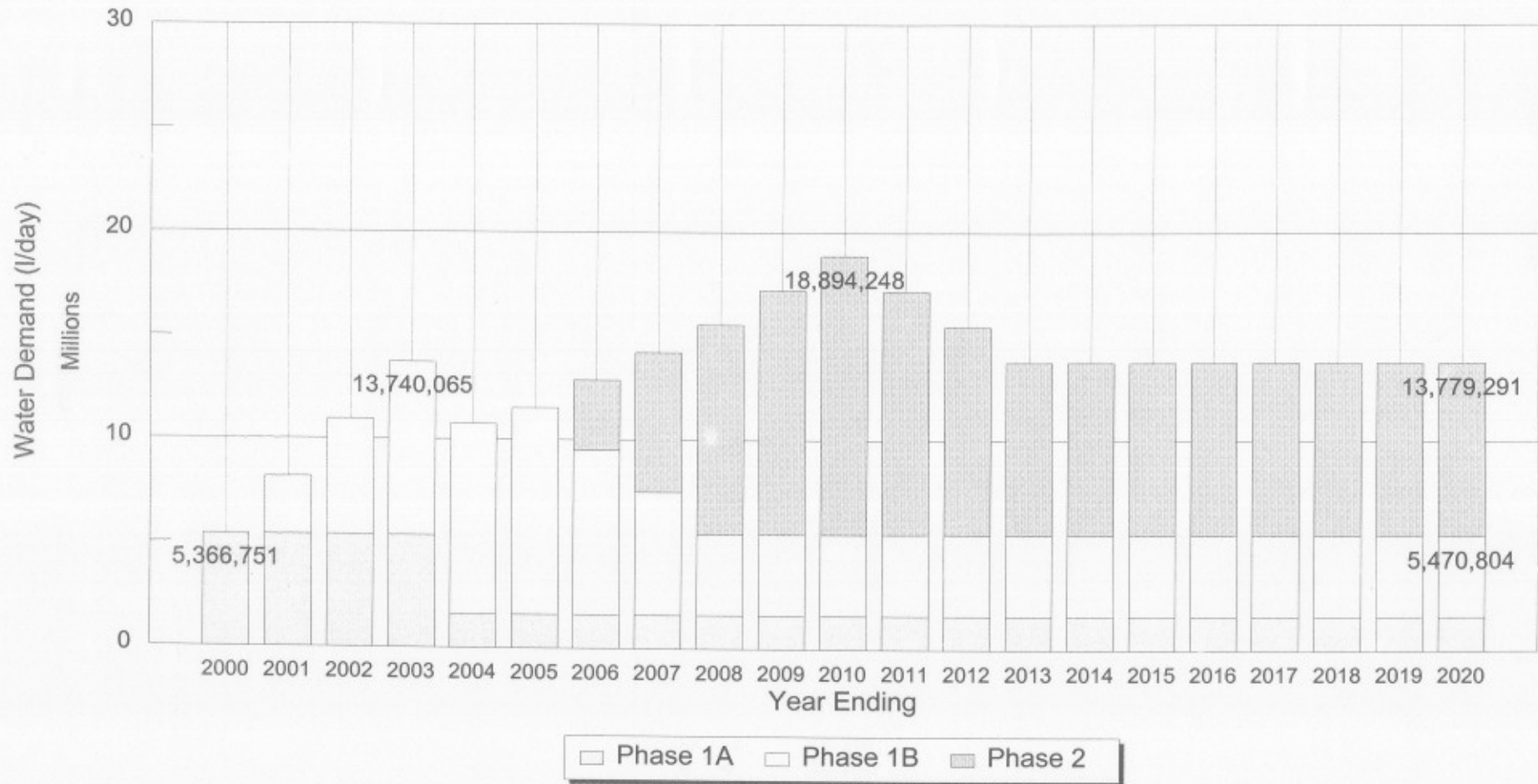


Figure 5.6 Water Demand For Option 1b
All 20 Precincts For Public Realm Only



**Figure 5.7 Water Demand For Option 2
For Proposed Precincts Using Lake Water**

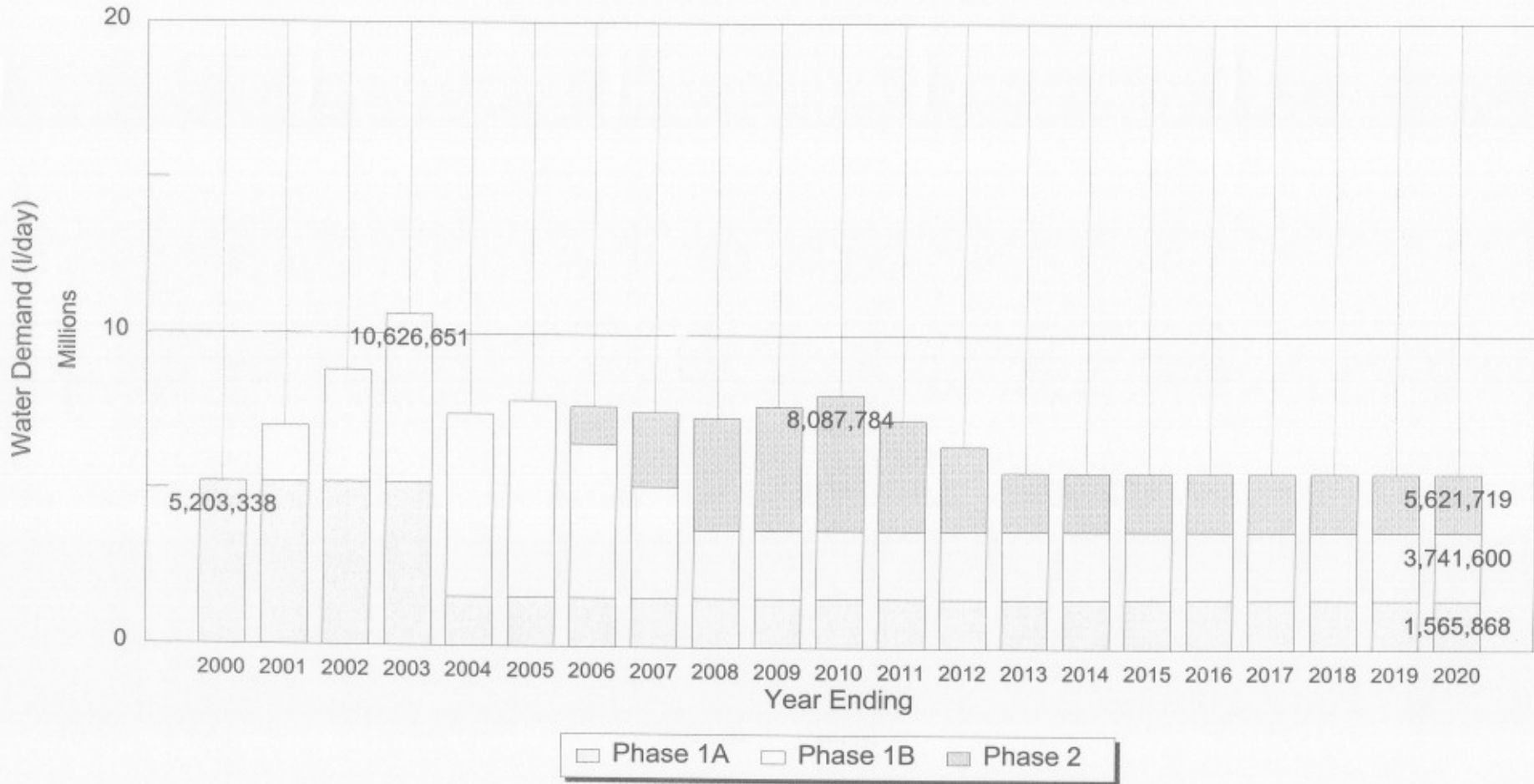
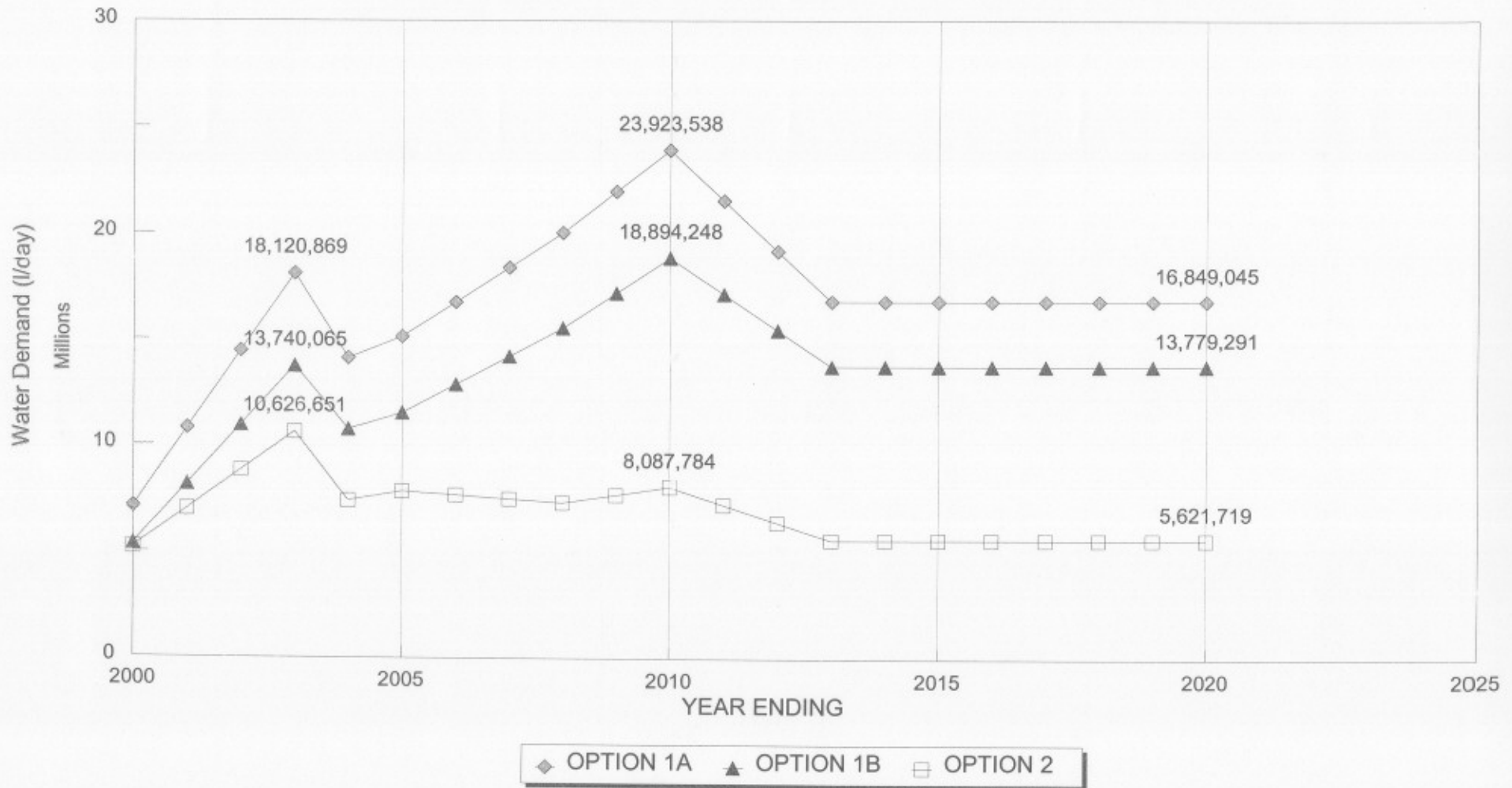
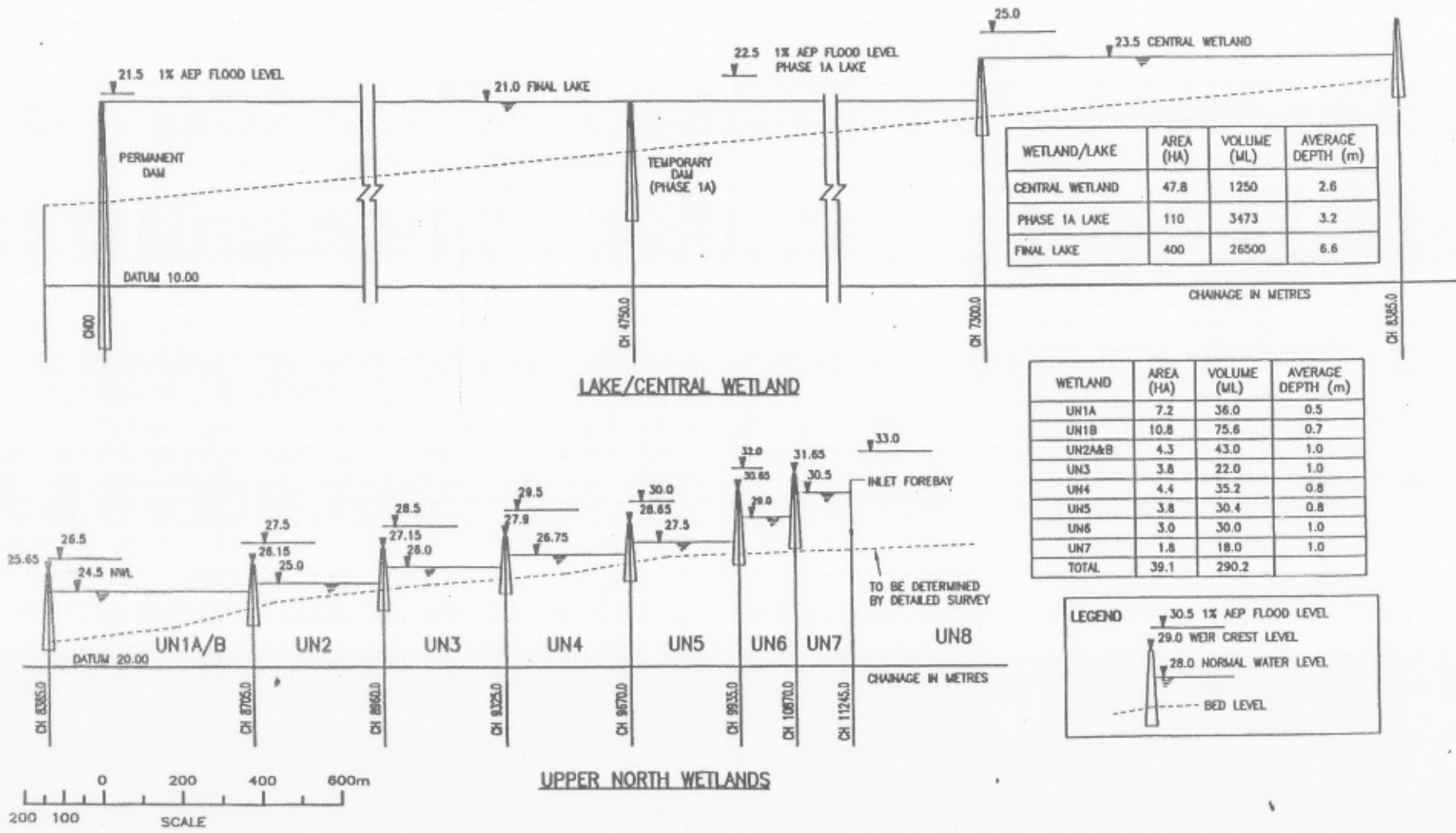


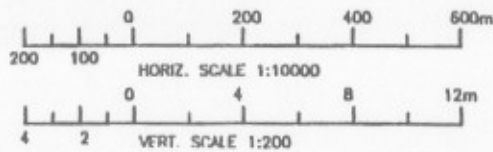
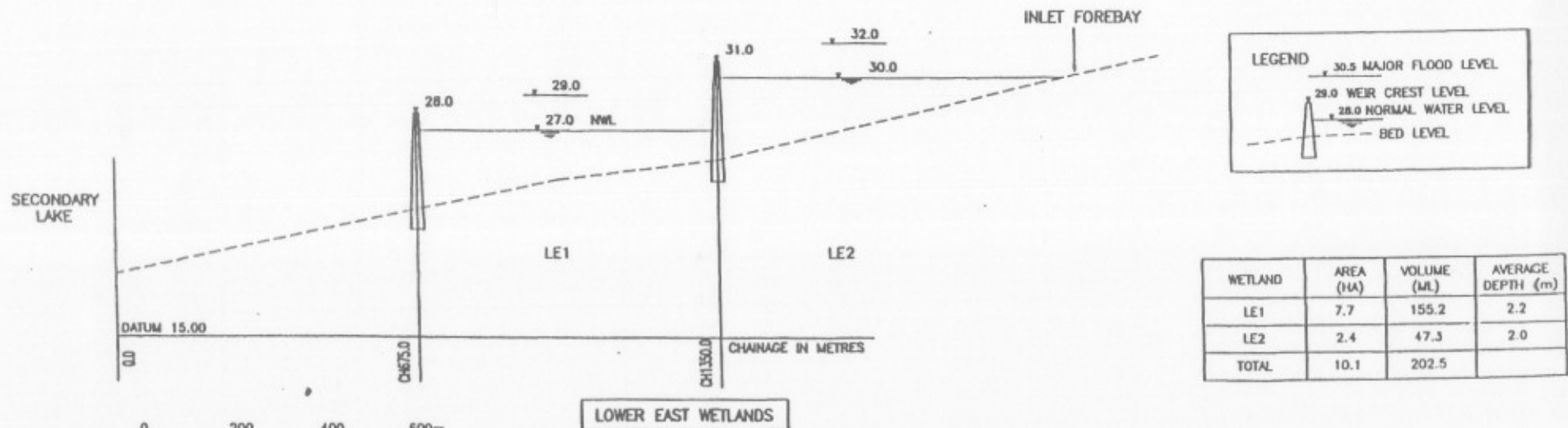
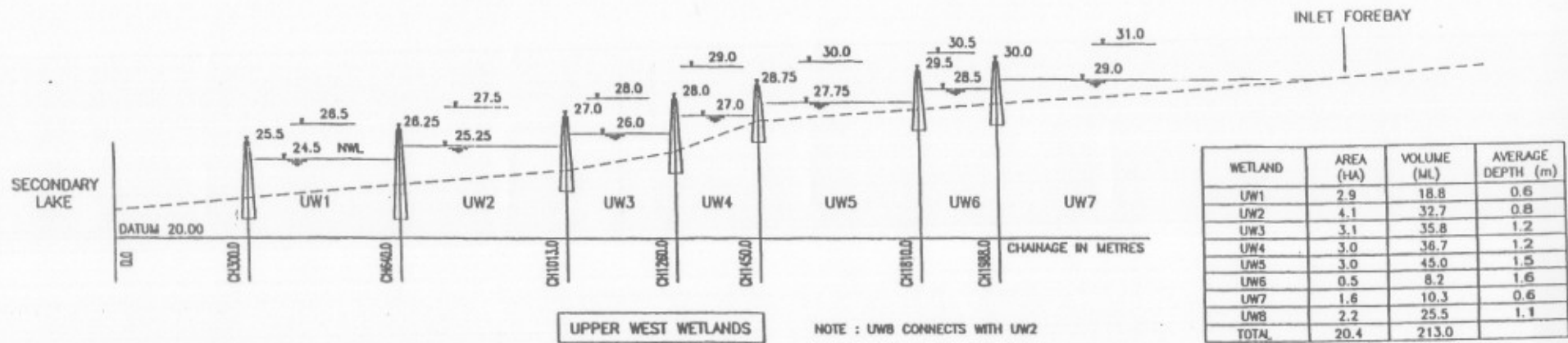
Figure 5.8 Water Demand for Various Options Using Lake Water



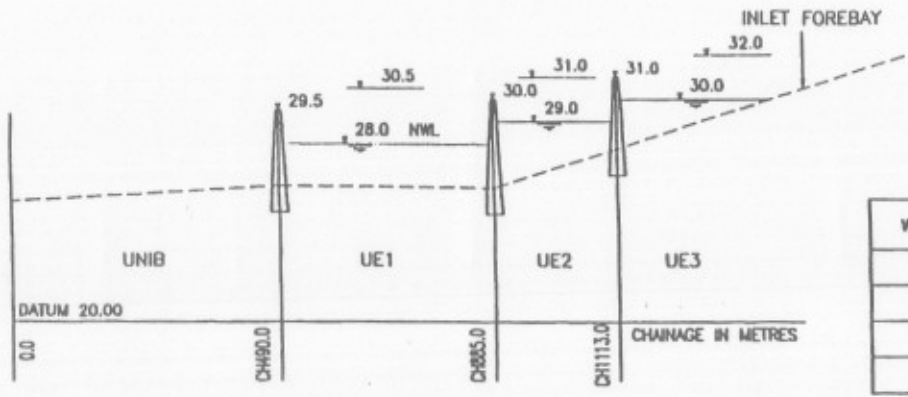


**IRRIGATION MASTER PLAN FOR PUTRAJAYA
LONGITUDINAL CROSS SECTIONS OF LAKE/WETLAND**

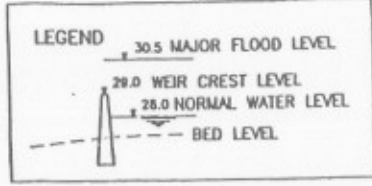
Figure 6.3 (1/3)



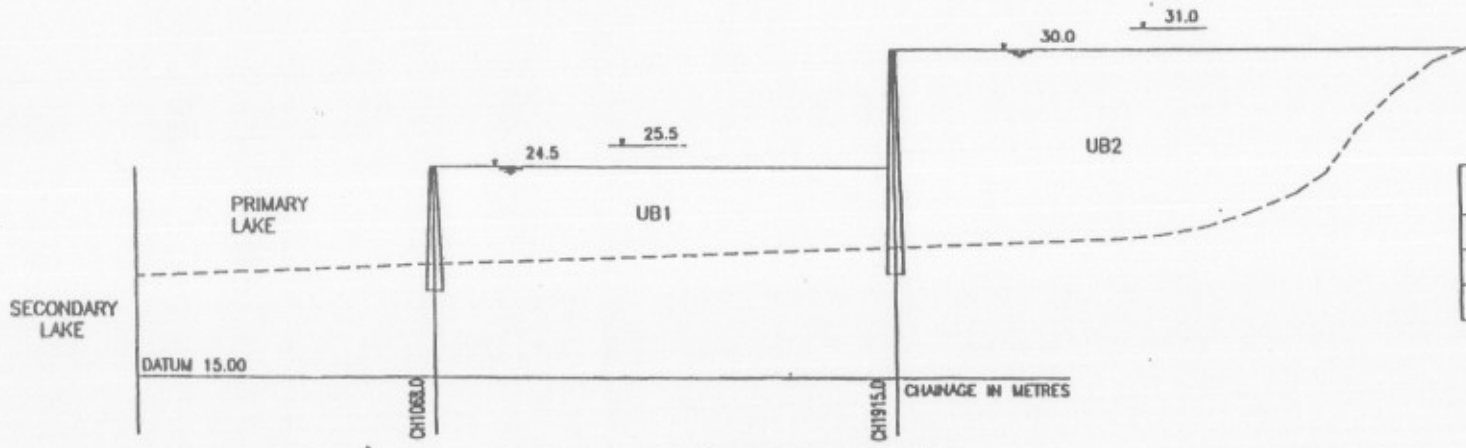
IRRIGATION MASTER PLAN FOR PUTRAJAYA
LONGITUDINAL CROSS SECTIONS OF LAKE/WETLAND (Con't)



WETLAND	AREA (HA)	VOLUME (ML)	AVERAGE DEPTH (m)
UE1	3.2	37.5	1.2
UE2	3.6	52.3	1.5
UE3	5.1	52.1	1.0
TOTAL	11.9	142	

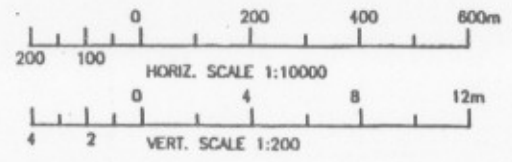


UPPER EAST WETLANDS



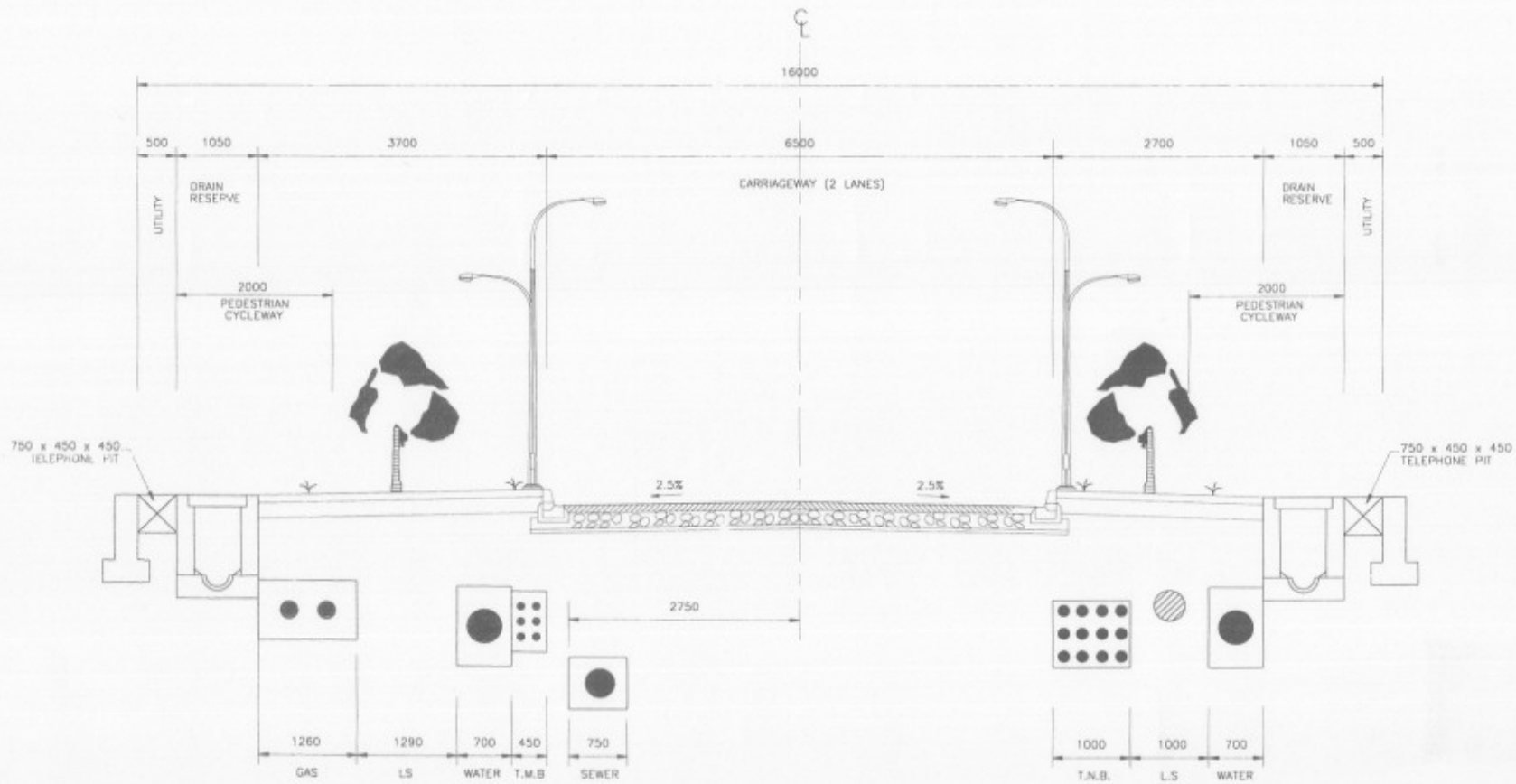
WETLAND	AREA (HA)	VOLUME (ML)	AVERAGE DEPTH (m)
UB1	10.9	335	3.1
UB2	10.2	294	2.9
TOTAL	21.1	628	

UPPER BISA WETLANDS



IRRIGATION MASTER PLAN FOR PUTRAJAYA
LONGITUDINAL CROSS SECTIONS OF LAKE/WETLAND (Con't)

Figure 6.3 (3/3)



1.5m MINIMUM COVER TO ALL UTILITIES
 ALL SEWER MANHOLES TO BE LOCATED
 AT EDGE OF ROAD.

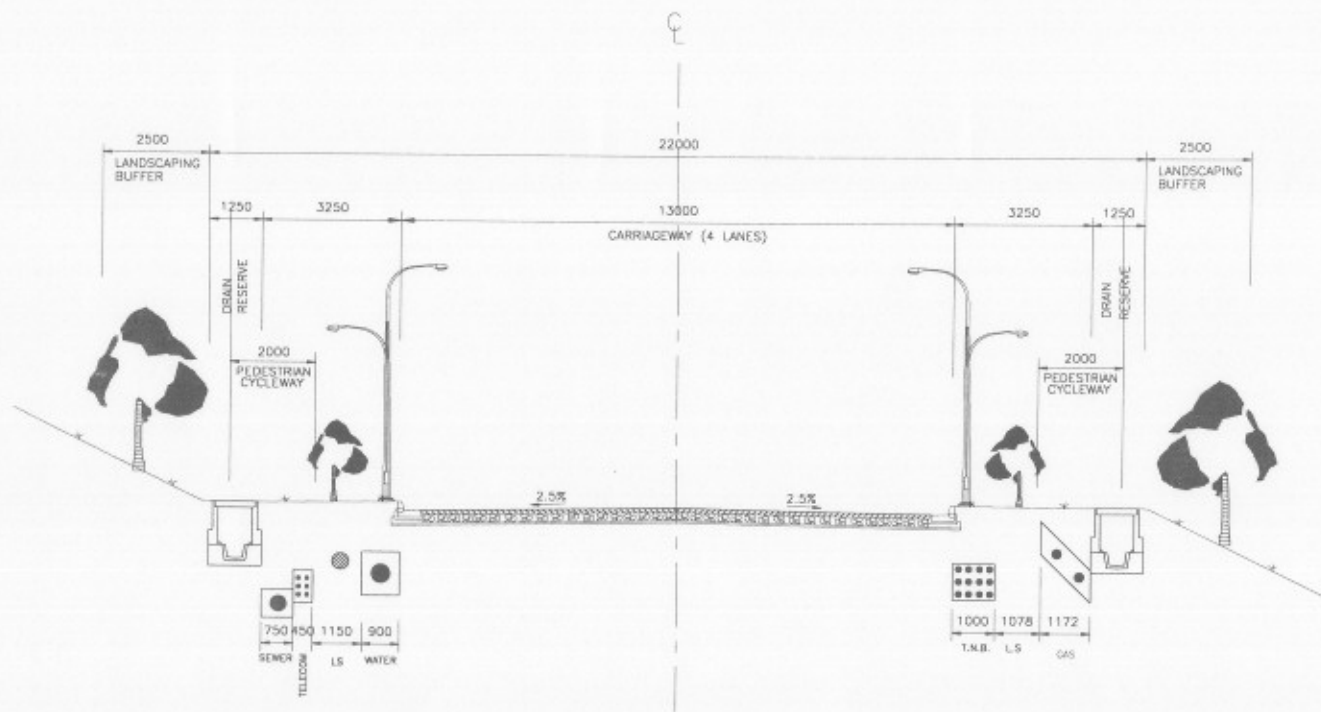
LEGEND

PROPOSED IRRIGATION PIPE LOCATION



IRRIGATION MASTER PLAN FOR PUTRAJAYA
 TYPICAL IRRIGATION PIPE LOCATION FOR 16m ROAD

Figure 9.1a



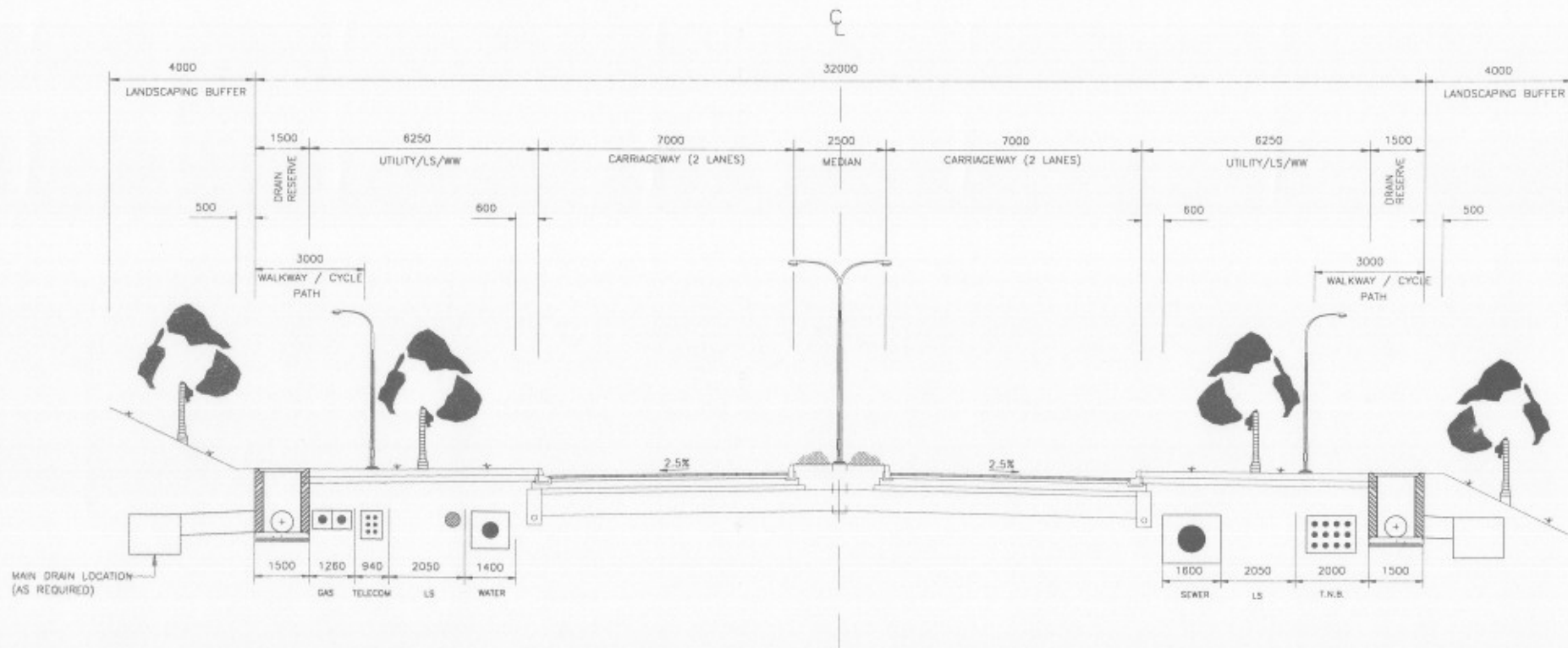
1.5m MINIMUM COVER TO ALL UTILITIES

LEGEND
 ● PROPOSED IRRIGATION PIPE LOCATION



IRRIGATION MASTER PLAN FOR PUTRAJAYA
 TYPICAL IRRIGATION PIPE LOCATION FOR 22m ROAD

Figure 9.1b



1.5m MINIMUM COVER TO ALL UTILITIES

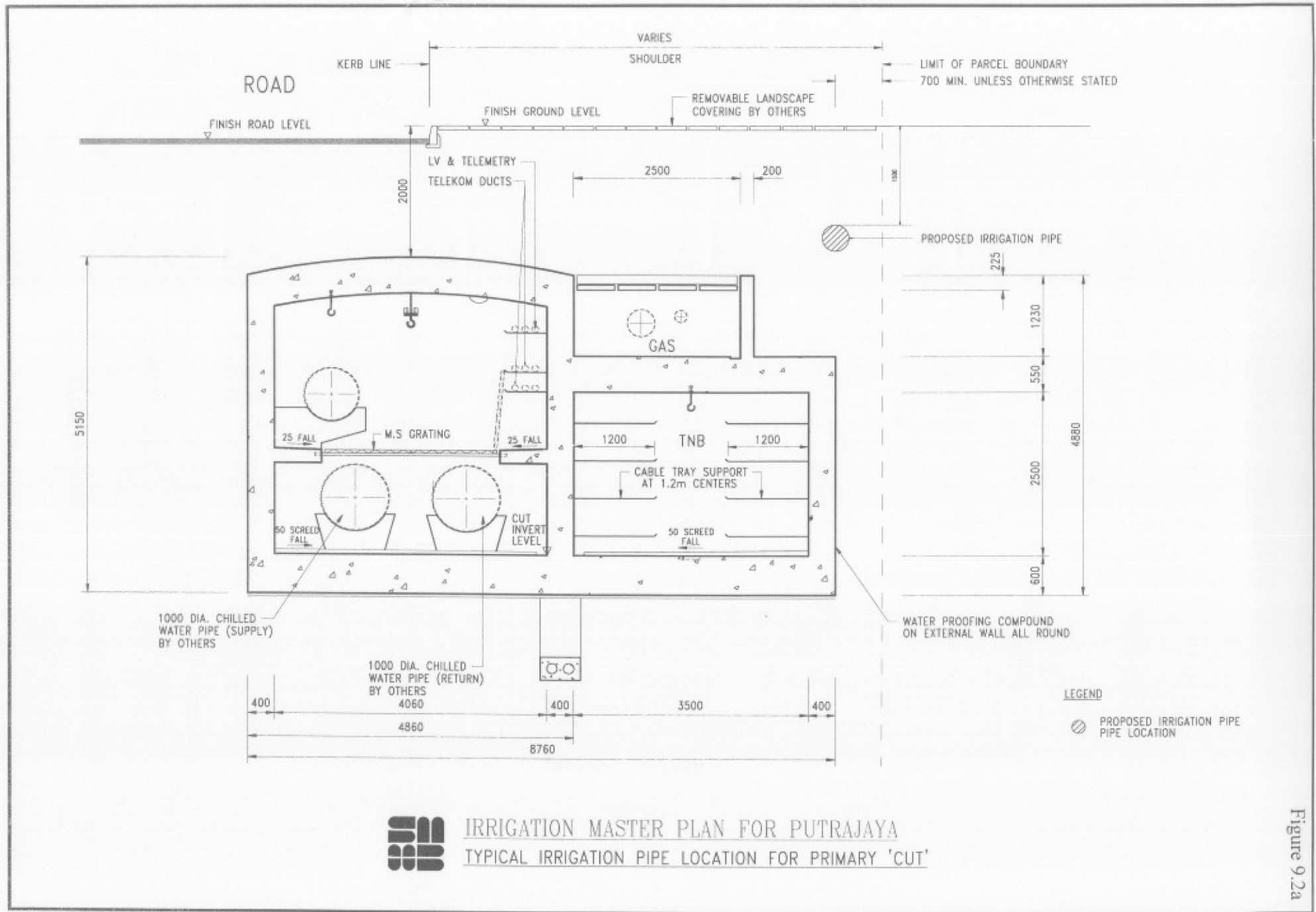
LEGEND

- PROPOSED IRRIGATION PIPE LOCATION



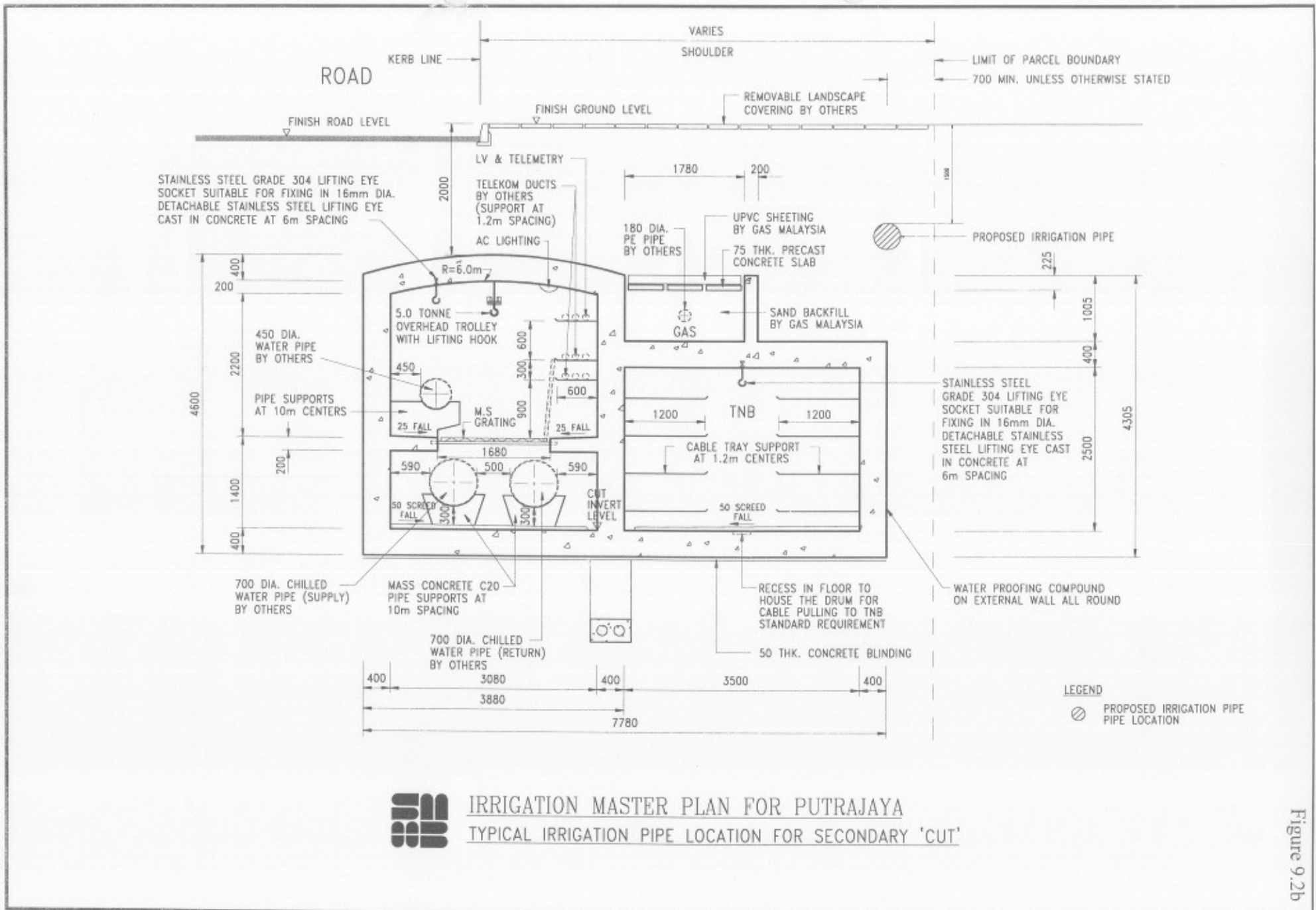
IRRIGATION MASTER PLAN FOR PUTRAJAYA
TYPICAL IRRIGATION PIPE LOCATION FOR 32m ROAD

Figure 9.1c



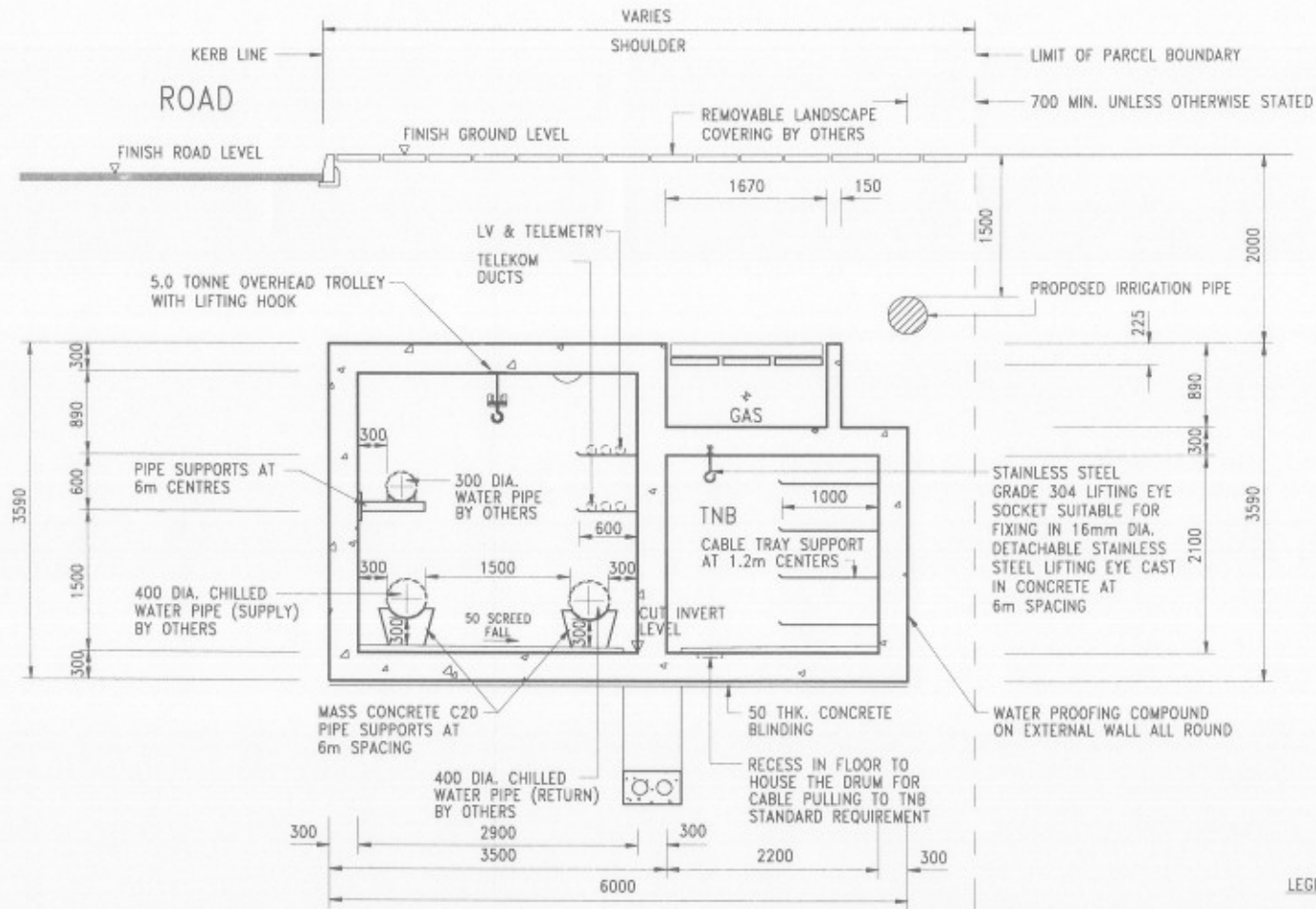
IRRIGATION MASTER PLAN FOR PUTRAJAYA
TYPICAL IRRIGATION PIPE LOCATION FOR PRIMARY 'CUT'

Figure 9.2a



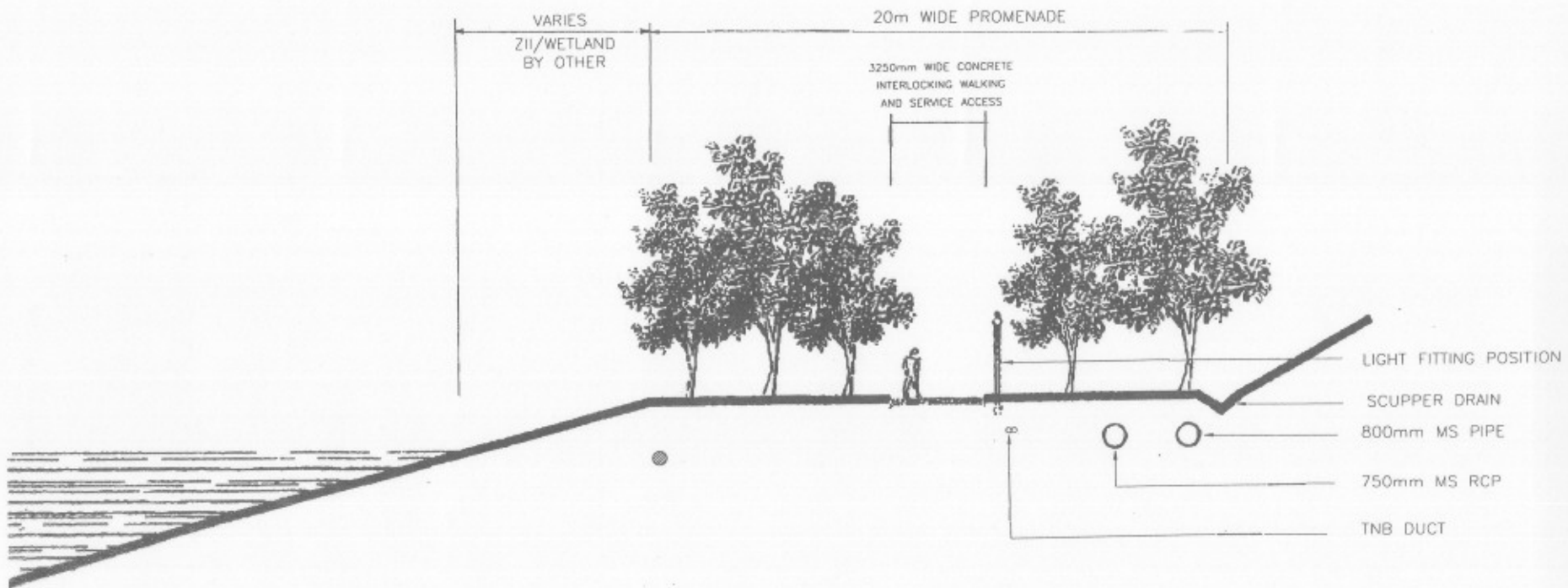
IRRIGATION MASTER PLAN FOR PUTRAJAYA
TYPICAL IRRIGATION PIPE LOCATION FOR SECONDARY 'CUT'

Figure 9.2b



IRRIGATION MASTER PLAN FOR PUTRAJAYA
TYPICAL IRRIGATION PIPE LOCATION FOR TERTIARY 'CUT'

Figure 9.2c



1.5m MINIMUM COVER TO ALL UTILITIES

LEGEND

- PROPOSED IRRIGATION PIPE LOCATION



IRRIGATION MASTER PLAN FOR PUTRAJAYA
TYPICAL IRRIGATION PIPE LOCATION FOR PROMENADE

Figure 9.3

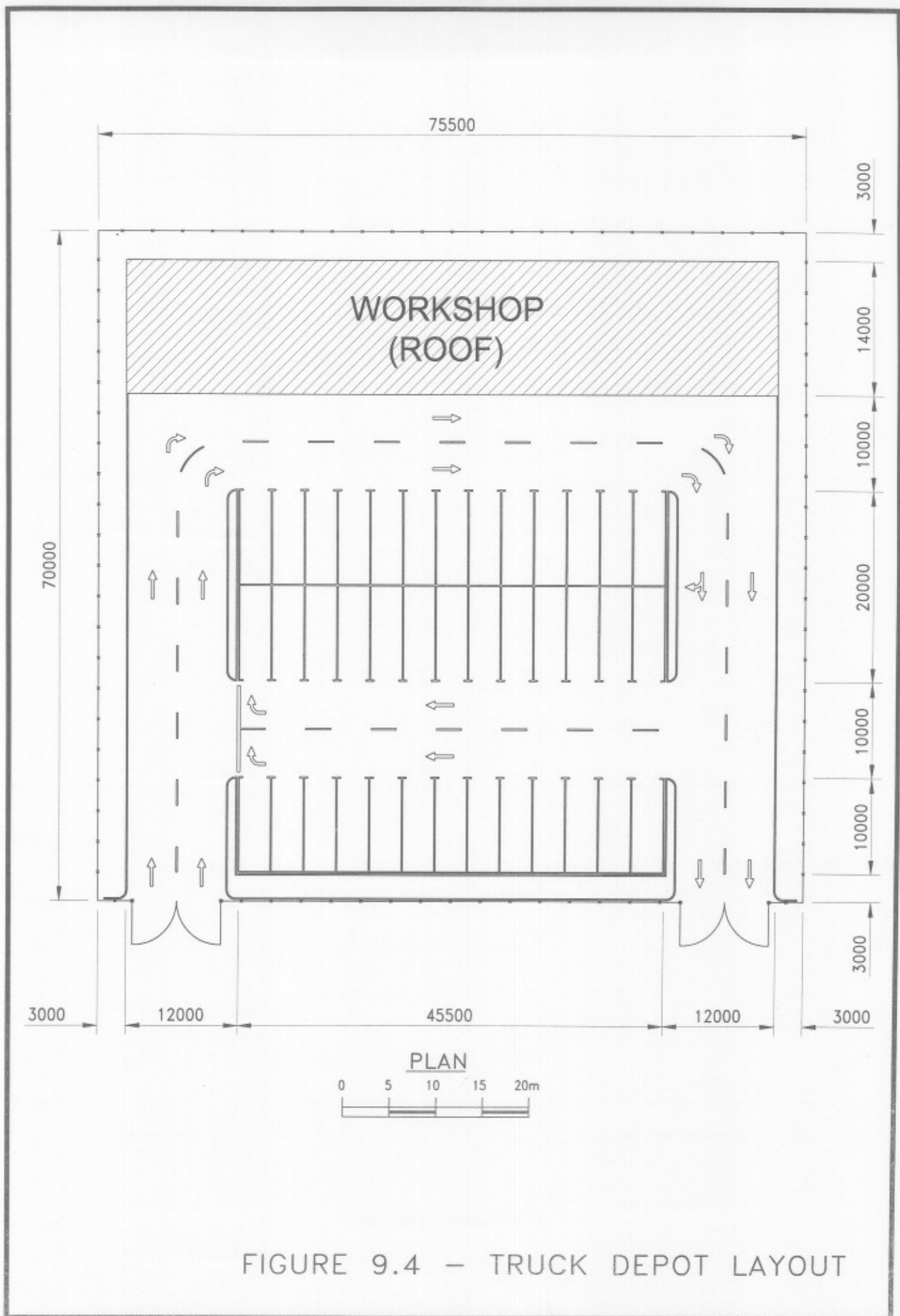


FIGURE 9.4 – TRUCK DEPOT LAYOUT

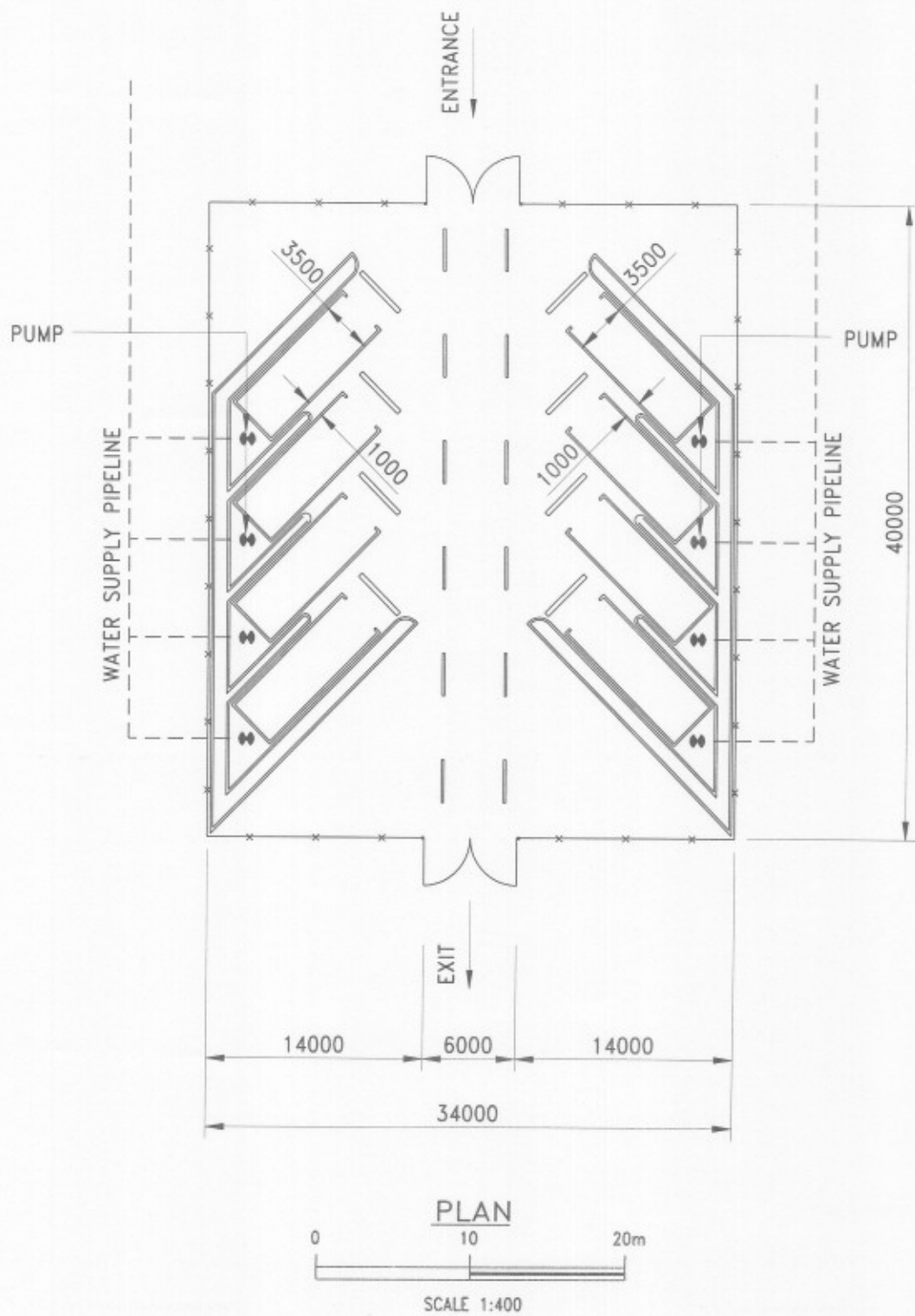
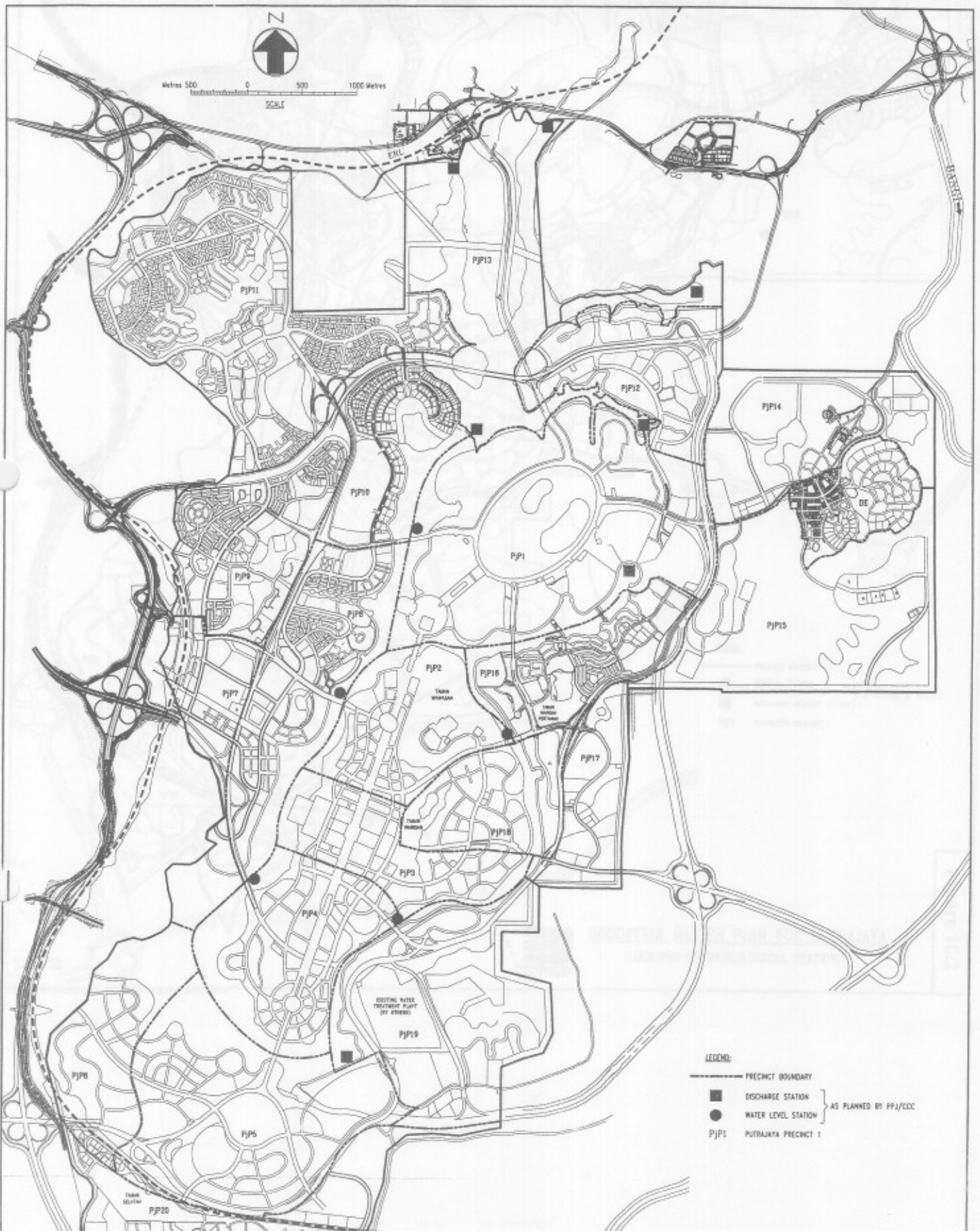
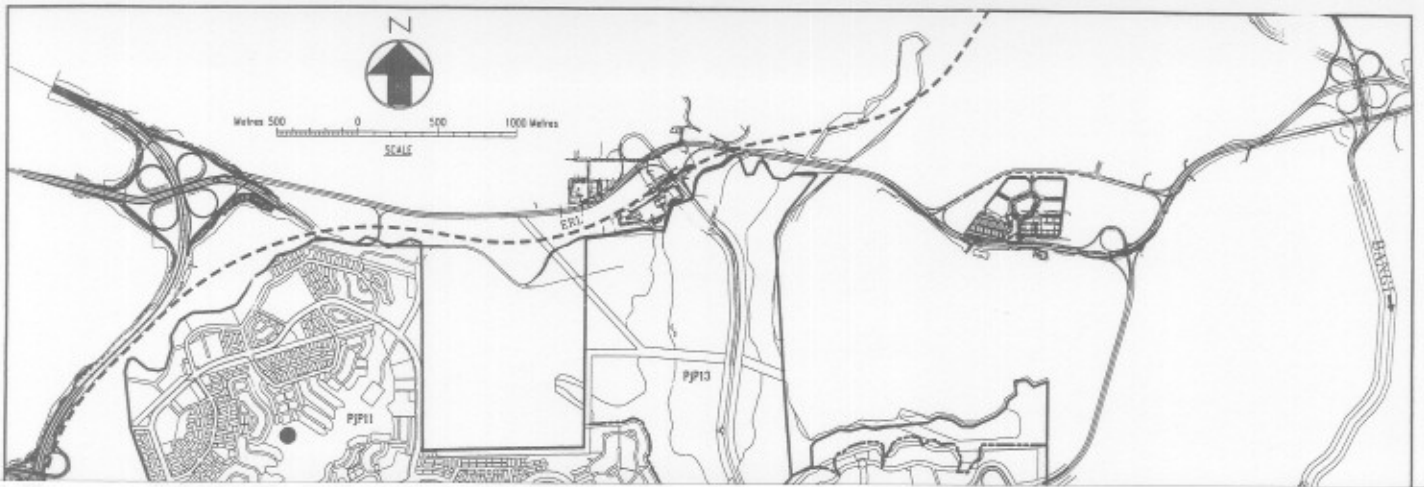


FIGURE 9.5 – TRUCK REFILLING KIOSK LAYOUT



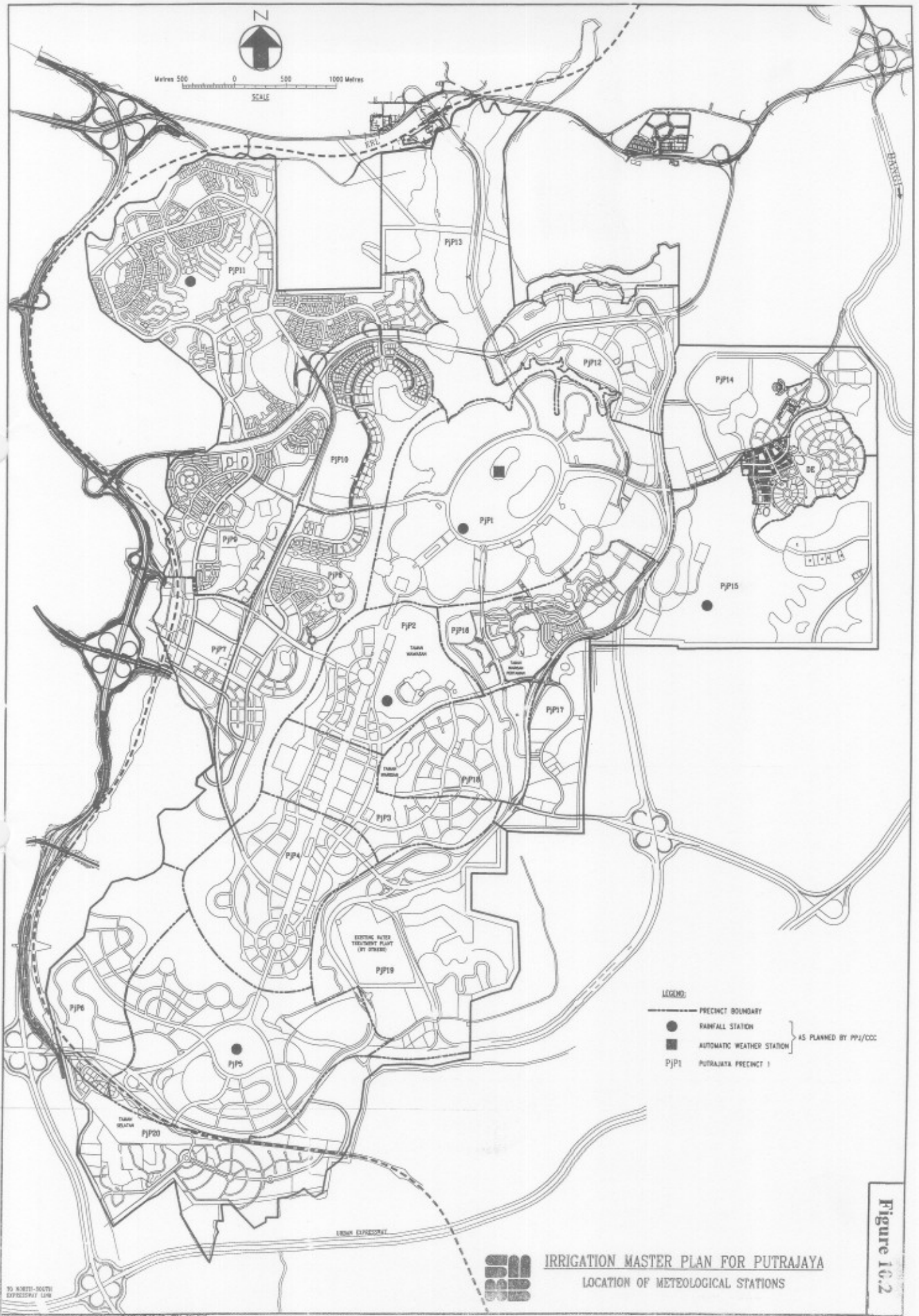


Figure 16.2

93 NORTH-SOUTH EXPRESSWAY LINK
 100% • P.1, 15/1, 16/1, 17/1, 18/1, 19/1, 20/1, 21/1, 22/1, 23/1, 24/1, 25/1, 26/1, 27/1, 28/1, 29/1, 30/1, 31/1, 32/1, 33/1, 34/1, 35/1, 36/1, 37/1, 38/1, 39/1, 40/1, 41/1, 42/1, 43/1, 44/1, 45/1, 46/1, 47/1, 48/1, 49/1, 50/1, 51/1, 52/1, 53/1, 54/1, 55/1, 56/1, 57/1, 58/1, 59/1, 60/1, 61/1, 62/1, 63/1, 64/1, 65/1, 66/1, 67/1, 68/1, 69/1, 70/1, 71/1, 72/1, 73/1, 74/1, 75/1, 76/1, 77/1, 78/1, 79/1, 80/1, 81/1, 82/1, 83/1, 84/1, 85/1, 86/1, 87/1, 88/1, 89/1, 90/1, 91/1, 92/1, 93/1, 94/1, 95/1, 96/1, 97/1, 98/1, 99/1, 100/1

APPENDICES

- Appendix A** **Guidelines On Rainwater Harvesting For Irrigation**
- Appendix B** **Ground Water Assessment**
- Appendix C** **Water Quality Assessment**
- Appendix D** **Intake And Pumphouse Design**
- Appendix E** **Locational And Design Criteria For Irrigation Facilities**
- Appendix F** **Irrigation Application System, Scheduling Concept And Centralised Control System**
- Appendix G** **Provision Under Waters Act, 1920 (Revised 1989)**
- Appendix H** **Checklist for Development Approval**
FORM SA (Pindaan 1)
FORM SA1 (Pindaan 1)
FORM PB (Pindaan 1)
FORM PB1 (Pindaan 1)
FORM PBS1 (Pindaan 1)
Lampiran B(i) (Pindaan 1) Laporan Sokongan LCP Termasuk Pelan/ Gambarajah/Model
Lampiran B(i) (Pindaan 1) Laporan Ringkasan Cadangan Pemajuan dan Pelan – pelan Sokongan Lain
- Appendix J** **Evaluation of Alternative Irrigation Systems**

APPENDIX A

**GUIDELINES ON RAINWATER HARVESTING
FOR IRRIGATION**

It is recommended that the government building and preferably where appropriate the private realm are encouraged to develop rainwater harvesting facilities to supplement irrigation water needs. This would cover: (in the order of priority).

- Government Building
- Commercial Blocks
- Condominiums, apartments, flats and townhouses
- Individual private homes i.e. terrace houses, semi detached houses and bungalows

Most government building's and private houses would normally use JBA tap water for watering the plants. However, in the event of an extreme drought event, the public is required to conserve water and hence the development of rainwater harvesting facilities in both the government building's and the private homes and other privately owned buildings are encouraged.

Water balance analysis indicates that the storage sizes required in terms of cubic metres per square meters of irrigated garden area to cope with various return period drought events are as follows:-

CA / IA	Storage volume required (m ³ /m ²)			
	5-yr	10-yr	25-yr	50-yr
2.0	0.18	0.25	0.40	0.60
2.5	0.10	0.15	0.25	0.25
3.0	0.07	0.12	0.18	0.22

Note :

- CA is the catchment area of the water harvesting facility (tanks, ponds etc.)
- IA is the extent of the irrigated area

It is recommended that private developments should provide rainwater harvesting facilities to cater at least for 5-year drought event.

As layout of buildings and gardens of each individual homes varies, the catchment area of rainfall harvesting achievable in each home also varies. Some houses may have larger built-up and smaller garden while some may have larger gardens. The terrain slope and modifications to the terrain will also affect the catchment area of the rainwater harvesting facility.

To maximise rainwater harvesting efficiency:-

- The catchment area of the rainwater harvesting facility should be maximised. It is therefore left to the ingenuity of the planner to maximise the catchment area within his development area.
- The area that needs irrigation should be minimised. This does not mean that developers do not provide for gardens but to minimise the need for irrigation by strategically planting for instance trees that requires less irrigation and establishing lawns with for instance cow grass which are more drought resistant.

Notwithstanding the variability of development layouts, below are rough guidelines for rainwater harvesting storage size to be provided based on assumed layouts of various types of development:

Type of buildings	Assumptions			Rainwater harvesting	Estimated Cost
	CA/IA	Required storage	Garden size	Storage required	
		(m ³ /m ²)	(m ²)	(m ³)	(RM)
Terrace house	3	0.07	20	2	3,000
Semi-detached house	3	0.07	80	6	8,000
Bungalow	2.5	0.1	150	15	20,000
Government &	3	0.07	20	2	4,000
Commercial Buildings	3	0.07	80	6	11,000
	3	0.07	115	8	14,000
	3	0.07	140	10	18,000
	3	0.07	290	20	32,000
	3	0.07	570	40	48,000

The above are merely guidelines. Provision of storage differing from the above could be allowed if it can be proven that irrigation requirement during a 5-year drought event can be taken care of.

This is possible if it can be shown that innovative changes to development layout and planting strategy to be implemented results in lower storage required.

For commercial buildings, condominiums etc. the parameters are too variable and it is proposed that the developer would have to compute the storage required based on the CA/IA ratio of the proposed layout.

Besides this there are other issues to be considered:-

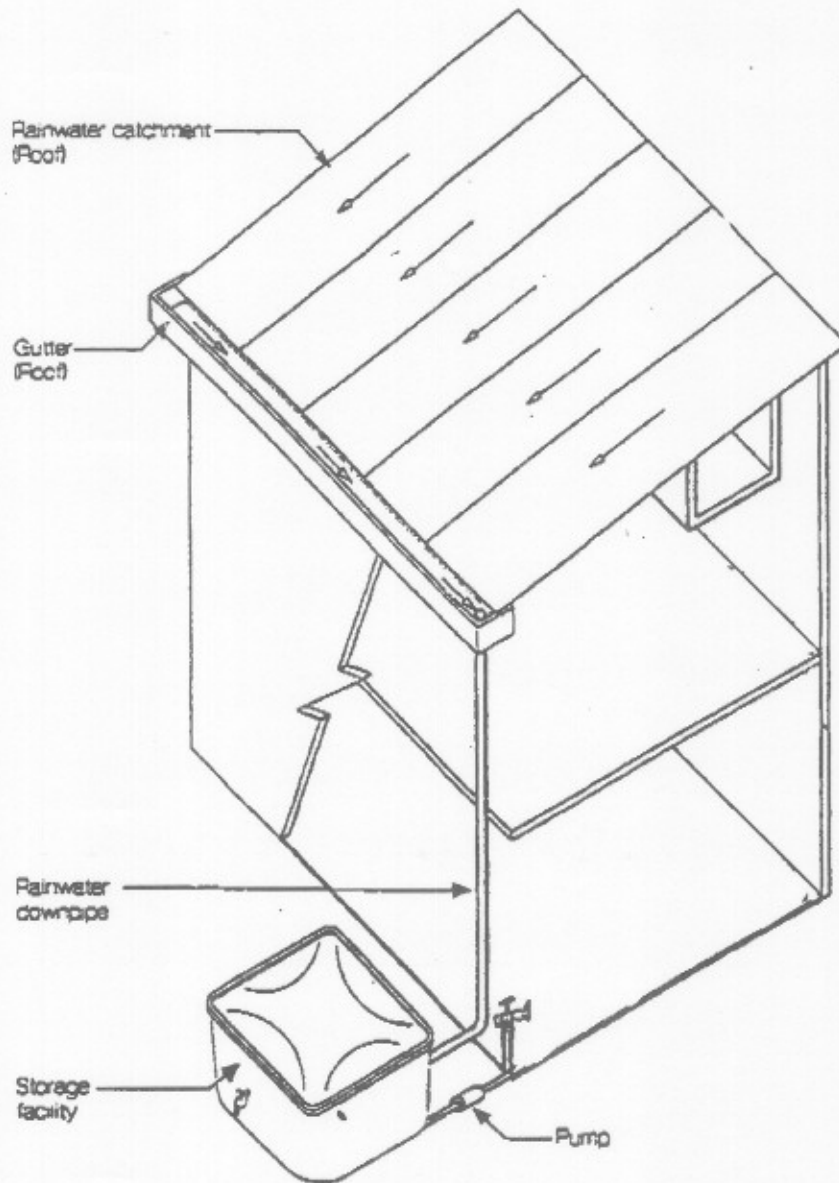
- The need to provide features to remove the usually heavy concentration of dirt and grit from the initial flush of runoff that could clog the system.
- The need to prevent leaf clogging.
- The need to insect proof the tank.
- The need to provide feature for regular flushing of sediments.

All these have been considered under the recent Guidelines for Installing a Rainwater Collection and Utilisation System prepared by the Kementerian Perumahan dan Kerajaan Tempatan. The relevant parts of this document are reproduced in Figures A1 - A6 to be incorporated in this guideline.

Whilst the above describes mainly rainwater harvesting using tanks, the developer could also provide ponds for rainwater harvesting. Again parameters in the case of ponds are too variable for any standardisation to be possible. The main guidelines would be the need to provide for a 5-year drought event and to consider the CA/IA ratio in their design.

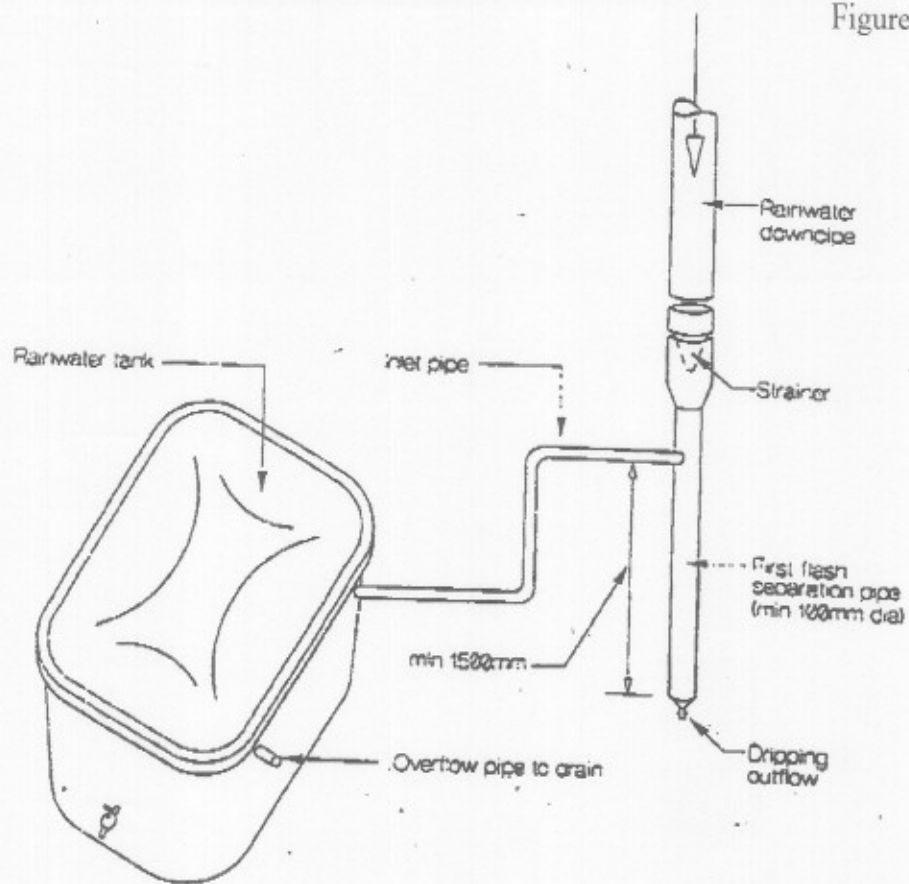
Costs as shown above vary depending on the type of material used for the tank. Estimates were made assuming fibre glass tanks complete with installation pipe connections.

Figure A1

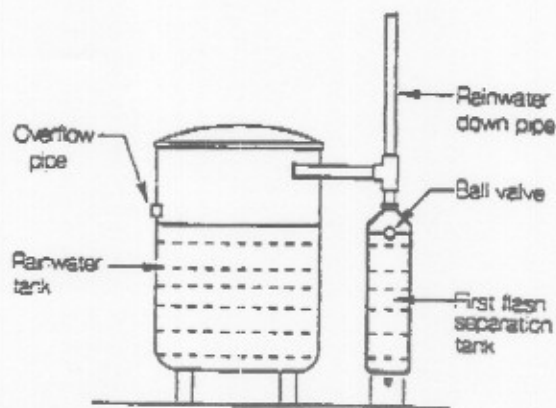


**IRRIGATION MASTER PLAN FOR PUTRAJAYA
ELEMENTS OF RAINWATER COLLECTION AND
UTILIZATION SYTEM**

Figure A2



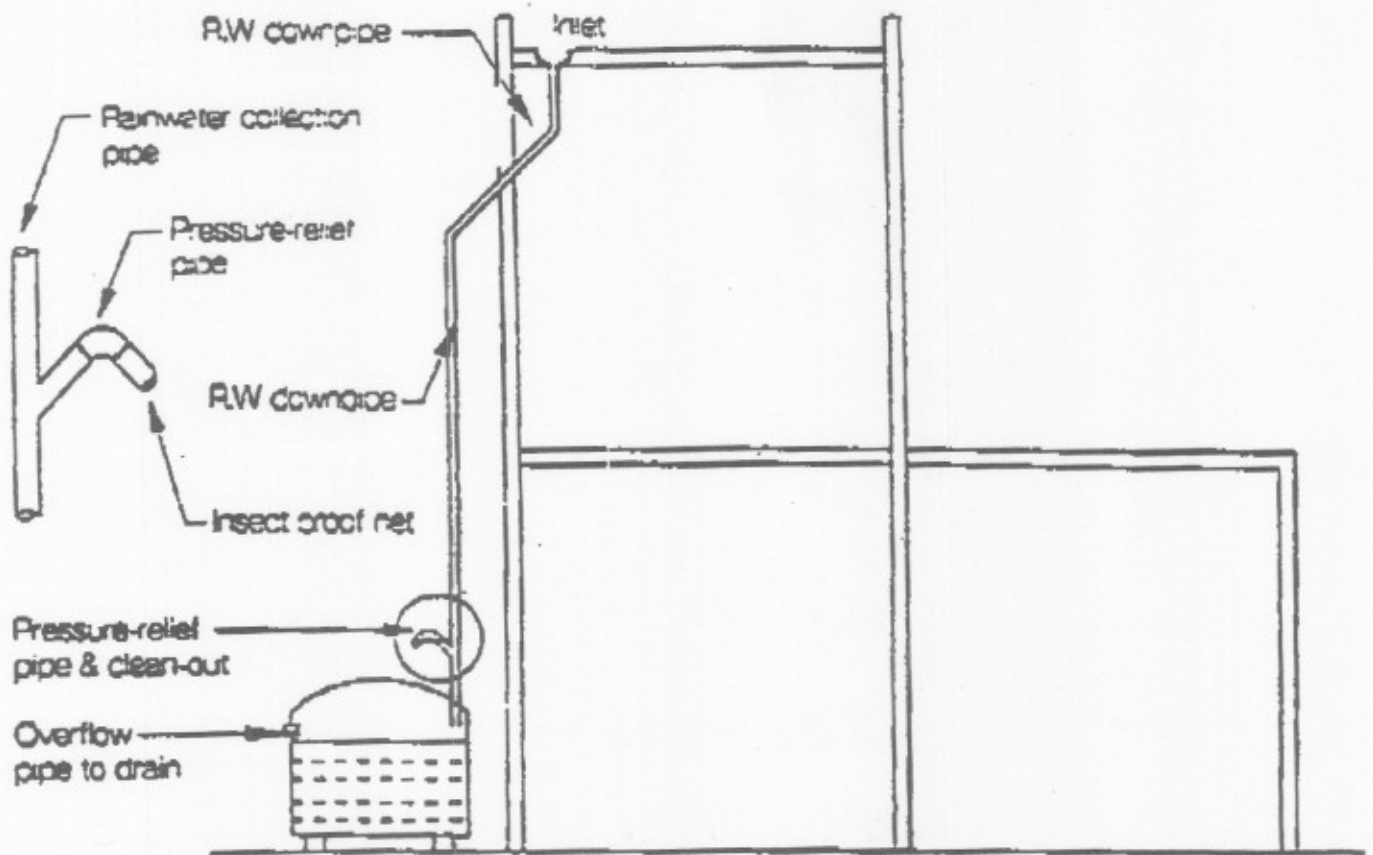
Type A : Using Separation Pipe



Type B : Using Separation Tank



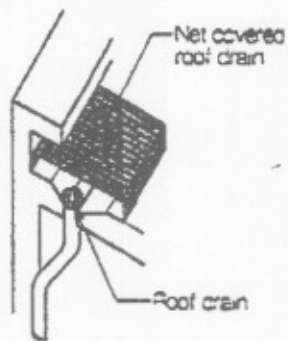
Figure A3



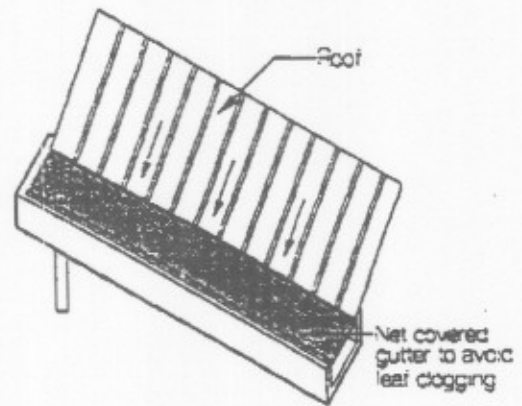
Using overflow pipe & pressure relief pipe



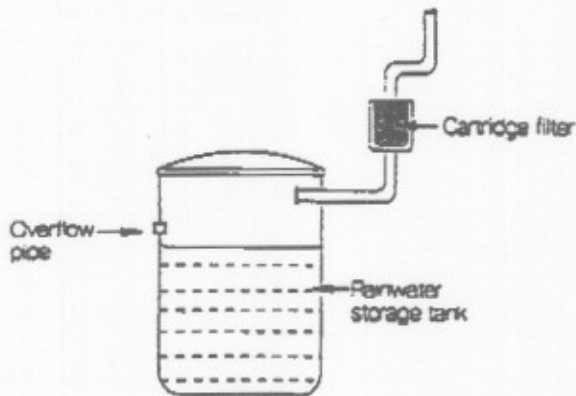
Figure A4



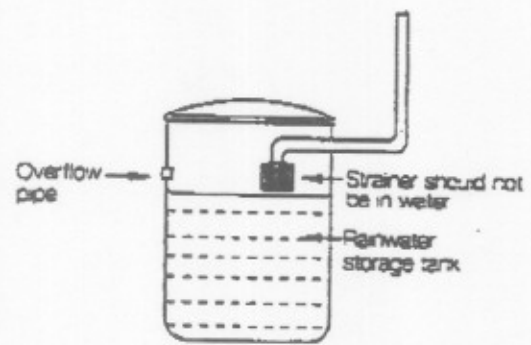
Type A : Net at roof drain



Type B : Net at gutter



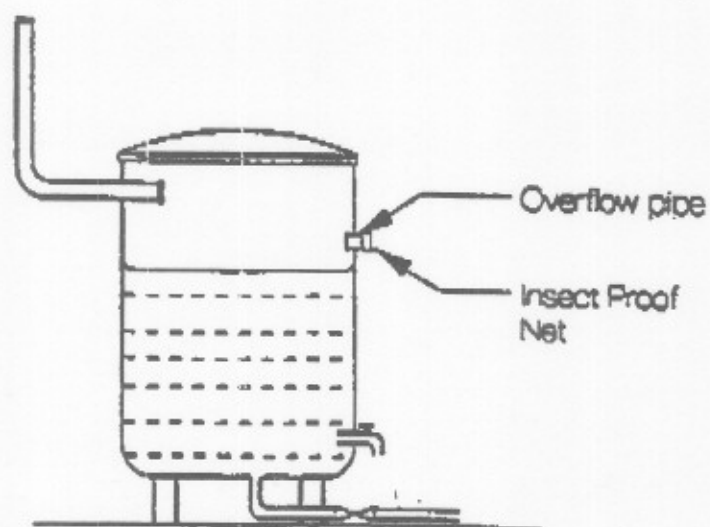
Type C : Filter in rainwater down pipe



Type D : Strainer in rainwater down pipe



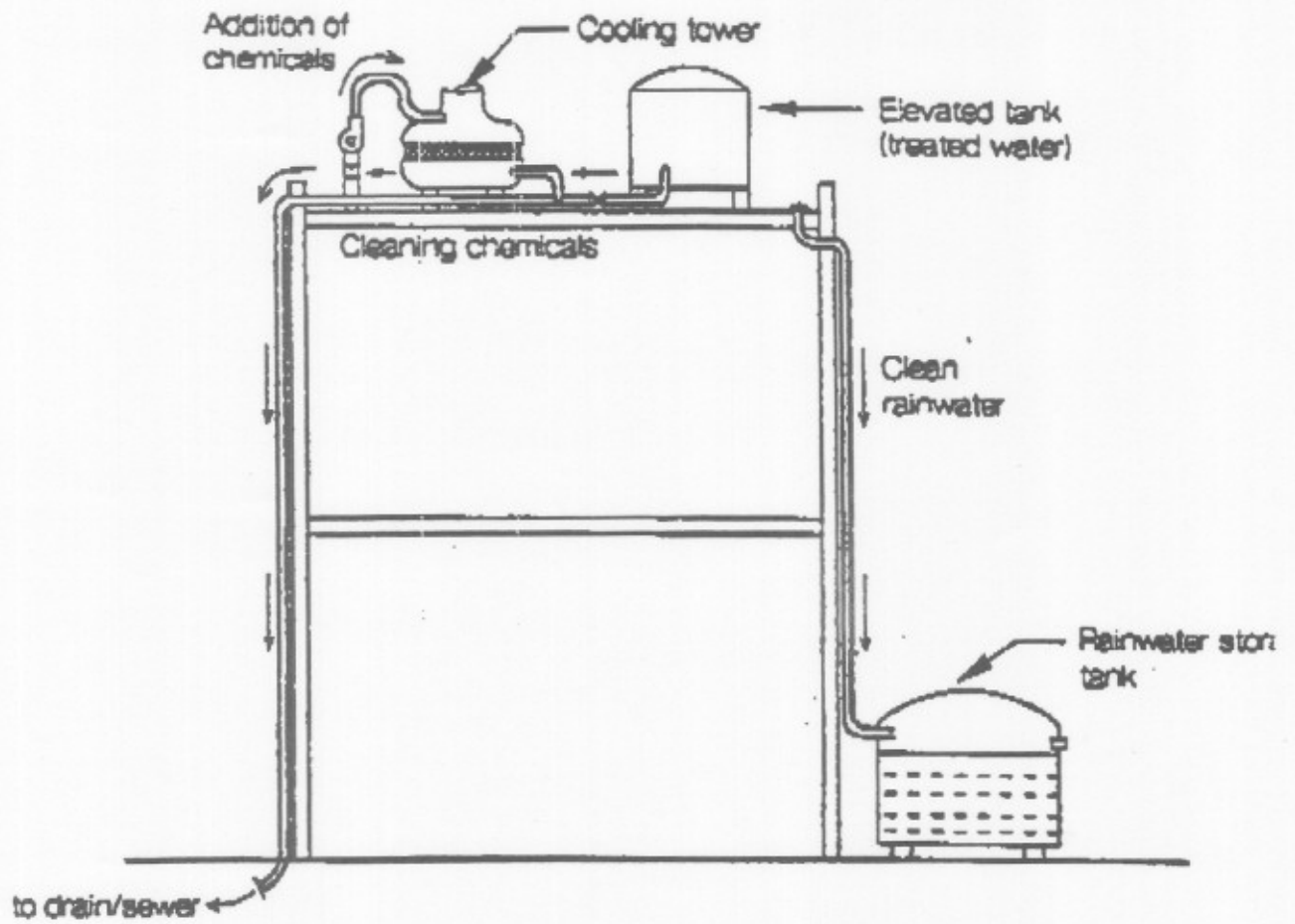
Figure A5



Using Insect Proof Net



Figure A6



Separate downpipe for rainwater collection and discharge from cooling tower and elevated tank



APPENDIX B

GROUND WATER ASSESSMENT

- 1 Introduction
- 2 Geological Setting
- 3 Hydrological Setting
- 4 Proposed Wells For Groundwater Extraction
- 5 Conclusion

TABLE

Table B1 Hydrogeological Information From Piezometers And Wells

FIGURE

Figure B1 Geology Of Putrajaya Lake Catchment

Figure B2 Location Of Groundwater Piezometers And Wells

GROUND WATER ASSESSMENT

1. Introduction

This report summarises the studies carried out under the previous study entitled Catchment Development and Management Plan for Putrajaya Lake, Draft Final Report (Volume 2: Sectoral Report) on the groundwater resources for possible prospective extraction for irrigation purposes, and makes recommendations on the probable quantities of groundwater which can be extracted to cater for the irrigation requirements.

2. Geological Setting

The Catchment area has an undulating topography with low hills rising up to over 100m above the sea level. The alluvium are found in the flat and low-lying areas in Central and Southern part of the catchment. They overlie the Hawthornden and Kenny Hill Formations. The Kenny Hill Formation is found in the West and North West and consists of sandstone and shale which have undergone some degree of regional metamorphism. The Hawthornden Formation occupies about 70% of the area. This unit is made up of metamorphosed rocks i.e. quartz-mica, schist, quartz schist and graphitic schist.

2.1 Structure

The geological environment in and around the catchment is regionally folded along NE-SW axis resulting in the development of broad anticlines and synclines. In addition to folding, the tectonic movement has also resulted in fracturing and the development of joints in the incompetent metamorphosed rocks. In the study the presence of 3 sets of lineaments trending NNE-SSW, NW-SE and NE-SW have been recognised.

3. Hydrological Setting

For the study area the groundwater catchment basin is similar in shape and size to that which has been established for water catchment and is the area demarcated by the basin's watershed boundary. The regional groundwater flow system register flow directions towards low-lying areas i.e. the valleys, rivers, streams and lakes.

3.1 Aquifer in Kenny Hill and Hawthornden Formations

The Kenny Hill and the Hawthornden have suffered regional metamorphism. The primary porosity of the rocks in these formations is low and not significant. The water bearing zones, commonly referred to hard rock aquifer, are related to secondary features such as joints and fractures. Joints and fractures increase the storage capacity and facilitate greater mobility of groundwater. The distribution of the major joints and fractures are shown in Figure B1.

Some characteristics of hard rock aquifer in Sungai Chuau catchment are recorded in two well localities as indicated in Figure B2. The wells, TWC -1 and TWC-2, built to reach depth of 137m and 53m, respectively gave an optimum yield of 16 m³/hour/well (3520 gallons/hour/well). It was noted that the initial discharge rate was higher, 22 m³/hour/well (4840 gallons/hour/well), indicating that the fracture system is local in extent and the aquifer is restrictive.

At the UPM, located in the North-Western end of the catchment, one well constructed to reach a depth of 60m and which intercepted a fractured zone between 42m and 52m below ground surface in the metamorphic rocks, gave an optimum yield of 6 m³ /hour (1320 gallons/hour) and 7 m³/hour (1540 gallons/hour), respectively confirming that the aquifer system in the hard rock is local in extent.

3.2 Aquifer in the Alluvium

The groundwater potential of the alluvium in the catchment has been investigated by GSM (Nazan et al.,1994). Table B1 gives the yield from the 27 piezometers and wells constructed in the alluvium. The alluvium was found to comprise of clay, sand, fine gravel, silt and peat and varies from 4m to 14.3m in thickness. The borehole records show that the coarse sediments (aquifer zone) of sand and gravel generally form the lower layers while finer components of clay and silt constitute the upper parts. Sand and gravel layers are thicker closer to the river, particularly along the flood plains and near the lower reaches of Sungai Chuau. Well sunk in these layers give up to 6.8 m³cubic metres/hour (1500 gallon/hour).

Pumping test analysis conducted by GSM shows transmissivity (T) and storage coefficient (S) of the alluvium aquifer range from 84 to 163 m²/day and 4.8 x 10⁻⁴ to 4.9 x 10⁻³ respectively.

4. Proposed Wells For Groundwater Extraction

The recommendations made for the abstraction of groundwater for irrigation purpose in the Catchment Development and Management Plan for Putrajaya Lake are to build a well field consisting of 6 wells designed to yield a total of 0.5 cusec (10,000 gallons/hour) from the alluvium downstream of the lake so as avoid disturb the hydrological regime of the lake.

It was anticipated that since the volume of water abstracted is small, there would have no implication on downstream water quantity.

5. Conclusion

The quantity of anticipated water abstraction from the proposed wells to be constructed downstream of the lake is small to meet the requirements of the proposed irrigation.

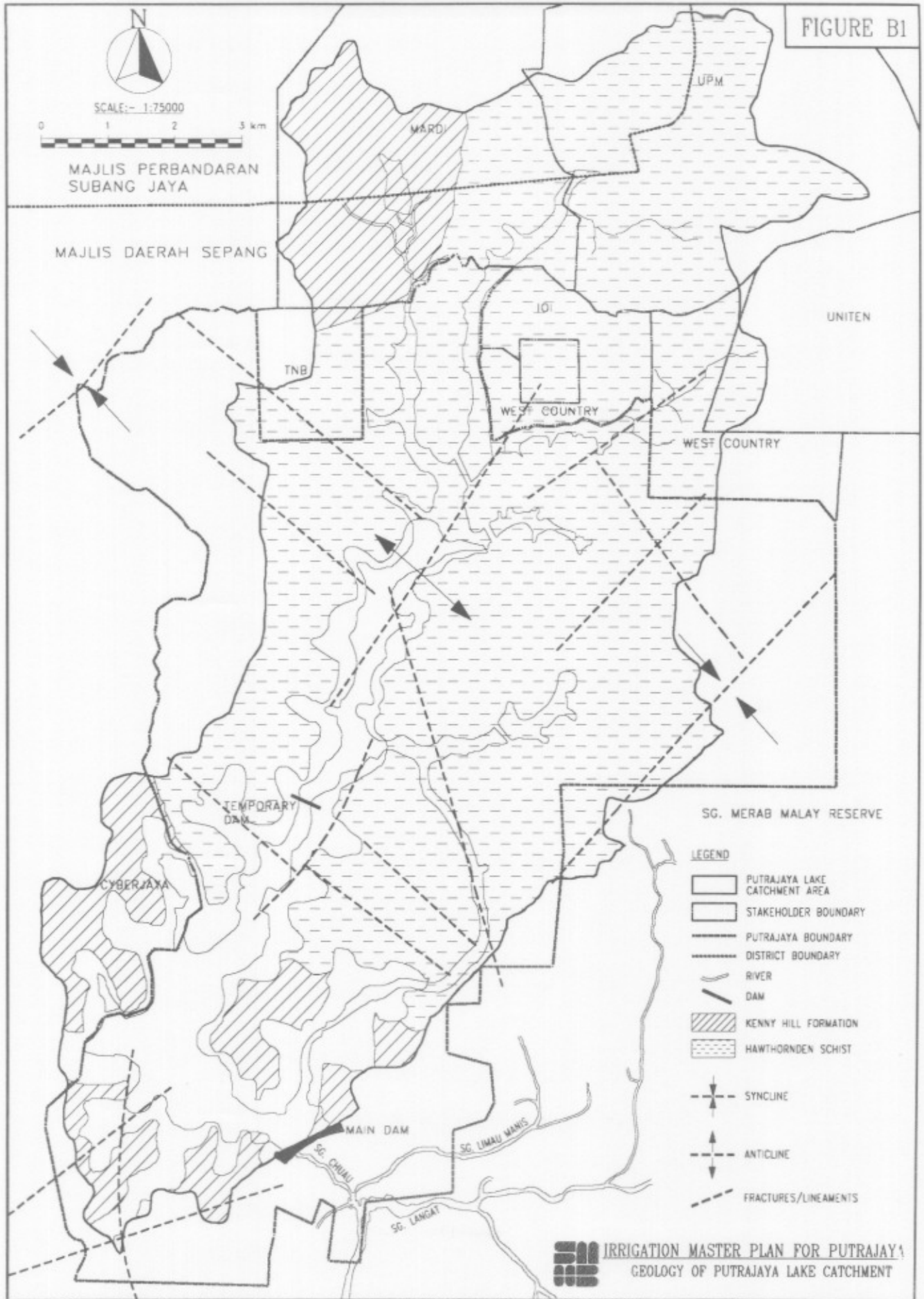
Table B1 Hydrogeological Information From Piezometers And Wells

Ref. No (HPB)	Depth (m)	Alluvium Thickness (m)	Water level (m) (B.G.L)	Yield (m ³ /hour)
1	6	6	0.91	0
2	6	4	2.54	7
3	12	12	1.14	0
4	6	8	0.09	11
5	7	6	0.71	3
6	7	6	1.52	11
7	6	8	1.22	0
8	6	6	0.84	7
9	6	6	1.12	1
10	6	6	0.57	5
11	6	6	0.34	6
12	6	6	0.90	0
13	6	7	6.94	0
14	6	7	3.0	0
15	6	14.3	0.70	6
16	6	9	4.80	4.8
17	6	10.5	5.5	0
18	6	19.2	3.0	4
19	6	8	3.44	0
20	6	6.5	1.14	0
21	6	12	7.17	0
22	6	18.45	0.93	1
23	6	6.5	0.45	0
24	6	12.0	0.89	4
25	6	9	1.52	10
26	3	3.02	0.32	0
27	6	9	3.0	0
TWC 1	137	-	15.3	16
TWC 2	53	-	10.5	16
UPM	60	-	7.4	7

Mohd Nazan et al 1994

Note : B.G.L - Below Ground Level

FIGURE B1

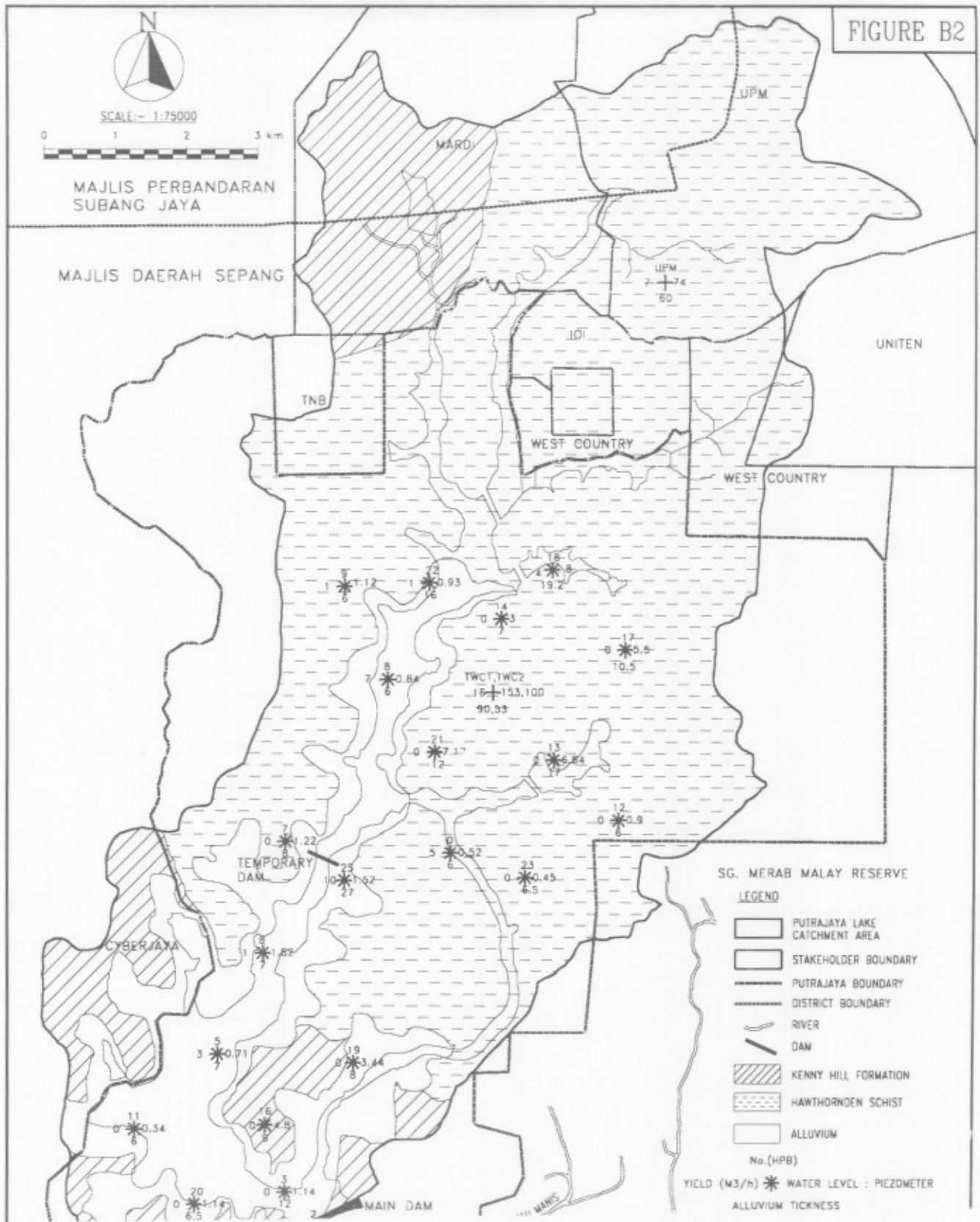


LEGEND

- PUTRAJAYA LAKE CATCHMENT AREA
- STAKEHOLDER BOUNDARY
- PUTRAJAYA BOUNDARY
- DISTRICT BOUNDARY
- RIVER
- DAM
- KENNY HILL FORMATION
- HAWTHORNDEN SCHIST
- SYNCLINE
- ANTICLINE
- FRACTURES/LINEAMENTS

IRRIGATION MASTER PLAN FOR PUTRAJAYA
GEOLOGY OF PUTRAJAYA LAKE CATCHMENT

FIGURE B2



APPENDIX C

WATER QUALITY ASSESSMENT

- 1 Introduction
- 2 Sources Of Water For Irrigation

TABLE

- | | |
|----------|--|
| Table C1 | Variation Of The Mean Water Quality Parameters Throughout Different Phases Of Lake Development And Monitoring |
| Table C2 | Averaged Water Quality Indices (WQI) In Various Compartments Of The Putrajaya Lake (January 1999-October 1999) |
| Table C3 | Sewage Effluent Monitoring Results |
| Table C4 | Results Of The Effluent Grab Sample |
| Table C5 | Water Quality Of A Grab Sample From Sg. Langat |
| Table C6 | Water Quality Of A Grab Samples From The Pond |

FIGURE

- | | |
|-----------|--|
| Figure C1 | Sampling Points in The Putrajaya Lake (Phase 1A) |
|-----------|--|

APPENDIX

APPENDIX C1

WATER QUALITY ASSESSMENT

1. Introduction

The Putrajaya Lake has been divided into seven sub-catchments namely the upper-west (UW) arm, upper-north (UN) arm, upper-east (UE) arm, lower-east (LE) arm, Sg. Bisa (B) arm, central wetlands (C) and primary lake (P). With the exception of the primary lake, the rest of the catchments are artificial wetlands which have been constructed to improve the lake water quality. The water quality is being monitored monthly at the inlet and outlet of the cells, as shown in Figure C1. The data is assessed in terms of compliance with the Putrajaya Lake Ambient Water Quality Standard. Secondly, the measurements for pH, total suspended solids (TSS), ammoniacal nitrogen (AN), dissolved oxygen (DO), chemical oxygen demand (COD) and biochemical oxygen demand (BOD) are translated into water quality indices (WQI), to indicate the most appropriate class of water usage as outlined in the Proposed Interim Water Quality Standards (INWQS).

1.1 Discussion on the Mean Water Quality Parameters

The water quality monitoring has been conducted throughout the various development phases of the artificial wetland. Table C1 shows the averaged values of the water quality parameters for all the cells within the Putrajaya Lake according to the phases of lake development. The variation in pollutant loadings from the seven catchment arms into the lake is given in Appendix C1.

The water in the Putrajaya Lake was found to be slightly acidic during the pre-construction phase. The values gradually increased to be within the neutral range of pH 7.0 during the early monitoring period. Subsequently, the values decreased to 6.1 in the late monitoring and maintenance period, below the stipulated range of 6.5-9.0. The turbidity and total suspended solids (TSS) parameters are indicators of siltation and sediment pollution due to land development activities. Table C1 shows that the concentrations of these two parameters were the highest during the construction of the artificial wetlands, with mean values of 696.5 FTU and 510 mg/L respectively. However, both parameters decreased consistently upon cessation of construction works, as indicated in the late monitoring results whereby they are below the standard limits of 50 FTU and 50 mg/L for turbidity and total suspended solids respectively.

The measurement for conductivity refers to the ability of water to conduct electricity due to the presence of ions in the water. The mean conductivity in the lake reached the maximum value of 107 $\mu\text{mhos/cm}$ just after the construction phase. Nevertheless, the value is still very much below the 1,000 $\mu\text{mhos/cm}$ limit of the Putrajaya Lake ambient water quality standard. Subsequently, the conductivity in the lake decreased to 89.7 $\mu\text{mhos/cm}$, as revealed in the monitoring results for the month of October 1999. However, the baseline conductivity value for the Putrajaya Lake could not be established since no measurements were made during the pre-construction phase.

The concentration limit for ammoniacal nitrogen in the lake is 0.3 mg/L. During the late construction phase, the concentration of ammoniacal nitrogen has increased to a maximum level of 1.0 mg/L. As seen in Table C1, the concentration of ammoniacal nitrogen gradually decreased to be 0.51 mg/L in the month of October 1999 which is slightly higher than the stipulated limit of 0.3 mg/L. Ammoniacal nitrogen is an indicator for sewage pollution and its concentration in the seven catchment arms within the Putrajaya lake have exceeded the 0.3 mg/L limit (see Appendix C1). Another parameter that is commonly used to detect the presence of sewage in the water is faecal coliform. *E. coli* is a predominant member of this group which is present in the excreta of warm-blooded animals. A mean value of 1,829 MPN/100 mL has already been observed during the pre-construction phase. The pathogens could probably have entered the lake from the tributaries of Sg. Chuau. The concentrations of faecal coliform in the Putrajaya Lake have always exceeded the limit of 100 MPN/100 mL stipulated in the Putrajaya Lake Ambient Water Quality Standard throughout the entire construction and monitoring period. As seen in Appendix C1, the average population counts of faecal coliform from the seven catchment arms were found to be high.

The concentrations of nitrate ($\text{NO}_3\text{-N}$) in the Putrajaya Lake so-far have been found to be below the stipulated limit of 7 mg/L. Table C1 shows that the values tend to vary throughout the various stages of lake development, with the highest measurement of 4.37 mg/L being recorded in the early monitoring period.

Phosphate is also included as one of the water quality monitoring parameters since it is a nutrient capable of causing algal blooms and eutrophication in still waters. As seen in Table C1, the mean concentrations of phosphate throughout the artificial wetland development have been found to be generally below the stipulated limit of 0.05 mg/L, except during the heavy construction period where the phosphate level reached 0.156 mg/L. The source of

phosphorus could be due to the natural weathering of rocks that are exposed during earthworks and construction activities. The latest results in the month of October 1999 showed phosphate level to be at 0.01 mg/L, indicating minimal nutrient input from urban runoff or landscaped areas in Putrajaya.

Monovalent and divalent cations such as potassium, magnesium, iron, mercury and lead are also included in the monthly monitoring programme. The mean concentrations of these ions do not indicate any distinctive trend of variation throughout lake development. There are no limits in the Putrajaya Lake Ambient Water Quality Standard for potassium and magnesium. Nevertheless, the concentration limit for iron is set at 1 mg/L, where this value has often been exceeded during the construction phase. The presence of iron in water is common since the metal is readily available in the soil. However, the concentrations of iron have gradually decreased upon cessation of construction activities, with the latest mean concentration of 0.16 mg/L in October 1999.

As for toxic heavy metals such as mercury and lead, the limits have been set at 0.0001 mg/L and 0.05 mg/L respectively. The concentrations of mercury in the Putrajaya Lake have been observed to be consistent, either at 0.001 or 0.002 mg/L. The highest concentration of lead at 0.11 mg/L was observed during the construction phase, after which the values were all below the 0.05 mg/L limit.

The dissolved oxygen level in the Putrajaya Lake was found to be satisfactory, with mean concentration values to be within the stipulated range of 5-7 mg/L. The presence of refractory organics in the lake waters is indicated by the chemical oxygen demand (COD), whose limit of 25 mg/L has not been surpassed so far throughout the different phases of artificial wetland development. Conversely, the biochemical oxygen demand (BOD) which measures the amount of oxygen consumed during microbial utilization of organics has a stipulated limit of 3 mg/L. As seen in Table C1, this limit has only been exceeded during the construction phase, whereby the values were within the range of 3.2-5.9 mg/L. Nonetheless, the condition in the lake has improved, with the latest concentration of 2.0 mg/L being recorded in October 1999.

Conclusion

The lake water quality was affected during the construction of the artificial wetlands. The parameters which have exceeded their respective limits include turbidity, total suspended

solids, ammoniacal nitrogen, faecal coliform, phosphate, iron, lead and biochemical oxygen demand. The cessation of construction works have led to the gradual recovery and improvement in the lake water quality.

There is a growing concern on the presence of faecal coliform, whose concentrations in all the seven catchment arms were found to be higher than the stipulated limit of 100 MPN/100 mL. As such, pretreatment of the irrigation water using standard disinfection techniques is recommended to reduce bacterial populations substantially and to minimise the risk of pathogenic infection to the surrounding population during spray irrigation.

1.2 Water Quality Assessment using the Water Quality Indices (WQI)

As part of this study, the WQI for all cells have been estimated to further confirm the water quality status of the lake (see Table C2). Based upon the monitoring results from January-October 1999, the averaged WQI values have been estimated to be between the Class II range of 76.5-92.7. Hence, this class is considered to be representative of the Putrajaya Lake. The Class II status applies for good quality water, suitable to be used for water supply, sustaining recreational activities and protection of sensitive aquatic species. Appendix C2 shows the WQI estimated for the seven subcatchments with respect to the different phases of lake development.

Conclusion

The WQI of the Putrajaya Lake has been observed to be generally within Class II, except during the construction phase where the water quality deteriorated to Class III standard. Upon completion of the construction phase, the lake reverted back to Class II standard which is higher than the Class IV standard specified for irrigation under the Proposed Interim National Water Quality Standards (INWQS). Hence, water from the lake is suitable to be used for irrigation.

2. Sources of Water for Irrigation

It is the intention of this study to explore the various sources of water that are available within Putrajaya for irrigation. The quality of water afforded by these alternatives is compared against the limits stipulated in the Environmental Quality (Sewage and Industrial Effluents) Regulations 1979 (SIER), Environmental Quality (Perbadanan Putrajaya) (Water Pollution Control) Regulations 1998 and Proposed Interim National Water Quality Standards (INWQS). In addition, the study will also forward appropriate recommendations to safeguard public health during irrigation.

Groundwater

Based on the previous studies by the Geological Survey Department (GSM) in 1994, the pH values of the groundwater in the Putrajaya Lake catchment area generally fell within the range of 6.1-7.3. According to the Catchment Development and Management Plan for Putrajaya Lake,¹ the concentrations of nitrate, sulphate and ammonia were found to be below their respective detection limits in all boreholes. The groundwater samples also registered trace amounts of heavy metals.

Groundwater samples from the hard rock strata showed higher concentrations of bicarbonate when compared to those taken from the alluvium areas. Excessive amounts of bicarbonate in the irrigation water can impact adversely on the irrigation equipment (e.g., formation of scales) and crop foliage (i.e., white precipitate of carbonates). An excessive amount of bicarbonate is normally indicated by pH of more than 8.3. Prolonged use of such water can be detrimental to plant growth due to the limitation of ion uptake.

Sewage Effluent

Presently, there is a sewage treatment plant which is located near to the Gate 1 of the Federal Administrative Center of Putrajaya. The quality of the sewage effluent is currently being monitored by its contractor, Syarikat Pembinaan Jayabumi Sdn. Bhd. Results of the monitoring which is conducted twice every month are given in Table C3.

The pH values have been observed to fall within the stipulated range of 6.0-9.0, which makes the water suitable for irrigation. Acidic irrigation water with pH less than 5 can lead to the mobilisation of various ions in the upper soil profile in concentrations toxic to plant growth.

Alkaline water having pH higher than 9.0 may reduce the availability of trace elements, causing nutrient imbalance to the plants.

In general, the effluent complies with the Standard A of the Environmental Quality (Sewage and Industrial Effluents) Regulations 1979 (SIER) prior to being discharged into Sg. Air Hitam. Apart from the monitoring results in Table C3, a grab sample was taken from the outlet of the sewage treatment plant on the 28 April 2000. A comprehensive analysis of the grab sample was carried out to include parameters listed in the Standard A schedule together with ammoniacal nitrogen and *E. coli* parameters. The quality of the grab sample is given in Table 4.

The concentration of manganese (i.e., 1.14 mg/L) and iron (i.e., 1.23 mg/L) were found to have exceeded their respective limits of 0.20 mg/L and 1.0 mg/L respectively. At concentration above 1.5 mg/L, the dissolved iron and manganese ions may precipitate as the water travels along the irrigation lines, gradually clogging irrigation equipments (trickle or drippers) and causing light-brown spots on the plants. Hence, the treatment would involve accelerating their rate of oxidation to insoluble forms during storage in order to facilitate their removal by filtration before the water can be delivered into the distribution lines. The options to be considered include the usage of chemical/sequestering agents such as permanganate, sodium silicates, phosphates, polyphosphates or installation of aerators. The selection of the most feasible option will obviously have to depend on the capital/operating cost as well as from the perspectives of technical feasibility. No treatment however, has been proposed for the removal of ammoniacal nitrogen although its concentration exceeded the Putrajaya Effluent standard limit of 1 mg/L.

Table C4 indicates the absence of *E. coli* in the grab sample. It is therefore recommended for additional sampling to be carried out during the operational phase of the treatment plant to reflect the actual quality of discharge. It is recommended that the effluent be disinfected to minimise the risk of disease transmission during spraying.

River water of Sg. Chuau/Sg. Langat

The Putrajaya Lake drains into Sg. Chuau before proceeding southwards to join Sg. Langat. Reference made from secondary data² has shown the water quality at station 2917608 which is located at the upper reaches of Sg. Chuau to be within Class II in 1995. As the river goes into the lake and flows downstream, water quality of Class II category was also noted at

station 2916603. However, the water quality at the confluence of Sg. Chuau and Sg. Langat was found to be at Class III. The deterioration in water quality could be attributed to pollution in Sg. Langat by agricultural runoff, industrial and domestic waste discharges.

In order to determine the water quality in Sg. Langat, a grab sample was taken on February 1999 near Kg. Simpang Empat, approximately 3.4 km upstream of the confluence between Sg. Langat and Sg. Chuau. Results of the water quality assessment are given in Table C5.

The results in Table C5 revealed high concentrations of iron, total coliform and *E. coli*. These parameters have surpassed their respective Class IV limits stipulated for irrigation under the Proposed Interim Water Quality Standards. The high concentration of iron in the river water necessitates its removal as it may precipitate and clog the irrigation equipment in a long run. Additionally, the river water should also be disinfected to prevent transmission of water-borne diseases caused by the *E. coli* bacteria during spraying or sprinkling.

Mining Pond

The study also considered the possibility of abstracting water from an ex-mining pond at Precinct 20 which is located near to the Taman Selatan in Dengkil. Two grab samples have been taken from the pond for water quality analysis. The results are given in Table C6.

The pH values in grab samples P1 and P2 measured only 2.5, indicating the pond water to be highly acidic. The concentrations of iron and manganese at the two sampling stations were found to be higher than the Class IV limits of the Proposed Interim Water Quality Standards for irrigation water. These two ions could probably have attributed to the appearance of the dark-coloured (black) water in the pond. Hence, it is likely that water from the pond will clog up the irrigation system and damage plant foliage in a long run, making it unsuitable to be used for irrigation. As for the rest of the heavy metals such as cadmium, lead, chromium (trivalent), copper, nickel, zinc and phenol, they were found to be present at trace concentrations in the pond. The ex-mining pond will eventually be filled in order for the area to be developed as a cemetery in the near future.

REFERENCES

1. Perbadanan Putrajaya. Catchment Development and Management Plan for Putrajaya Lake. (December 1999).
2. Economic Planning Unit. National Water Resources Study, 2000-2050.
3. National Water Quality Management Strategy. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Agricultural water use-Rationale and detailed discussions. July 1999.

Table C1 : Variation of the Mean Water Quality Parameters throughout Different Phases of Lake Development and Monitoring

Development Phase	Monitoring Perimeter															
	pH (unitless)	Turbidity (FTU)	TSS (mg/L)	Conductivity (µmhos/cm)	NH ₄ -N ₂ (mg/L)	NO ₃ -N (mg/L)	P (mg/L)	K (mg/L)	Mg (mg/L)	Fe (mg/L)	Hg (mg/L)	Pb (mg/L)	D.O. (mg/L)	COD (mg/L)	BOD (mg/L)	Faecal Coliform (MPN/100 mL)
Pre-construction*	6.3	12.7	20.4	Not sampled	0.3	1.80	0.02	Not sampled	Not sampled	1.10	0.001	0.04	7.2	5.1	0.8	1,829
Early construction* (3/97-5/97)	6.5	200.1	73.9	45.2	0.43	1.18	0.03	1.69	0.86	1.10	0.001	0.06	5.4	9.3	3.2	759
Heavy construction* (6/97-8/97)	6.8	360.3	235.4	83.4	0.88	1.62	0.156	3.45	1.45	1.74	0.001	0.11	4.4	22.2	5.9	4,093
Late construction* (9/97-3/98)	7.3	696.5	510.0	97.9	1.00	1.66	0.036	3.36	1.42	2.05	0.002	0.04	6.5	10.1	4.1	9,856
Early monitoring (4/98-9/98)	7.0	282.2	226.2	107.1	0.47	4.37	0.012	2.13	0.47	0.17	0.001	0.02	6.0	6.9	2.2	2,707
Middle monitoring (10/98-3/99)	6.5	69.9	27.2	100.0	0.29	1.52	0.011	1.93	0.62	0.04	0.001	0.01	6.0	9.0	3.3	1,215
Late monitoring (4/99-9/99)	6.1	15.2	15.6	87.7	0.29	1.35	0.03	1.79	0.16	0.02	0.001	0.02	6.3	8.9	2.2	15,755
Maintenance (from 10/99)	6.1	24.0	15.1	89.7	0.51	2.83	0.01	2.92	1.41	0.16	0.001	0.01	6.2	4.5	2.0	5,853
Putrajaya Lake Water Quality Standard	6.5-9.0	50	50	1,000	0.3	7.0	0.05	Not Available	Not Available	1.0	0.0001	0.05	5-7	25	3	100

* in relation to the construction of artificial wetlands

Source : Perbadanan Putrajaya, 1999

Table C2: Averaged Water Quality Indices (WQI) in Various Compartments of The Putrajaya Lake (January 1999 - October 1999)

Location	Jan-99	Feb-99	Mac 1999	Apr-99	May-99	Jun-99	Jul-99	Aug-99	Sep-99	Oct-99
<u>Upper-west Arm (UW)</u>										
UW8I	83.1	75.7	89.7	83.7	78	78.5	75.4	84	82.1	81.9
UW8O	85.7	82.2	72.9	85.6	86.5	86.7	73.5	82	84.5	85.5
UW7I	88.7	90.5	89.6	87.9	90.4	85.7	84.5	89	86.5	83.5
UW7O	82.7	88.6	84.8	87.1	85	86.7	82.3	89	86.9	84.5
UW5I	88.8	84.1	82.4	83.2	74.4	79.4	80.7	89	87.6	83.1
UW5O	87.2	84.6	83.1	88.5	87.5	87.6	84.3	88	88.6	86.4
UW4O	87.7	85.8	90.1	86.5	89.2	87.4	87.4	90	86.3	87.5
UW3O	88.4	87.4	85.4	82.9	87.5	85.7	84.1	92	88.9	88.3
UW2O	91	89.4	83.9	87.6	86	90.1	86.4	90	89.2	87.9
UW1O	92.2	86.8	78	85.6	89	90.7	88.7	89	90.2	89
AVERAGE	87.6 (II)	85.5 (II)	84.0 (II)	85.9 (II)	85.3 (II)	85.9 (II)	82.7 (II)	88.2 (II)	87.08 (II)	85.8 (II)

Location	Jan-99	Feb-99	Mac 1999	Apr-99	May-99	Jun-99	Jul-99	Aug-99	Sep-99	Oct-99
<u>Upper-north Arm (UN)</u>										
UN8I	83.6	81.1	76.3	82.9	81.9	82.1	82.3	81	78	84
UN8O	84.1	83.2	80.5	84.8	87.6	75	81.7	86	78.5	85.1
UN7O	85.6	85.9	81.3	82.4	87.3	83	85.5	88	83.5	85.5
UN6I	86.3	84.4	82.2	83.1	85.9	84.6	86.7	86	85.1	85
UN6O	88.5	88.5	82.5	84.5	85.9	87	86.4	88	87.9	78.3
UN5O	87.8	85.9	81.1	86.8	87.5	82.9	87	92	90.8	82.3
UN4O	93.2	88	78.2	82.7	86.3	86.1	85.7	91	88.9	85.4
UN3O	84.1	88.6	83.3	86.5	83.6	85.2	85.9	88	90	87
UN2O	89.7	88.7	87.4	88.7	86.8	88.5	85.3	90	90	88
UN1O	86.7	86.4	87.1	86.7	85.2	85.8	85.3	89	92	86.1
AVERAGE	87.0 (II)	86.1 (II)	82.0 (II)	84.9 (II)	85.8 (II)	84.0 (II)	85.2 (II)	87.9 (II)	86.47 (II)	84.7 (II)

Con't...

Location	Jan-99	Feb-99	Mac 1999	Apr-99	May-99	Jun-99	Jul-99	Aug-99	Sep-99	Oct-99
<u>Upper-east Arm</u>										
(UE)										
UE3I	84	88.1	83.2	84.7	82.8	85.2	83.7	87	89.1	79.4
UE3O	85.1	86.8	81.5	84.8	85.1	86.4	86.9	91	91.7	80.9
UE2O	90.3	88.1	83.2	84.7	87.4	86.4	85.9	90	90.5	81.8
UE1O	87.2	88.3	86.5	87.2	87.8	86.9	84.7	91	88.1	86
AVERAGE	86.7 (II)	87.8 (II)	83.6 (II)	85.4 (II)	85.8 (II)	86.2 (II)	85.3 (II)	89.8 (II)	89.85 (II)	82.0 (II)

<u>Lower-east Arm</u>										
(LE)										
LE2I	84.4	84.7	75.6	84.2	82.7	86.8	86.5	90	83.7	81.6
LE2O	86.2	84.2	81.8	84.2	88.3	84.2	84.7	90	89.7	86.8
LE1O	87	82.9	83.6	86.3	89.2	87.8	85.5	90	89.5	89.3
AVERAGE	85.9 (II)	84.0 (II)	80.3 (II)	85.0 (II)	86.7 (II)	86.3 (II)	85.6 (II)	90.0 (II)	87.63 (II)	85.9 (II)

<u>Bisa Arm (B)</u>										
UB(2I)	77.8	84.4	88.8	87.7	87.7	92	85.6	91	92.6	88.1
UB(2O)	83.5	84.1	90.6	86.2	86.6	86.8	87.8	90	89.8	87.2
UB(1O)	88.8	87.9	89.3	90.3	88.4	88.3	88.6	89	88.6	88.7
AVERAGE	83.4 (II)	85.5 (II)	89.6 (II)	88.1 (II)	87.6 (II)	89.0 (II)	87.3 (II)	90.0 (II)	90.33 (II)	88.0 (II)

<u>Central Wetlands</u>										
C(P1)	87	86.5	88.1	87	86.9	87	86	92	88.3	86.1
C(P2)	88.7	89.4	87.5	87.7	89.5	88.9	87.9	88	88.4	86.9
C(P3)	-	86.2	89	87.2	89.8	87.2	86.8	92	92	89.1
C(P4)	-	89.7	90	86.8	89.9	88.5	86.6	89	88.7	88.9
AVERAGE	87.9 (II)	88.0 (II)	88.7 (II)	87.2 (II)	89.0 (II)	87.9 (II)	86.8 (II)	90.3 (II)	89.35 (II)	87.8 (II)

Con't...

Primary Lake										
P(P1)	86.6	92.2	89.3	88.9	89.2	89.5	87.7	89	90.4	89.4
P(P2)	86.6	91.7	89.2	86.9	91.3	87	89.1	90	90.7	90.3
P(P3)	85.1	90.9	88.9	82.6	87.8	88.4	87.2	89	91.8	87.6
P(P4)	-	87.1	90.1	87.6	92.2	88.4	89.4	90	90.3	89.7
AVERAGE	86.1 (II)	90.5 (II)	89.4 (II)	86.5 (II)	90.1 (II)	88.3 (II)	88.4 (II)	89.5 (II)	90.8 (II)	89.3 (II)

I-Denotes the inlet point to the cell

O-Denotes the outlet point of the cell

Source : Perbadanan Putrajaya, 1999

Table C3 : Sewage Effluent Monitoring Results

Parameter	14.9.99	29.9.99	7.10.99	22.10.99	9.11.99	22.11.99	8.12.99	21.12.99	5.1.00	24.1.00	10.2.00	21.2.00	Std. A
pH	7.8	7.5	7.2	7.3	6.5	7.4	6.8	7.3	7.6	7.2	7.2	7.4	6.0-9.0
BOD ₅	N.D.	3	N.D.	3	3	2	3	5	1	2	1	N.D.	20
COD	N.D.	6	N.D.	5	5	4	16	6	2	5	4	N.D.	50
TSS	10	18	12	14	14	12	28	16	10	12	24	16	50
Oil & grease	N.D.	N.D.	1	1	N.D.	N.D.	2	1	N.D.	N.D.	2	1	N.D.
Ammoniacal nitrogen	N.D.	N.D.	0.97	0.94	0.47	0.94	N.D.	1.41	1.88	1.91	8.57	N.D.	-

N.D.-Not detected

Source : Syarikat Pembinaan Jayabumi Sdn. Bhd., 2000

Table C4: Results of the Effluent Grab Sample

Parameter	Result	Standard A	Effluent Limit**
pH	7.2	6.0-9.0	6.0-9.0
BOD ₅ , mg/L	3	20	10
COD, mg/L	6	50	30
Total Suspended Solids, mg/L	18	50	50
Mercury, mg/L	ND	0.005	0.001
Cadmium, mg/L	ND	0.01	0.01
Chromium (hexavalent), mg/L	ND	0.05	0.05
Arsenic, mg/L	ND	0.05	0.05
Cyanide, mg/L	ND	0.05	0.02
Lead, mg/L	ND	0.10	0.05
Chromium (trivalent), mg/L	ND	0.20	0.20
Copper, mg/L	ND	0.20	0.10
Manganese, mg/L	1.14*	0.20	0.20
Nickel, mg/L	ND	0.20	0.20
Tin, mg/L	ND	0.20	0.20
Zinc, mg/L	0.03	1	1
Boron, mg/L	ND	1	1
Iron, mg/L	1.23*	1	1
Phenol, mg/L	ND	0.001	0.001
Free chlorine, mg/L	0.02	1	1
Sulphide, mg/L	ND	0.50	0.50
Oil & grease, mg/L	1	ND	ND
Ammoniacal nitrogen, mg/L	1.91	-	1
<i>E. coli</i> , MPN/100 mL	ND	-	2,000

*- Exceeded all limits

** - Environmental Quality (Perbadanan Putrajaya) (Water Pollution Control) Regulations, 1998
(Effluent Standard for discharge onto land).

N.D.-Not detected

Source : Consolidated Laboratory (M) Sdn. Bhd., 2000

Table C5: Water Quality of a Grab Sample from Sg. Langat

Parameter	Grab Sample	Class IV Limit
Ammoniacal nitrogen, mg/L	0.43	2.7
Biochemical oxygen demand, mg/L	6.2	12
Chemical oxygen demand, mg/L	15.6	100
Chloride, mg/L	11.4	80
Nitrate, mg/L	0.45	5
Iron, mg/L	16.8	1.0
Manganese, mg/L	0.11	0.2
Mercury, mg/L	0.001	0.002
Cadmium, mg/L	0.002	0.01
Arsenic, mg/L	0.005	0.10
Cyanide, mg/L	0.01	-
Lead, mg/L	<0.04	5
Zinc, mg/L	0.04	2
Orthophosphate, mg/L	<0.01	-
Oil and grease, mg/L	<0.1	-
Total coliform, MPN/100 mL	300,000	50,000
<i>E. coli</i> , MPN/100 mL	17,000	5,000

Note : Parameters which exceeded the Class IV limits are indicated in bold.

Source : Permulab Sdn. Bhd., 1999

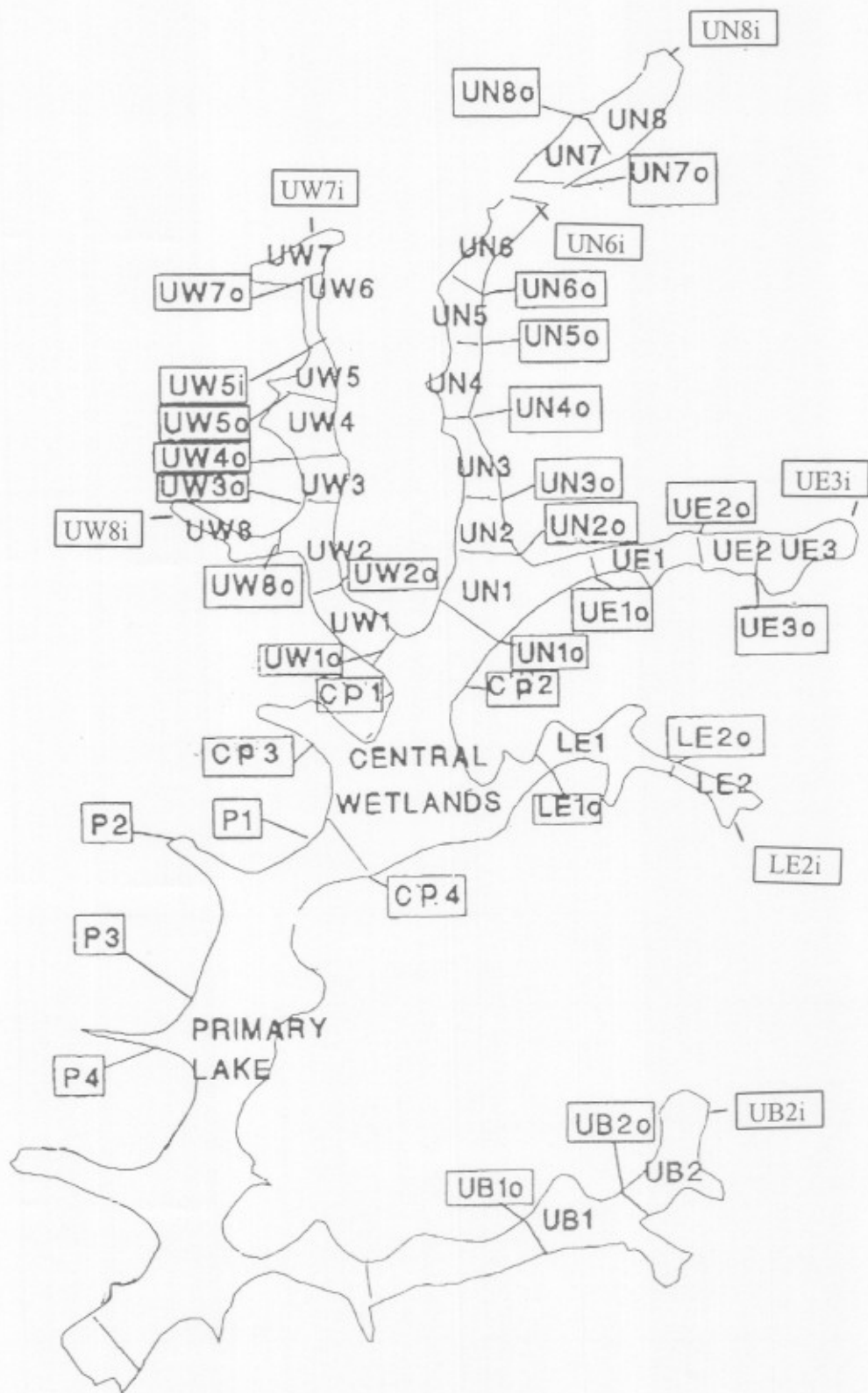
Table C6 : Water Quality of Grab Samples from the Pond

Parameter	P1	P2
PH	2.5	2.5
BOD, mg/L	2	2
COD, mg/L	13	10
TSS, mg/L	16	20
Mercury, mg/L	ND	ND
Cadmium, mg/L	0.018	0.018
Chromium (Hexavalent), mg/L	ND	ND
Arsenic, mg/L	ND	ND
Cyanide, mg/L	ND	ND
Lead, mg/L	0.04	0.04
Chromium (Trivalent), mg/L	0.03	0.05
Copper, mg/L	0.80	0.78
Manganese, mg/L	3.25	3.15
Nickel, mg/L	0.23	0.20
Tin, mg/L	ND	ND
Zinc, mg/L	1.68	1.59
Boron, mg/L	ND	ND
Iron, mg/L	98.26	97.80
Phenol, mg/L	0.012	0.005
Free Chlorine, mg/L	ND	ND
Sulphide, mg/L	ND	ND
Oil and grease, mg/L	ND	ND

ND-Not Detected

Source : PAG Consult Sdn. Bhd., 1998

Figure C1



IRRIGATION MASTER PLAN FOR PUTRAJAYA
SAMPLING POINTS IN THE PUTRAJAYA LAKE (PHASE 1A)

APPENDIX C1

pH

SE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
n	6.6	6.5	6.0	6.5	5.7	6.5	6.5	6.3
ion*	6.7	6.7	6.2	6.3	6.5	6.6	-	6.5
ation*	7.4	6.8	6.2	6.3	6.5	7.6	6.7	6.8
on*	7.4	7.8	7.1	7.1	7.2	7.4	7.3	7.3
ig	6.9	7.0	6.8	6.7	7.2	7.1	7.3	7.0
ing	6.4	6.6	6.3	6.5	6.8	6.5	6.6	6.5
;	6.3	6.4	6.3	3.4	7.1	6.4	6.9	6.1
	5.9	6.1	5.5	6.1	6.6	6.2	6.5	6.1

the construction of artificial wetlands

t arm

B-Bisa arm

UN-Upper-north arm

LE-Lower-east arm

UE-Upper-east arm

PL-Primary lake

anan Putrajaya, 1999

TURBIDITY (FTU)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	11.6	21.5	19.3	8.2	11.7	8.2	8.2	12.7
Early construction* (3/97-5/97)	118.4	107.2	162.1	401.3	291.5	120.1	-	200.1
Heavy construction* (6/97-8/97)	261.3	192.5	872.4	273.1	439.0	277.3	206.7	360.3
Late construction* (9/97-3/98)	227.9	928.9	339.9	204.6	1880.4	760.9	532.9	696.5
Early monitoring (4/98-9/98)	36.1	30.1	23.0	17.2	1263.2	164.0	441.6	282.2
Middle monitoring (10/98-3/99)	28.3	22.9	20.5	12.1	151.4	25.0	229.0	69.9
Late monitoring (4/99-9/99)	16.8	21.3	17.2	9.3	13.8	11.9	16.3	15.2
Maintenance (from 10/99)	30.3	26.3	30.5	39.7	5.0	10.8	12.0	24.0

* in relation to the construction of artificial wetlands

UW-Upper-west arm

B-Bisa arm

UN-Upper-north arm

LE-Lower-east arm

CL-Central lake

UE-Upper-east arm

PL-Primary lake

Source : Perbadanan Putrajaya, 1999

TSS (mg/L)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Preconstruction	43.0	23.0	21.0	14.0	14.0	14.0	14.0	20.4
Early construction* (3/97-5/97)	88.2	46.5	97.0	88.2	61.2	62.3	-	73.9
Heavy construction* (6/97-8/97)	243.3	175.7	433.6	212.4	226.9	219.0	137.2	235.4
Late construction* (9/97-3/98)	130.8	659.1	165.5	166.5	1402.3	670.9	375.2	510.0
Early monitoring (4/98-9/98)	26.1	25.4	18.0	20.8	992.2	148.5	352.2	226.2
Middle monitoring (10/98-3/99)	17.2	17.0	15.1	11.3	71.2	15.7	43.1	27.2
Late monitoring (4/99-9/99)	15.4	16.3	12.7	13.3	18.9	18.5	13.9	15.6
Maintenance (from 10/99)	15.1	17.9	21.5	28.3	6.3	6.3	7.3	15.1

* in relation to the construction of artificial wetlands

UW-Upper-west arm

B-Bisa arm

UN-Upper-north arm

LE-Lower-east arm

CL-Central lake

UE-Upper-east arm

PL-Primary lake

Source : Perbadanan Putrajaya, 1999

CONDUCTIVITY ($\mu\text{mhos/cm}$)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	NOT SAMPLED							
Early construction* (3/97-5/97)	47.7	73.2	28.7	47.5	27.8	46.3	-	45.2
Heavy construction* (6/97-8/97)	86.8	122.1	53.6	70.0	59.0	86.6	105.4	83.4
Late construction* (9/97-3/98)	83.4	132.4	81.3	113.3	69.3	84.5	121.0	97.9
Early monitoring (4/98-9/98)	167.1	91.7	66.0	113.5	105.6	97.5	108.0	107.1
Middle monitoring (10/98-3/99)	70.3	84.5	50.8	104.2	187.0	86.0	117.4	100.0
Late monitoring (4/99-9/99)	75.7	81.7	49.8	102.3	124.4	76.4	103.8	87.7
Maintenance (from 10/99)	90.5	87.5	53.3	104.7	131.3	79.8	97.5	89.7

* in relation to the construction of artificial wetlands

UW-Upper-west arm

B-Bisa arm

UN-Upper-north arm

LE-Lower-east arm

CL-Central lake

UE-Upper-east arm

PL-Primary lake

Source : Perbadanan Putrajaya, 1999

AMMONIACAL NITROGEN (mg/L)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	0.30	0.40	0.10	0.30	0.30	0.30	0.30	0.30
Early construction* (3/97-5/97)	0.57	0.59	0.30	0.39	0.31	0.40	-	0.43
Heavy construction* (6/97-8/97)	0.13	1.98	0.69	0.57	0.67	1.07	1.03	0.88
Late construction* (9/97-3/98)	0.83	1.28	0.83	1.03	0.85	1.07	1.09	1.00
Early monitoring (4/98-9/98)	0.34	0.35	0.27	0.91	0.56	0.38	0.49	0.47
Middle monitoring (10/98-3/99)	0.25	0.29	0.25	0.28	0.38	0.23	0.38	0.29
Late monitoring (4/99-9/99)	0.30	0.34	0.34	0.30	0.29	0.24	0.23	0.29
Maintenance (from 10/99)	0.44	0.56	0.47	0.46	0.63	0.58	0.49	0.51

* in relation to the construction of artificial wetlands

UW-Upper-west arm

B-Bisa arm

UN-Upper-north arm

LE-Lower-east arm

CL-Central lake

UE-Upper-east arm

PL-Primary lake

Source : Perbadanan Putrajaya, 1999

NITRATE (mg/L)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	1.90	2.20	1.40	2.00	1.20	2.00	2.00	1.80
Early construction* (3/97-5/97)	1.18	3.15	1.66	1.31	1.41	2.03	-	1.18
Heavy construction* (6/97-8/97)	1.62	2.74	1.71	2.04	1.87	2.68	3.92	1.62
Late construction* (9/97-3/98)	1.49	7.94	1.37	1.31	1.61	2.15	2.38	1.66
Early monitoring (4/98-9/98)	12.02	1.77	1.50	2.26	1.71	2.05	2.26	4.37
Middle monitoring (10/98-3/99)	1.67	1.75	0.82	1.19	2.24	0.86	1.30	1.52
Late monitoring (4/99-9/99)	0.86	2.01	1.48	1.40	1.35	1.39	0.97	1.35
Maintenance (from 10/99)	3.26	3.24	2.12	4.50	1.79	2.17	1.62	2.83

* in relation to the construction of artificial wetlands

UW-Upper-west arm

B-Bisa arm

UN-Upper-north arm

LE-Lower-east arm

CL-Central lake

UE-Upper-east arm

PL-Primary lake

Source : Perbadanan Putrajaya, 1999

PHOSPHORUS (mg/L)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	0.010	0.030	0.010	0.010	0.030	0.010	0.010	0.020
Early construction* (3/97-5/97)	0.030	0.030	0.030	0.030	0.030	0.030	-	0.030
Heavy construction* (6/97-8/97)	0.167	0.167	0.167	0.167	0.167	0.167	0.090	0.156
Late construction* (9/97-3/98)	0.012	0.107	0.024	0.021	0.021	0.021	0.045	0.036
Early monitoring (4/98-9/98)	0.021	0.010	0.010	0.010	0.010	0.010	0.010	0.012
Middle monitoring (10/98-3/99)	0.015	0.014	0.010	0.010	0.010	0.010	0.010	0.011
Late monitoring (4/99-9/99)	0.027	0.014	0.011	0.012	0.024	0.016	0.103	0.030
Maintenance (from 10/99)	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010

* in relation to the construction of artificial wetlands

UW-Upper-west arm

B-Bisa arm

UN-Upper-north arm

LE-Lower-east arm

CL-Central lake

UE-Upper-east arm

PL-Primary lake

Source : Perbadanan Putrajaya, 1999

POTASSIUM (mg/L)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	NOT SAMPLED							
Early construction* (3/97-5/97)	1.74	2.18	1.22	2.27	1.28	1.45	-	1.69
Heavy construction* (6/97-8/97)	2.69	2.38	3.21	5.04	2.60	2.97	5.28	3.45
Late construction* (9/97-3/98)	2.47	2.31	5.01	4.73	2.98	2.48	3.54	3.36
Early monitoring (4/98-9/98)	1.47	1.38	1.25	3.15	3.07	2.01	2.55	2.13
Middle monitoring (10/98-3/99)	1.12	1.18	0.88	1.98	4.72	1.40	2.25	1.93
Late monitoring (4/99-9/99)	1.68	1.33	1.02	1.75	2.74	1.79	2.24	1.79
Maintenance (from 10/99)	3.74	2.44	1.81	2.39	3.68	2.32	2.88	2.92

* in relation to the construction of artificial wetlands

UW-Upper-west arm

B-Bisa arm

UN-Upper-north arm

LE-Lower-east arm

CL-Central lake

UE-Upper-east arm

PL-Primary lake

Source : Perbadanan Putrajaya, 1999

MAGNESIUM (mg/L)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	NOT SAMPLED							
Early construction* (3/97-5/97)	0.91	1.21	0.76	0.97	0.44	0.85	-	0.86
Heavy construction* (6/97-8/97)	1.29	1.75	1.20	1.63	0.98	1.52	1.78	1.45
Late construction* (9/97-3/98)	1.30	1.81	1.57	1.59	0.90	1.36	1.43	1.42
Early monitoring (4/98-9/98)	0.22	0.32	0.28	1.01	0.39	0.56	0.51	0.47
Middle monitoring (10/98-3/99)	0.22	0.50	0.21	1.10	0.69	0.72	0.86	0.62
Late monitoring (4/99-9/99)	0.13	0.18	0.11	0.27	0.17	0.15	0.13	0.16
Maintenance (from 10/99)	1.61	1.38	1.03	1.87	1.12	1.32	1.32	1.41

* in relation to the construction of artificial wetlands

UW-Upper-west arm

B-Bisa arm

UN-Upper-north arm

LE-Lower-east arm

CL-Central lake

UE-Upper-east arm

PL-Primary lake

Source : Perbadanan Putrajaya, 1999

IRON (mg/L)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	0.90	1.00	0.80	1.20	1.40	1.20	1.20	1.10
Early construction* (3/97-5/97)	1.33	1.07	0.80	1.71	0.70	1.02	-	1.10
Heavy construction* (6/97-8/97)	1.88	0.94	1.44	2.41	1.70	1.72	2.08	1.74
Late construction* (9/97-3/98)	1.44	1.78	1.99	3.42	1.88	1.82	2.00	2.05
Early monitoring (4/98-9/98)	0.06	0.05	0.04	0.64	0.24	0.11	0.08	0.17
Middle monitoring (10/98-3/99)	0.04	0.03	0.04	0.14	0.005	0.008	0.002	0.04
Late monitoring (4/99-9/99)	0.03	0.03	0.05	0.004	0.002	0.005	0.002	0.02
Maintenance (from 10/99)	0.22	0.24	0.32	0.002	0.002	0.002	0.002	0.11

* in relation to the construction of artificial wetlands

UW-Upper-west arm

B-Bisa arm

UN-Upper-north arm

LE-Lower-east arm

CL-Central lake

UE-Upper-east arm

PL-Primary lake

Source : Perbadanan Putrajaya, 1999

MERCURY (mg/L)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Early construction* (3/97-5/97)	0.001	0.001	0.001	0.002	0.001	0.001	-	0.001
Heavy construction* (6/97-8/97)	0.001	0.001	0.001	0.004	0.001	0.001	0.001	0.001
Late construction* (9/97-3/98)	0.001	0.001	0.001	0.003	0.003	0.002	0.002	0.002
Early monitoring (4/98-9/98)	0.001	0.001	0.002	0.002	0.001	0.001	0.001	0.001
Middle monitoring (10/98-3/99)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Late monitoring (4/99-9/99)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Maintenance (from 10/99)	0.001	0.001	0.001	0.002	0.002	0.001	0.001	0.001

* in relation to the construction of artificial wetlands

UW-Upper-west arm

B-Bisa arm

UN-Upper-north arm

LE-Lower-east arm

CL-Central lake

UE-Upper-east arm

PL-Primary lake

Source : Perbadanan Putrajaya, 1999

LEAD (mg/L)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	0.070	0.030	0.030	0.030	0.030	0.030	0.030	0.040
Early construction* (3/97-5/97)	0.110	0.080	0.062	0.030	0.032	0.045	-	0.060
Heavy construction* (6/97-8/97)	0.115	0.098	0.108	0.094	0.107	0.133	0.125	0.111
Late construction* (9/97-3/98)	0.034	0.030	0.037	0.054	0.041	0.029	0.034	0.037
Early monitoring (4/98-9/98)	0.013	0.011	0.013	0.014	0.027	0.014	0.018	0.016
Middle monitoring (10/98-3/99)	0.007	0.006	0.008	0.006	0.006	0.006	0.006	0.006
Late monitoring (4/99-9/99)	0.018	0.018	0.018	0.020	0.018	0.025	0.018	0.019
Maintenance (from 10/99)	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006

* in relation to the construction of artificial wetlands

UW-Upper-west arm

B-Bisa arm

UN-Upper-north arm

LE-Lower-east arm

CL-Central lake

UE-Upper-east arm

PL-Primary lake

Source : Perbadanan Putrajaya, 1999

DISSOLVED OXYGEN (mg/L)

E	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
on*	7.3	7.2	7.2	7.2	7.0	7.2	7.2	7.2
	4.9	5.0	5.6	5.2	6.1	5.8	-	5.4
ion*	4.1	4.0	4.5	4.1	5.1	4.8	4.4	4.4
n*	6.4	6.6	6.3	6.6	6.4	6.6	6.5	6.5
g	6.0	6.2	6.1	6.0	5.8	6.0	5.9	6.0
ing	6.0	5.8	5.8	5.9	5.9	6.2	6.1	6.0
	6.0	5.9	6.1	6.4	6.8	6.4	6.5	6.3
	6.1	6.1	5.7	6.0	6.3	6.7	6.7	6.2

the construction of artificial wetlands

t arm

B-Bisa arm

UN-Upper-north arm

LE-Lower-east arm

UE-Upper-east arm

PL-Primary lake

anan Putrajaya, 1999

CHEMICAL OXYGEN DEMAND (mg/L)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	4.0	6.0	7.0	3.0	10.0	3.0	3.0	5.1
Early construction* (3/97-5/97)	14.5	11.3	10.4	4.7	8.7	6.1	-	9.3
Heavy construction* (6/97-8/97)	26.9	20.2	36.9	14.6	16.2	16.4	24.1	22.2
Late construction* (9/97-3/98)	10.4	8.7	8.2	12.4	12.2	10.3	8.8	10.1
Early monitoring (4/98-9/98)	5.10	6.3	6.1	11.3	6.1	5.9	7.8	6.9
Middle monitoring (10/98-3/99)	8.90	8.4	7.1	12.3	9.9	8.9	7.8	9.0
Late monitoring (4/99-9/99)	8.30	9.1	7.7	10.7	10.5	9.3	9.7	8.9
Maintenance (from 10/99)	3.90	7.9	5.3	1.0	1.0	1.0	1.5	4.5

* in relation to the construction of artificial wetlands

UW-Upper-west arm

B-Bisa arm

UN-Upper-north arm

LE-Lower-east arm

CL-Central lake

UE-Upper-east arm

PL-Primary lake

Source : Perbadanan Putrajaya, 1999

BIOCHEMICAL OXYGEN DEMAND (mg/L)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	0.8	0.9	0.7	0.8	0.5	0.8	0.8	0.8
Early construction* (3/97-5/97)	4.6	3.7	4.0	2.0	3.2	1.8	-	3.2
Heavy construction* (6/97-8/97)	8.3	7.4	4.5	4.6	5.0	4.2	7.7	5.9
Late construction* (9/97-3/98)	3.8	3.7	3.1	6.1	3.8	4.5	3.9	4.1
Early monitoring (4/98-9/98)	2.0	2.1	2.1	2.3	2.2	2.2	2.8	2.2
Middle monitoring (10/98-3/99)	3.1	3.0	2.5	4.1	3.4	3.5	3.5	3.3
Late monitoring (4/99-9/99)	2.1	2.1	2.1	2.2	2.4	2.2	2.2	2.2
Maintenance (from 10/99)	2.1	2.0	2.0	2.0	2.0	2.0	2.0	2.0

* in relation to the construction of artificial wetlands

UW-Upper-west arm

B-Bisa arm

UN-Upper-north arm

LE-Lower-east arm

CL-Central lake

UE-Upper-east arm

PL-Primary lake

Source : Perbadanan Putrajaya, 1999

FAECAL COLIFORM (MPN/100 mL)

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	Mean
Pre-construction	300	5,000	500	500	500	3,000	3,000	1,829
Early construction* (3/97-5/97)	1,300	1,661	315	212	567	498	-	759
Heavy construction* (6/97-8/97)	10,946	8,793	608	1,569	1,545	3,268	1,919	4,093
Late construction* (9/97-3/98)	18,483	4,564	10,680	4,779	18,874	9,579	2,033	9,856
Early monitoring (4/98-9/98)	1,217	2,584	1,202	2,992	6,578	1,488	2,886	2,707
Middle monitoring (10/98-3/99)	2,179	2,099	889	408	1,145	1,308	475	1,215
Late monitoring (4/99-9/99)	29,887	21,823	5,881	2,667	23,338	17,908	8,779	15,755
Maintenance (from 10/99)	7,080	6,330	8,425	2,663	4,167	5,400	3,150	5,853

* in relation to the construction of artificial wetlands

UW-Upper-west arm

B-Bisa arm

UN-Upper-north arm

LE-Lower-east arm

CL-Central lake

UE-Upper-east arm

PL-Primary lake

Source : Perbadanan Putrajaya, 1999

APPENDIX C2

PHASE	CATCHMENT ARM							
	UW	UN	UE	LE	B	CL	PL	MEAN
Pre-Construction	-	-	-	-	-	-	-	88.6 (II)
Early construction* (3/97-5/97)	75.7 (III)	79.8 (II)	81.5 (II)	80.8 (II)	83.9 (II)	84.2 (II)	-	81.0 (II)
Heavy construction* (6/97-8/97)	62.3 (III)	62.6 (III)	67.4 (III)	68.4 (III)	71.6 (III)	69.6 (III)	63.8 (III)	66.5 (III)
Late construction* (9/97-3/98)	78.9 (II)	75.3 (III)	79.3 (II)	45.5 (IV)	71.1 (III)	75.7 (III)	76.2 (III)	71.7 (III)
Early monitoring (4/98-9/98)	86.4 (II)	87.1 (II)	87.5 (II)	84.0 (II)	78.5 (II)	82.1 (II)	79.3 (II)	83.6 (II)
Middle monitoring (10/98-3/99)	86.1 (II)	85.5 (II)	85.9 (II)	84.4 (II)	81.3 (II)	87.0 (II)	84.9 (II)	85.0 (II)
Late monitoring (4/99-9/99)	86.7 (II)	86.1 (II)	87.4 (II)	87.6 (II)	88.7 (II)	88.3 (II)	89.0 (II)	87.7 (II)
Maintenance (from 10/99)	85.8 (II)	84.7 (II)	82.0 (II)	86.0 (II)	88.0 (II)	87.7 (II)	89.2 (II)	86.2 (II)

* in relation to the construction of artificial wetlands

UW-Upper-west arm

B-Bisa arm

UN-Upper-north arm

LE-Lower-east arm

CL-Central lake

UE-Upper-east arm

PL-Primary lake

Source : Perbadanan Putrajaya, 1999

APPENDIX D

INTAKE AND PUMPHOUSE DESIGN

- 1 Intake Design
- 2 Pumphouse Design

FIGURE

- Figure D1 General Arrangement Of Pumphouse Plan For Submersible Multistaged Pump
(Borehole Type, Vertically Mounted)
- Figure D2 General Arrangement Of Pumphouse Plan For Vertical Turbine Pump
- Figure D3 General Arrangement Of Pumphouse Plan For Vertical Multistaged Centrifugal Pump
- Figure D4 General Arrangement Of Pumphouse Plan For Submersible Multistaged Pump
(Encapsulated and Horizontally Mounted)

INTAKE AND PUMPHOUSE DESIGN**1. INTAKE DESIGN**

Two options of intake design (see Figure D1a) are proposed as follows:-

a) Option I – Piped Intake

An intake pipe of suitable diameter is connected from the pump sump which is located below the pumphouse, to a strainer at the end of the pipe which extends into the lake.

A sectional view of this option is shown in Figure D1b.

b) Option II – Channelled Intake

In this design, box culverts are used to provide a channel for water to flow from the lake to the pump sump located below the pumphouse.

A sectional view of this option is shown in Figure D1c.

2. PUMPHOUSE DESIGN

Two basic types of pumphouses are proposed, one which is underground, i.e. concealed type and the other which is above ground i.e. exposed type.

For both types of pumphouses, provision is made for a removal screen which is proposed to be located before the inlet to the pump sump. The purpose of the screen is to trap and remove any debris found in the lake water and also to prevent the debris from entering the pump sump. In order to minimize space usage, the pump sump is proposed to be located directly below the pumphouse.

Due to the relatively high delivery heads required that range from about 6 bar to 12 bar for the pumping plants under consideration, the selection of pumps is limited to the following types :-

- (i) Submersible multistaged (borehole type, vertically mounted)
- (ii) Vertical turbine

- (iii) Vertical multistaged centrifugal
- (iv) Submersible multistaged (encapsuled and horizontally mounted)

Type (i) has the advantage of the motor being submersible but the disadvantage is that a building is required to house the pumps for normal operation and maintenance.

Type (ii) is suitable for high capacity and high head applications but a superstructure is required to house the pumps for normal operation and maintenance and also the motor is not submersible.

Type (iii) has the advantage of being smaller in physical dimensions and the pumps can be accommodated in an underground pumphouse. However, this type of pump is limited to capacity of about 50 m³/h and about 100m head. Also, the motor is not submersible.

Type (iv) is basically similar to type (i) except that it has a wider pump capacity range coverage and can be installed vertically or horizontally in-line in a pipe. However the cost of the pump is generally higher than the other types by about 30%.

2.1 Option of Pumphouse

In consideration of the above, the following options have been proposed:-

Option A

Type (i) or Type (ii) pumps for all 9 nos pumphouses. All the pumphouses are above ground i.e. exposed type.

The general arrangement of Type (i) pumps is shown in Figure D1a – 1c whereas the general arrangement of Type (ii) pumps is shown in Figure D2a and D2b.

Option B

Type (iii) pumps of lower capacity range for 7 nos pumphouses which are underground (concealed type), Type (iii) pump of lower capacity range for 1 nos pumphouse which is aboveground and Type (ii) pumps of larger capacity range for 1 nos pumphouse which is above ground (exposed type).

The general arrangement of Type (iii) pumps is shown in Figure D3a and D3b.

Option C

Type (iv) pumps which are installed horizontally for all 9 nos pumphouses which are underground (concealed type)

The general arrangement of Type (iv) pumps is shown in Figure D4a and D4b.

2.2 Evaluation of Option

For Option A, all the pumphouses will be above ground and exposed. The advantages of this option are as follows:-

- (a) All the control and starterboards will be above the flood level and hence there is no danger of ingress of water into the boards.
- (b) This arrangement provides better access to the pumping equipment for the purpose of installation, operation and maintenance.

However, the disadvantages are :-

- (a) Being above ground and exposed, the pumphouses will be aesthetically obtrusive.

For Option B, 7 of the 9 proposed pumphouses will be underground and 2 other above ground. The advantages are :-

- (a) The aesthetic impact is less profound as 7 of the pumphouses will be underground. 2 of above ground pumphouses are located at the sewerage treatment plants (most of the structures are already aboveground) and require no consideration on the aesthetics aspect.

However, the disadvantages are :-

- (a) There is a possibility of flooding of the underground pumphouse and cause damage to the pump motors which are not submersible and electrical boards.

- (b) Access for maintenance is difficult and inconvenient.

For Option C, all the 9 pumphouses will be underground and concealed. The main advantages of this option are :-

- (a) The pumps are submersible and can still operate in the unlikely event of flooding in the pumphouse. However the electrical boards are still susceptible to flooding.
- (b) Minimal space is required for installation of the pumps.
- (c) The noise levels of the pumps are comparatively lower.

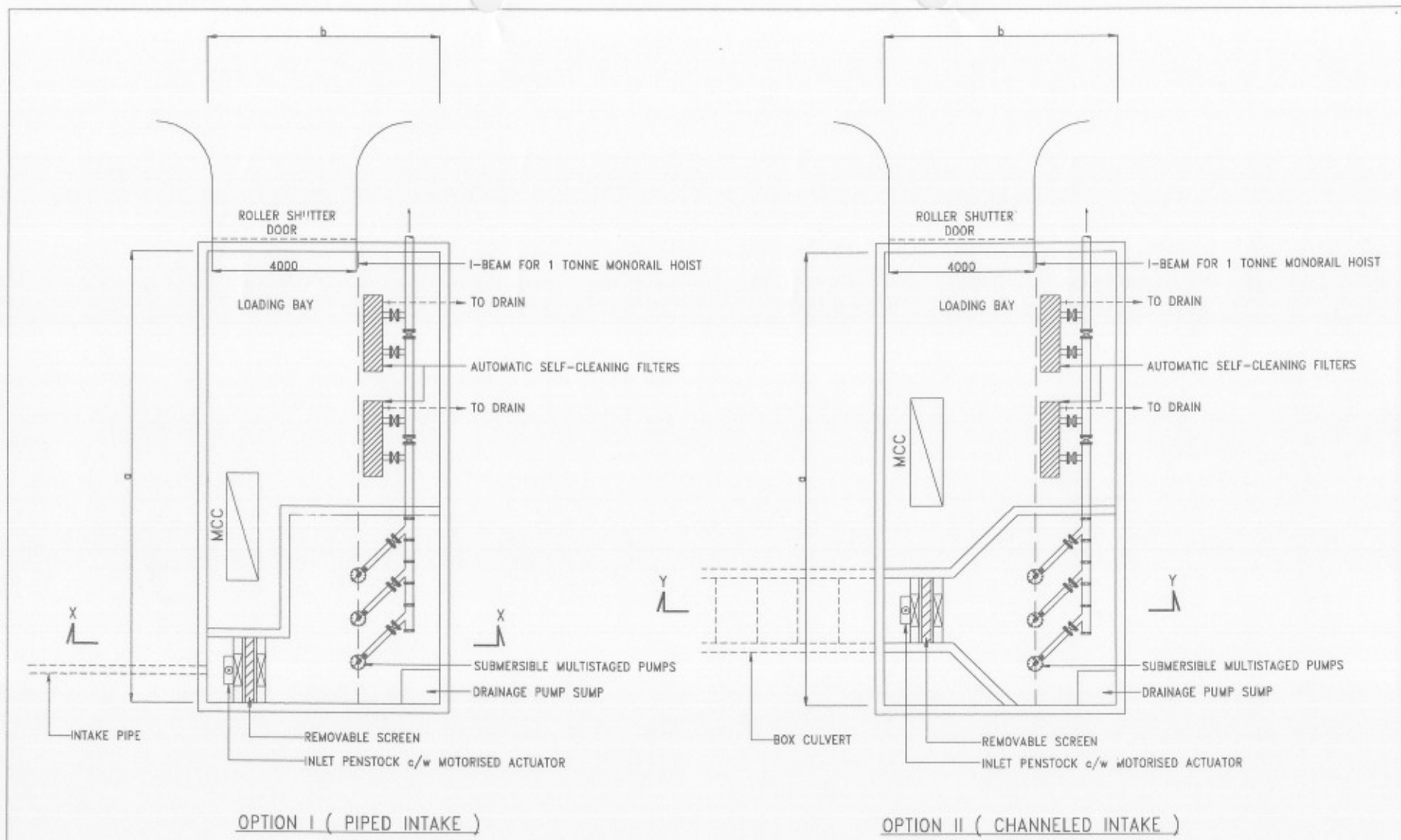
However, the disadvantage of this option is :-

- (a) The pumps are generally about 20 – 30% more expensive than the other types of pumps.

2.3 Recommendation

We would like to recommend that Option A which all the pumphouses to be above ground and exposed be adopted for the following reasons:-

- (i) Aboveground pumphouse provides better access for installation, operation and maintenance works.
- (ii) There is no chance of the electrical switchboards and pump motors being flooded.
- (iii) Artificial rocks and vegetation can be used to camouflage the pumphouses.



GENERAL ARRANGEMENT OF PUMPHOUSE PLAN

TOTAL FLOW (cu.m/h)	'a' (mm)	'b' (mm)	NO OF PUMPHOUSE
< 15	7000	5000	0
15 to 510	10,000	6000	8
> 510	12,000	8000	1

Figure D1a

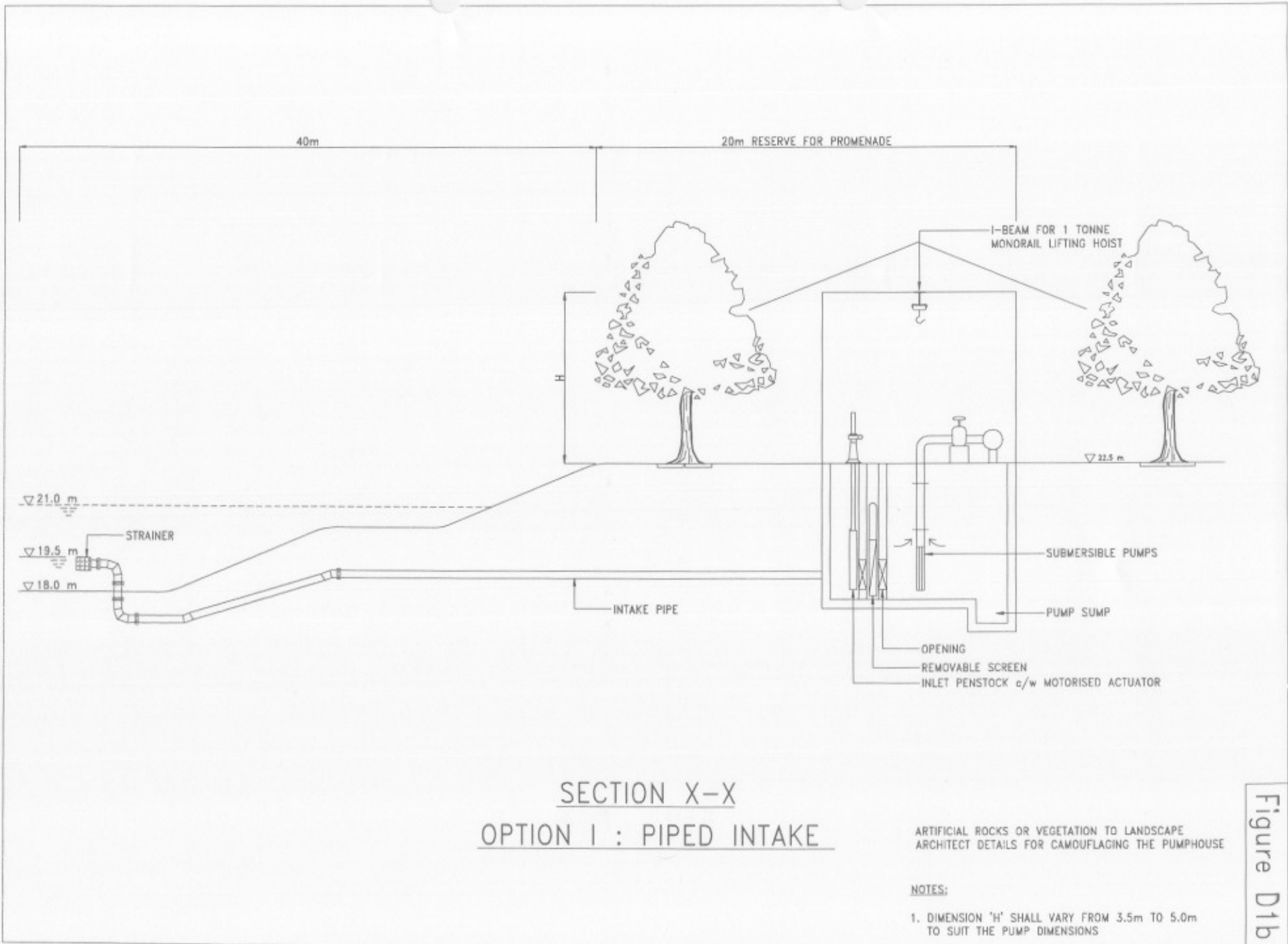
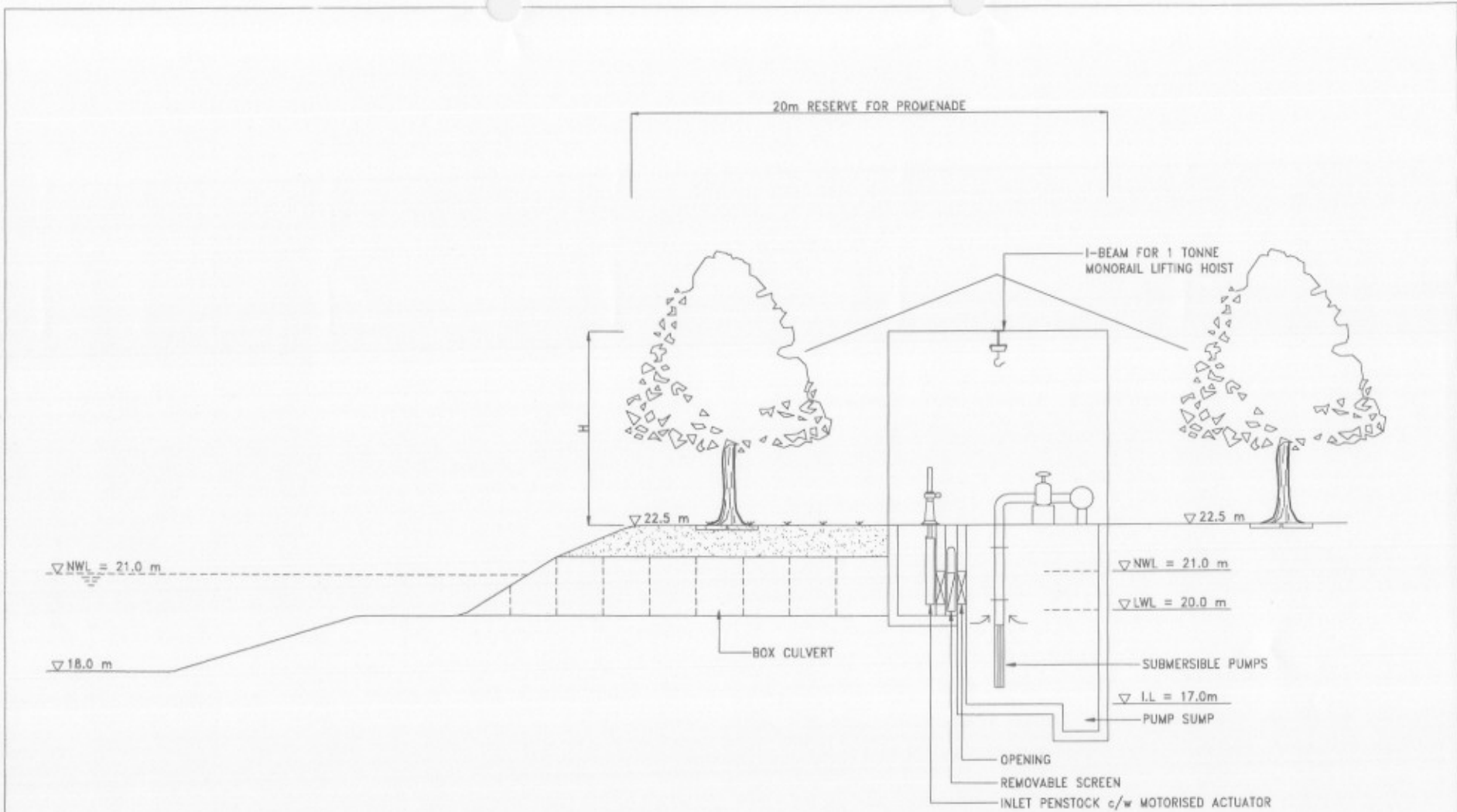


Figure D1b



SECTION Y-Y
OPTION II : CHANNELLED INTAKE

ARTIFICIAL ROCKS OR VEGETATION TO LANDSCAPE
ARCHITECT DETAILS FOR CAMOUFLAGING THE PUMPHOUSE

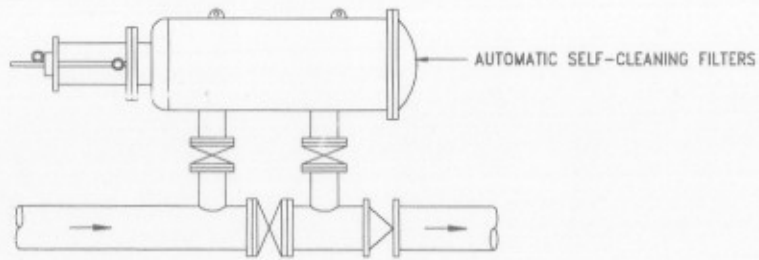
NOTES:

1. THE I.L. OF THE PUMP SUMP SHALL VARY TO SUIT THE PUMP SIZE.
2. A NOMINAL I.L IS 17.0m
3. DIMENSION 'H' SHALL VARY FROM 3.5m TO 5.0m TO SUIT THE PUMP DIMENSIONS

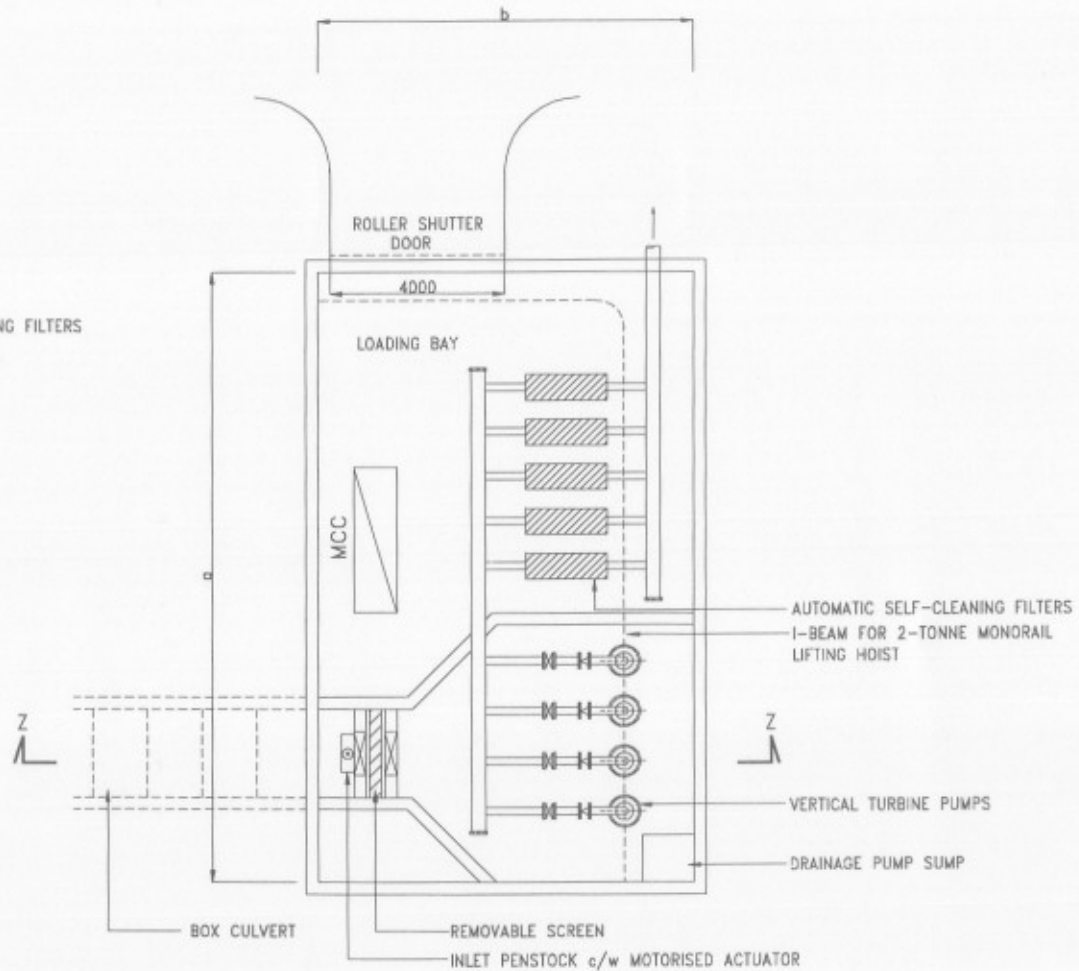
Figure D1c

NOTES:

1. THIS ARRANGEMENT IS APPLICABLE TO ONLY ONE OF THE 13 nos OF PUMPHOUSE PROPOSED.



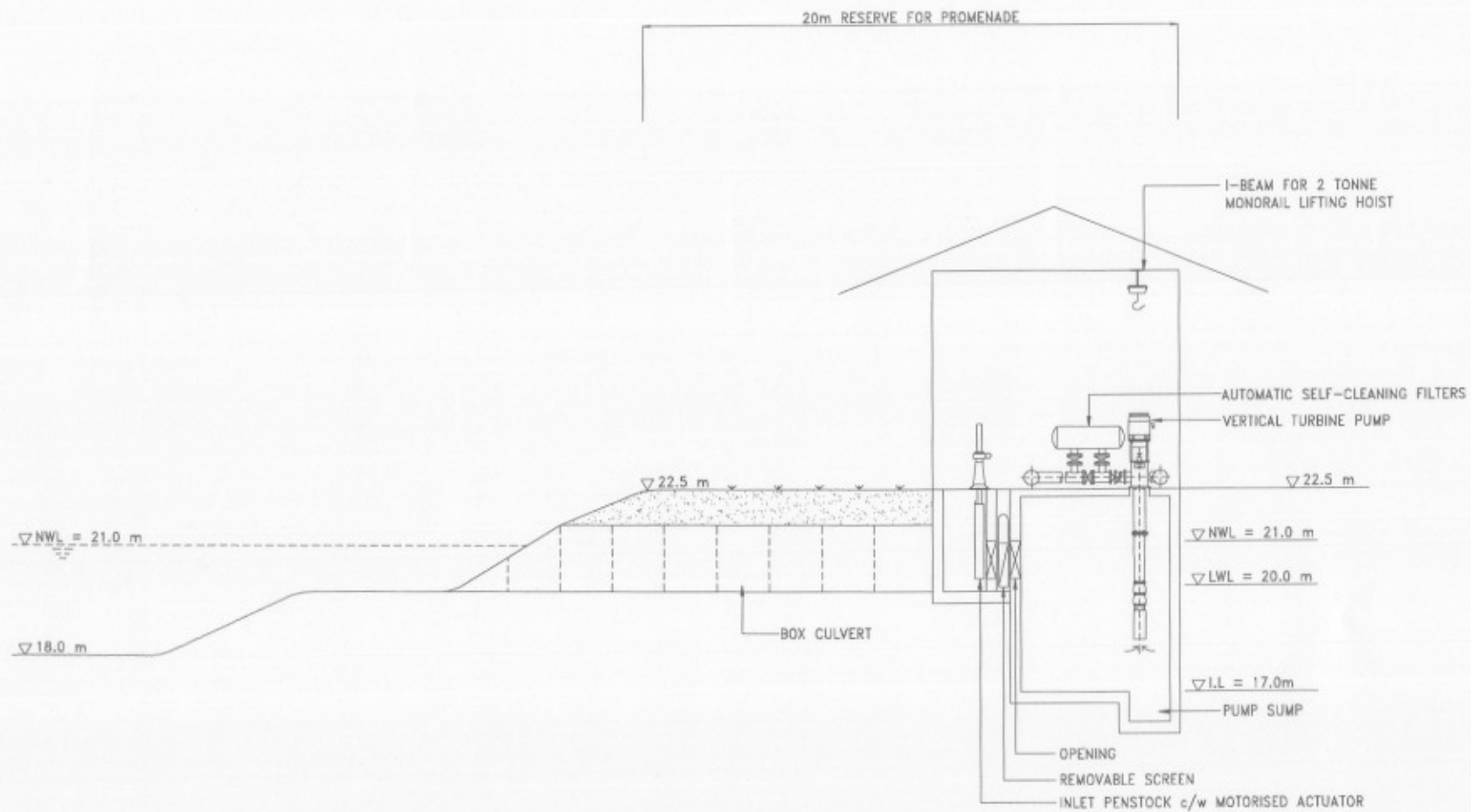
TYPICAL PIPEWORK ARRANGEMENT FOR AUTOMATIC SELF-CLEANING FILTER



TOTAL FLOW (cu.m/h)	'a' (mm)	'b' (mm)	NO OF PUMPHOUSE
< 15	7000	5000	0
15 to 510	10,000	6000	8
> 510	12,000	8000	1

GENERAL ARRANGEMENT OF PUMPHOUSE PLAN

Figure D2a



SECTION Z-Z
OPTION II : CHANNELLED INTAKE

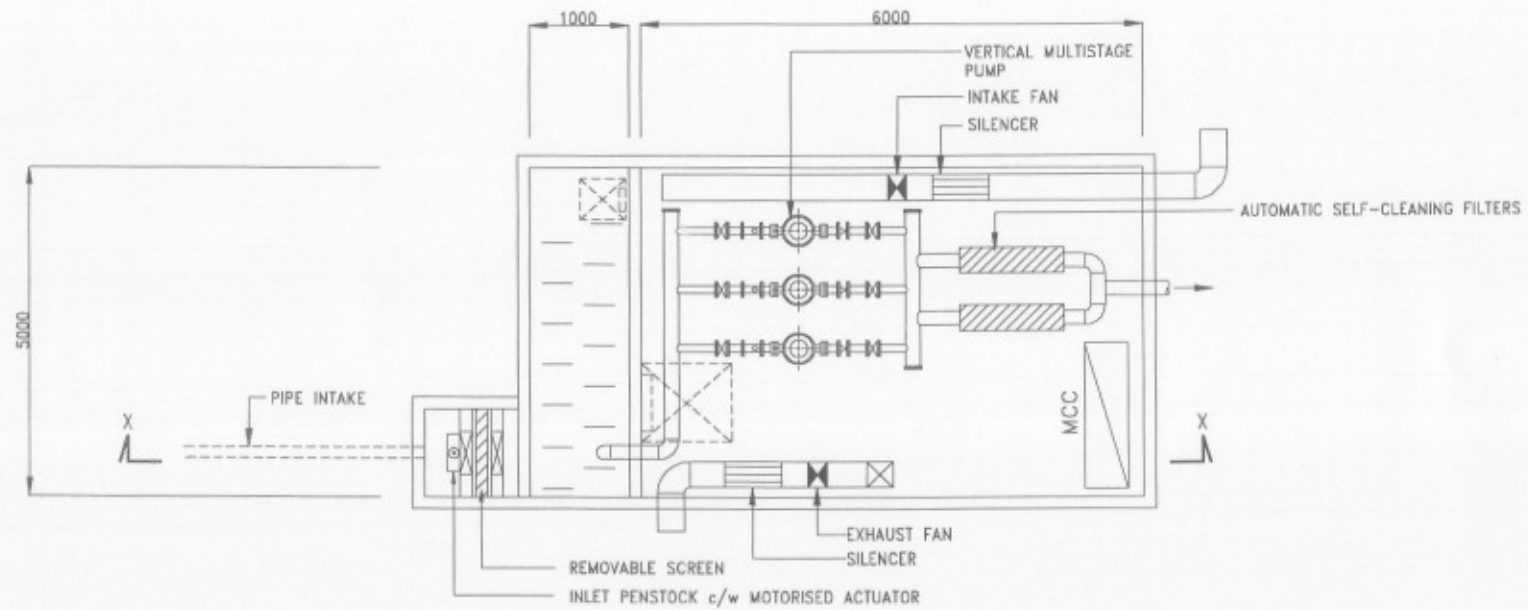
NOTES:

1. THE I.L. OF THE PUMP SUMP SHALL VARY TO SUIT THE PUMP SIZE.
2. A NOMINAL I.L. IS 17.0m

Figure D2b

ALTERNATIVE PUMPHOUSE DESIGN - OPTION (B)

(FOR TOTAL FLOW LESS THAN 150 cu.m/h AND TOTAL HEAD LESS THAN 90m)

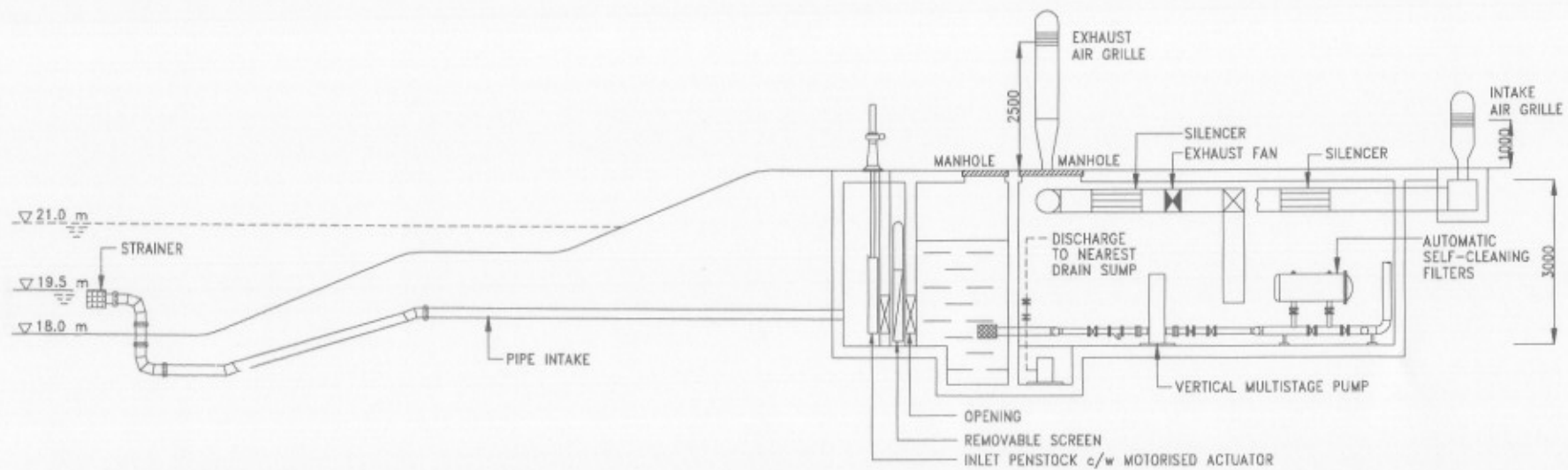


GENERAL ARRANGEMENT OF PUMPHOUSE PLAN (PIPED INTAKE)

Figure D3a

ALTERNATIVE PUMPHOUSE DESIGN - OPTION (B)

(FOR TOTAL FLOW LESS THAN 150 cu.m/h AND TOTAL HEAD LESS THAN 90m)

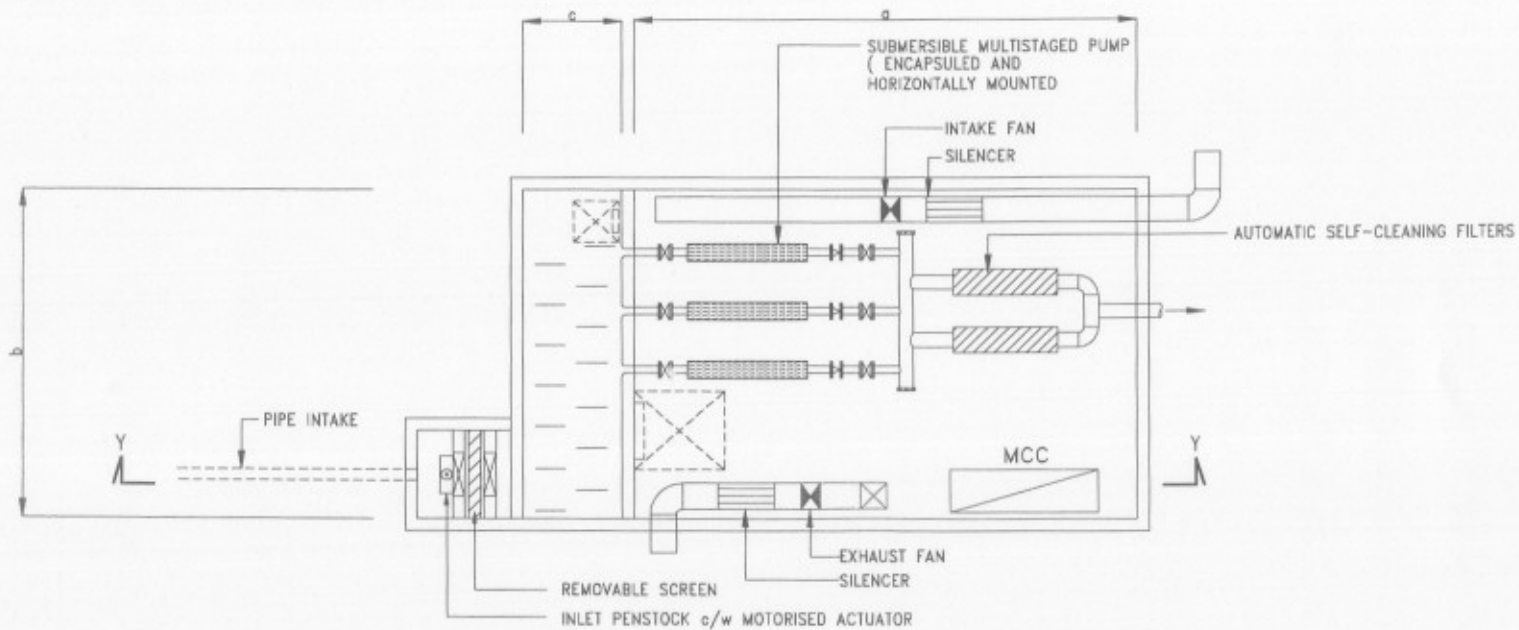


SECTION X-X

Figure D3b

ALTERNATIVE PUMPHOUSE DESIGN – OPTION (C)

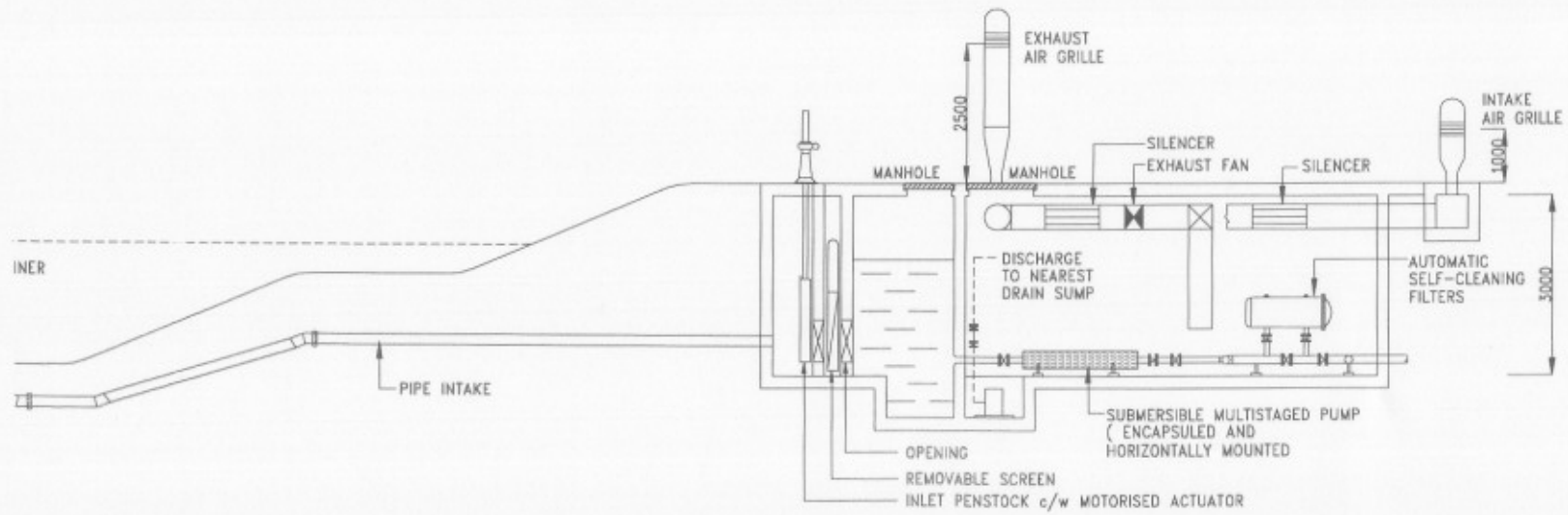
TOTAL FLOW (cu.m/h)	'a' (mm)	'b' (mm)	'c' (mm)	NO OF PUMPHOUSE
< 160	6000	5000	1000	8
200 to 510	7000	5000	1500	0
> 510	12,000	7000	3000	1



GENERAL ARRANGEMENT OF PUMPHOUSE PLAN (PIPED INTAKE)

Figure D4a

FIVE PUMPHOUSE DESIGN - OPTION (C)



SECTION Y-Y

Figure D4b

APPENDIX E

LOCATIONAL AND DESIGN CRITERIA FOR IRRIGATION FACILITIES

1 Introduction

TABLE

Table E1	Locational And Design Criteria For Pump House
Table E2	Locational And Design Criteria For Pump House For Storage Pond
Table E3	Locational And Design Criteria For Truck Depot
Table E4	Locational And Design Criteria For Truck Refilling Kiosk
Table E5	Locational And Design Criteria For Holding Pond (Storage, Disinfection and Treatment)

LOCATIONAL AND DESIGN CRITERIA FOR IRRIGATION FACILITIES

1. INTRODUCTION

Site identification and selection for pump houses, truck depots (for overnight parking and repairs), water filling stations (for trucks) and ponds for storage and disinfection (of treated water from the sewage treatment plants) are to be undertaken by the respective planners or designers for the precinct.

However, the following locational and design criteria given in Table E1 – E5 are to be used as guidelines in site selection and planning and design of these facilities i.e.,

- a) Table E1 Locational And Design Criteria For Pump House
- b) Table E2 Locational And Design Criteria For Pump House For Storage Pond
- c) Table E3 Locational And Design Criteria For Truck Depot
- d) Table E4 Locational And Design Criteria For Truck Refilling Kiosk
- e) Table E5 Locational And Design Criteria For Holding Pond (Storage, Disinfection and Treatment)

Table E1 Locational And Design Criteria For Pump House – 1/4

Pump Houses	Land Area (sqm)	Locational Criteria	Design Criteria
PH1 (Zone 1/ PjP 2, 3 & 18)	16x12	<ol style="list-style-type: none"> 1. The facility may be located along a green connector or promenade; and adjacent to or in close proximity to an existing or proposed vehicular maintenance reserve. 2. The facility is to be setback at least 3m from private property line; 3m from the water's edge and away from major activity areas. 3. A reserve of at least 3.5m along the promenade or green connector is to be maintained for pedestrian and bicycle circulation. 4. The facility may not be positioned or located in a way that it hinders pedestrian circulation or safety. 	<ol style="list-style-type: none"> 1. Design of the facility must be consistent with the overall landscape design concept of the promenade or green connector. 2. Security fencing must adopt a soft fencing approach. 3. The site must be adequately landscaped; and security signs kept to a minimum. 4. Building, preferably, should be set below grade to minimize visibility.
PH2 (Zone 2/ PjP 3 & 4)	16x12	<ol style="list-style-type: none"> 1. The facility may be located along a green connector, linear park or promenade; and adjacent to or in close proximity to an existing or proposed vehicular maintenance reserve. 2. The facility is to be setback at least 3m from private property line; 3m from the water's edge and away from major activity areas. 3. A reserve of at least 3.5m along the promenade or green connector is to be maintained for pedestrian and bicycle circulation. 4. The facility may not be positioned or located in a way that it hinders pedestrian circulation or safety. 	<ol style="list-style-type: none"> 1. Design of the facility must be consistent with the overall landscape design concept of the promenade or green connector. 2. Security fencing must adopt a soft fencing approach. 3. The site must be adequately landscaped; and security signs kept to a minimum. 4. Building, preferably, should be set below grade to minimize visibility.

Table E1 Locational And Design Criteria For Pump House (Cont'd) – 2/4

Pump Houses	Land Area (sqm)	Locational Criteria	Design Criteria
PH3 (Zone 3/ PjP 16, 17 & 19)	16x12	<ol style="list-style-type: none"> 1. The facility may be located along a green connector or promenade; and adjacent to or in close proximity to an existing or proposed vehicular maintenance reserve. 2. The facility is to be setback at least 3m from private property line; 3m from the water's edge and away from major activity areas. 3. A reserve of at least 3.5m along the promenade or green connector is to be maintained for pedestrian and bicycle circulation. 4. The facility may not be positioned or located in a way that it hinders pedestrian circulation or safety. 	<ol style="list-style-type: none"> 1. Design of the facility must be consistent with the overall landscape design concept of the promenade or green connector. 2. Security fencing must adopt a soft fencing approach. 3. The site must be adequately landscaped; and security signs kept to a minimum. 4. Building, preferably, should be set below grade to minimize visibility.
PH4 (Zone 4/ PjP7, 8, 9 & 10)	16x12	<ol style="list-style-type: none"> 1. The facility may be located along a green connector, linear park or promenade; and adjacent to or in close proximity to an existing or proposed vehicular maintenance reserve. 2. The facility is to be setback at least 3m from private property line; 3m from the water's edge and away from major activity areas. 3. A reserve of at least 3.5m along the promenade or green connector is to be maintained for pedestrian and bicycle circulation. 4. The facility may not be positioned or located in a way that it hinders pedestrian circulation or safety. 	<ol style="list-style-type: none"> 1. Design of the facility must be consistent with the overall landscape design concept of the promenade or green connector. 2. Security fencing must adopt a soft fencing approach. 3. The site must be adequately landscaped; and security signs kept to a minimum. 4. Building, preferably, should be set below grade to minimize visibility.

Table E1 Locational And Design Criteria For Pump House (Cont'd) – 3/4

Pump Houses	Land Area (sqm)	Locational Criteria	Design Criteria
PH5 (Zone 5/ PjP 5,6, & 20)	16x12	<ol style="list-style-type: none"> 1. The facility may be located along a green connector, linear park or promenade; and adjacent to or in close proximity to an existing or proposed vehicular maintenance reserve. 2. The facility is to be setback at least 3m from private property line and 3m from the water's edge. 3. The facility is to be located away from major public activity and residential areas. 4. A reserve of at least 3.5m along the promenade or green connector is to be maintained for pedestrian and bicycle circulation. 5. The facility may not be positioned or located in a way that it hinders pedestrian circulation or safety. 	<ol style="list-style-type: none"> 1. Design of the facility must be consistent with the overall landscape design concept of the promenade or green connector. 2. Security fencing must adopt a soft fencing approach. 3. The site must be adequately landscaped; and security signs kept to a minimum. 4. Building, preferably, should be set below grade to minimize visibility.

Table E1 Locational And Design Criteria For Pump House (Cont'd) – 4/4

Pump Houses	Land Area (sqm)	Locational Criteria	Design Criteria
PH6 (Zone 6/ PjP 12)	16x12	<ol style="list-style-type: none"> 1. The facility may be located along a green connector, linear park or promenade; adjacent to or in close proximity to an existing or proposed vehicular maintenance reserve; and accessible to the open pond of Lower East 1. 2. The facility may not be located along the wetlands maintenance reserve, inside the zone of intermittent inundation (ZII) or wetland zone. 3. The facility is to be setback at least 3m from private property line and 3m from the top of the ZII. 4. The facility is to be located away from major public activity and residential areas. 5. A reserve of at least 3.5m along the promenade or green connector is to be maintained for pedestrian and bicycle circulation. 6. The facility may not be positioned or located in a way that it hinders pedestrian circulation or safety. 	<ol style="list-style-type: none"> 1. Design of the facility must be consistent with the overall landscape design concept of the promenade or green connector. 2. Security fencing must adopt a soft fencing approach. 3. The site must be adequately landscaped; and security signs kept to a minimum. 4. Building, preferably, should be set below grade to minimize visibility.
PH7 (Zone 7/ PjP 13)	16x12	<ol style="list-style-type: none"> 1. The facility may not be located along the wetlands maintenance reserve, inside the zone of intermittent inundation (ZII) or wetland zone. 2. Extraction is confined to the open ponds in Upper West 4 or Upper West 5. 	<ol style="list-style-type: none"> 1. Design of the facility must be consistent with the overall landscape design concept of the wetlands.

Table E2 Locational And Design Criteria For Pump House At Storage Pond

Storage Ponds	Land Area (sqm)	Locational Criteria	Design Criteria
SP1 (Zone 9/ PjP14, 15 & DE)	16x12	1. The pump house is to be located within the compound of the sewerage treatment plant (STP1).	
SP2 (Zone 10/ PjP 5, 19 & 20)	18x14	1. The pump house is to be located adjacent to the compound of the sewerage treatment plant (STP2).	

Refer Table 9.3, Map 2 and Map 2a – 2h.

Table E3 Locational And Design Criteria For Truck Depot

Depot	Land Area (sqm)	Locational Criteria	Design Criteria
Precinct 16	25 x25	<ol style="list-style-type: none"> 1. Truck depots are to be located in the vicinity of utility reserves and away from main activity and residential areas. 2. Vehicular parking areas inside Metropolitan parks (Taman Jati, Taman Rimba Alam, Taman Wetland) may be considered for overnight truck parking. 	<ol style="list-style-type: none"> 1. The depot must be adequately landscaped, screened and signed for safety and security reasons.
Precincts 11	35 x35	<ol style="list-style-type: none"> 1. Truck depots are to be located in the vicinity of utility reserves and away from main activity and residential areas. 2. Reserves outside Putrajaya are recommended. 	<ol style="list-style-type: none"> 1. The depot must be adequately landscaped, screened and signed for safety and security reasons.

Refer Table 9.3 and Map 4.

Table E4 Locational And Design Criteria For Truck Refilling Kiosk – 1/2

Refilling Kiosk	Land Area (sqm)	Locational Criteria	Design Criteria
Precincts 16	1 nos x 20 x 40	<ol style="list-style-type: none"> 1. The facility may be located along a green connector, linear park, promenade, road (as layby) or sewerage treatment plant (STP1); and adjacent to or in close proximity to an existing or proposed vehicular maintenance reserve. 2. The facility is to be setback at least 3m from private property line; 3m from the water's edge and away from major activity areas. 3. A reserve of at least 3.5m along the promenade or green connector is to be maintained for pedestrian and bicycle circulation. 4. The facility may not be positioned or located in a way that it hinders pedestrian circulation or safety. 	<ol style="list-style-type: none"> 1. Design of the facility must be consistent with the overall landscape design concept of the promenade or green connector. 2. Security fencing must adopt a soft fencing approach. 3. The site must be adequately landscaped and signed for safety reasons.
Precincts 11	1 nos x 20 x 40	<ol style="list-style-type: none"> 1. The facility may be located along a green connector, linear park, promenade or road (as layby); and adjacent to or in close proximity to an existing or proposed vehicular maintenance reserve. 2. The facility is to be setback at least 3m from private property line; 3m from the water's edge and away from major activity areas. 3. A reserve of at least 3.5m along the promenade or green connector is to be maintained for pedestrian and bicycle circulation. 4. The facility may not be positioned or located in a way that it hinders pedestrian circulation or safety. 	<ol style="list-style-type: none"> 1. Design of the facility must be consistent with the overall landscape design concept of the promenade or green connector. 2. Security fencing must adopt a soft fencing approach. 3. The site must be adequately landscaped and signed for safety reasons.

Refer Table 9.3 and Map 4.

Table E5 Locational And Design Criteria For Holding Pond (Storage, Disinfection and Treatment)

Holding Ponds	Land Area (sqm)	Locational Criteria	Design Criteria
SP1 (STP1) <ul style="list-style-type: none"> • Storage • Disinfection 	<ul style="list-style-type: none"> • 40x40 • 10x15 	1. The facility is to be located adjacent to the compound of the sewerage treatment plant (STP1).	1. The pond must be adequately landscaped and signed for safety reasons.
SP2 (STP2) <ul style="list-style-type: none"> • Storage • Disinfection 	<ul style="list-style-type: none"> • 70x70 • 10x15 	1. The facility is to be located adjacent to the compound of the sewerage treatment plant (STP2).	1. The pond must be adequately landscaped and signed for safety reasons.

Refer Table 9.3, Map 2 and Map 2a – 2h.

APPENDIX F

IRRIGATION APPLICATION SYSTEM, SCHEDULING CONCEPT AND CENTRALISED CONTROL SYSTEM

- 1 Irrigation Application System
- 2 Irrigation Scheduling Concept
- 3 Irrigation Centralised Control System

TABLE

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| Table F1 | Application System For Each Plant Group |
| Table F2 | Adjustment In Head Spacing For Wind Conditions |
| Table F3 | Maximum Precipitation Rate Based On Soil and Slope Type |
| Table F4 | Emitter Flow Rate With Proper Emitter And Lateral Spacing For Different Soil And Plant Types |
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FIGURE

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| Figure F1 | Schematic Diagram Of Block System |
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**IRRIGATION APPLICATION SYSTEM, SCHEDULING CONCEPT
AND CENTRALISED CONTROL SYSTEM**

1. Irrigation Application System

1.1 Watering System

Two types of watering system which are commonly used are the Spray System and Drip System. These systems are preferred as they are more suitable in its application at Putrajaya which could cover large lawn areas as well as landscape areas. The spray system is generally used for the grass areas, groundcovers, low shrubs and short species herbaceous plants; whereas drip system is utilized for the shrubs, seedlings and saplings, trees and palms. The system generally used for the various plant types are as tabulated in Table F1.

1.1.1 Spray System

Sprinkler or spray system refers to the system which accomplishes water distribution in a form of stream or fine spray by forcing water flowing through sprinklers having a nozzle orifice. There are many types of sprinklers available for different areas of coverage and rates of application. Two types of sprinklers that are suitable for Putrajaya applications are: 1) spray sprinkler; 2) rotary sprinkler.

Both the spray and rotary sprinkler systems are much the same in its basic design, but varying primarily in size and type of equipment and piping used, spacing of the sprinklers, and the methods of operation control.

Sprinkler Head

Sprinkler head is used to direct water to a specified area. Two types of sprinklers head identified are *Spray Head* and *Rotary Head*.

Spray heads are stationary and discharge water continuously in the form of a fine, uniform spray that resembles small droplets or individual jets. The heads are popped out of the ground by water pressure and spray water in pattern of nozzle selected. When the pressure stops, the heads retract back to grade level and do not provide any obstructions. A spray head

is limited as to the distance it can throw a circle of water, usually up to a maximum radius of from 2 to 5 m.

Rotary heads utilise slow-rotating, high velocity streams to distribute water over relatively large circular or part circular areas. The heads rotate to throw water evenly over the distribution area, and the arc can be adjusted. Because rotary heads throw water in a concentrated stream(s), they can throw water greater distances than spray heads. Diameter of coverage ranges from 10 m to over 60 m.

Generally, the following specifications of sprinkler heads shall be considered:

- Non-metalline material to be used for body and riser. Non-corrodible heavy-duty plastic is recommended.
- Pop up feature to be incorporated.
- Low head drainage prevention check valve to be used.
- Non-portable alert covers to be provided. "Purple" is the standard colour code used for indicating the use of non-portable water.

Design Considerations

The design considerations are as follows:

i) *Sprinklers selection*

The sprinkler heads are the most visible and critical of the components making up the irrigation system. Selection of sprinkler heads to be used depends upon the following criteria:

- Size and shape of the area to be irrigated.
- Types of plants to be irrigated.
- Water pressure and flow availability.
- Required rate of head discharge.
- Compatibility of sprinkler type with others in area.
- Obstructions preventing proper distribution of water.
- Serviceability and dependability.
- Client preferences.

ii) *Distribution uniformity*

Distribution of water to each area of coverage should be as uniform in application as possible. A coefficient is used to measure the uniformity of coverage. This coefficient is designated as the Christiansen Coefficient or Uniformity Coefficient (C_u) and is defined by the equation,

$$C_u = 100 \times \left(1.0 - \frac{\sum x}{m n} \right)$$

In which x is the deviation of individual observations from the mean value m and n is the number of observations. $\sum x$ is the sum of the deviations of the individual observations from the mean value.

An absolutely uniform application is represented by a uniformity coefficient of 100 percent; a less uniform application by some lower percentage.

This coefficient is more important for large spray sprinklers of radius more than 15 m. A uniformity coefficient of 80% and above is recommended.

iii) *Spacing patterns and distances*

The amount of water applied to an area decreases as the distance from sprinkler increases. In order to obtain a reasonable uniformity of application, sprinkler heads should be placed so that adjacent sprinklers overlap each other and the end of the spray radius of one head hits the adjacent head's spray. The overlapped spacings are based on a percentage of sprinklers' measurable wetted diameter. Sprinkler heads can be located in either a square or triangular pattern. The triangular method results in wider spacing and is usually better for irregular boundaries.

Table F2 shows the adjustment spacing recommended for estimated wind conditions.

iv) *Precipitation rate*

The precipitation rate (PR) of individual sprinkler operating zones is an important factor for design and system operation. Precipitation rate describes the length of time required to deposit a given depth of water on an area. PR is normally measured in inches per hour .

The following formula is used to derive the precipitation rate in inches per hour.

$$\text{Precipitation Rate in inches per hour} = \frac{96.3 \times \text{the total gpm in a given area}}{\text{Square feet of the area being covered}}$$

The figure 96.3 above is a constant that helps to convert the gallons per minute (gpm) and the square feet of the area being sprinkled into an inches per hour figure.

v) *Soil and slope type*

Soil is composed of particles of sand, loam, clay, and organic matter. The speed that at which the water travels deeper into the soil structure varies with the texture and structure of the soil, and is called the *percolation or infiltration rate*.

There are two considerations that affect the soil's infiltration rate. They are the composition of the soil and the slope of the soil. The application rate of water should be kept below the infiltration rate of the soils to avoid occurring of surface runoff.

Table F3 lists the maximum precipitation rate based on soil and slope type.

vi) *System efficiencies*

More water than the actual amount absorbed into the ground must be discharged by the sprinkler system due to the following distribution inefficiencies:

- Water is lost through evaporation into the air from the time it is discharged from the head until it lands on the ground. This loss is greater during the daytime than at night.
- Loss of water through wind drift must be allowed for.
- System is rarely shut off at the exact instant that the soil demand has been satisfied.
- Water should not be applied faster than the infiltration rate of the soil (the rate at which the soil can accept the water), otherwise water will be lost through runoff on the surface of the ground. The infiltration rate and the slope of the land determine the maximum infiltration rate.

- The difference in water pressure between the first head in any branch and the last head causes the head with less pressure to discharge less water. Good practice calls for a maximum difference of 10 percent.
- Plant water demand

1.1.2 *Filtration System*

Filtration of the source water is necessary to prevent the damaging effects of dissolved and suspended solids which can clog water outlets, damage components or cause failure of moving parts. Automatic self-cleaning screen filter units are proposed to be the filtration equipment for the spray system.

1.1.3 *Drip System*

Drip irrigation or “trickle irrigation” refer to slow application of water through mechanical devices called emitters (drippers or applicators) located at selected points along water delivery lines to the root zone of a plant. The objective of drip irrigation is to frequently supply each plant with sufficient soil moisture to meet evapotranspiration demands.

Emitter

The emitter acts as the sprinkler head for the drip method of watering. Water is sent under pressure in a tube and the emitter controls the flow to the soil. Two types of emitters are identified to be relevant for Putrajaya application, i.e. *on-line* and *in-line* emitter.

On-line emitters have a “barbed” inlet port which is inserted through a hole in the hose. They are generally inserted into the hose after the hose has been laid out in the field. This includes micro-jets which may utilise a barbed coupler.

In-line emitters are attached or welded to the inside of the hose, with a hole provided in the hose for the flow discharge. They cannot be seen unless the hose is cut apart.

Generally, the following specifications of emitters shall be considered:

- Resistance to sunlight. Housing constructed of durable, UV resistant plastic is recommended.
- Pressure compensating mechanism to be incorporated.

- Self-flushing action to minimise clogging.
- Anticipated life for at least two years.

Design Considerations

Objective of good drip irrigation system design and management is to provide sufficient system flow capacity to adequately irrigate all the plants. The four important design considerations are as follows:

i) *Water quality*

Water quality is an important consideration in drip design to prevent emitter plugging. Drip systems have very small outlets, ranging from about 0.3 mm – 1.8 mm in diameter. A rule of thumb in the drip design is that all particles greater than 1/10 the diameter of the emission holes must be removed from water to prevent clogging. Therefore, drip filtration must remove particles down to the 0.03 mm - 0.18 mm diameter size.

ii) *Soil Types*

For design purposes, soil classifications of clay (heavy), loam (medium) and sand (light) are used in conjunction with plant types to determine the emitter and lateral spacings necessary to provide a uniform subsurface soil moisture regime for the plant material.

Drip emitters create different subsurface wetting patterns in different soil types. The wetted area on the surface and the shape of the wetted pattern below surface are influenced by the type of soil. The wetted pattern of soil will affect the selection of emitter (application rate), emitter spacing and the operating time.

As with all types of landscape irrigation systems, properly prepared soil is necessary to provide a homogenous bed for proper plant establishment, plant growth and uniform water distribution. Heavily compacted and layered soils should be ripped and tilled at a uniform eight- to twelve-inch depth to improve the consistency and tilth of the soil.

Table F4 shows the emitter flow rate with proper emitter and lateral spacing for different soil and plant types.

iii) *Plant Types and Layout*

Emitter and lateral spacings are determined by soil and plant material classifications. Planting layouts determine the size and type of subsurface irrigation design necessary to provide uniform moisture distribution.

Narrow, linear tree and shrub plantings require narrow, linear subsurface grids consisting of two to four laterals. More intense plantings that provide a complete foliage canopy at maturity require a grid design that applies uniform moisture levels within the foliage canopy (turf, groundcover, and dense shrub and tree plantings).

Table F4 shall be used as a guideline to determine the proper emitter and lateral spacing.

iv) *Slope and elevation differences*

Driplines should be located parallel to the contour of slopes whenever possible. Since subsurface runoff occurs on areas with a slope of greater than 3%, consideration must be given to dripline density from the top to the bottom of the slope. The dripline on the top two-thirds of the slope should be placed at the recommended spacings for the soil type and plant material in use. On the lower one-third, the driplines should be spaced 25% wider. The last dripline can be eliminated on slopes exceeding 5%. For areas exceeding ten feet in elevation change, zone the lower one-third of the slope separately from the upper two-thirds in order to help control drainage.

When utilising non-pressure-compensating dripline, elevation differences of five feet or more require separate zones or individual pressure regulators for each six-foot difference on uniform slopes.

When working with rolling landscapes with elevation differences of five feet or more within a zone, it is best to use pressure-compensating dripline to equalise pressure differentials created by the elevation differences.

Subsurface irrigation zones must have a vacuum relief valve at the highest point in order to eliminate the vacuum created by low-line drainage, which causes soil ingestion. This is especially crucial when the dripline laterals are placed

perpendicular to the contour of the slope as in street medians. All dripline laterals within the elevated area must be connected with an air relief lateral.

In-line spring-check or swing-check valves should be used on slopes where low-line drainage could cause wet areas in the lowest areas of an irrigation zone

Filtration System

Most water must be as clean as drinking water to be used in drip system. To accomplish this, two stage of filtration design is introduced. Sand media filter is considered as the initial filtration process after pump; followed by the disc strainer located at the connection point between dripper lines and lateral lines.

Water Quality

Quality standards have been recommended for irrigation that are as complete as those issued for portable water. Table F5 lists recommended maximum levels of trace constituents in irrigation water.

Owing to the large volume of water used for crop irrigation generally, water treatment for removal of specific constituents has historically been considered uneconomical. For the most part, the only treatment being practised is threshold treatment for (1) scale control in distribution systems and (2) to prevent calcium carbonate precipitation in flume water to which ammonia has been added as a fertiliser. The addition of ammonia to irrigation water with a positive Langelier index may cause calcium carbonate to precipitate, but this can be controlled by the use of polyphosphates. In the newer drip-irrigation systems, where very small volumes of water are brought to individual plants, because of the small flow through the individual distribution units, plugging is an ever-present threat. Clarification, treatment with dispersants, application of biocides, or a combination of these may be necessary to keep the system functioning.

The use of municipal sewerage plant effluent for irrigation of croplands can serve both the municipality and agricultural interests. Spray irrigation has proved to be an effective tertiary treatment for both municipal and certain industrial wastes such as food processing wastes. There will undoubtedly be increased use of waste effluents for irrigation. However, the tertiary treatment system required at the sewage treatment plant to treat the effluent can be expensive in order to meet the quality suitable for the irrigation system.

2. Irrigation Scheduling Concept

Irrigation scheduling concept refers to the methodology which are chosen to run the watering system. The concept chosen affects not only the sprinklers or drippers but also the valves, pipe and fittings and control lines. The three basic concepts are as follows:

- Block System
- Valve-In-Head System
- Quick Coupling System

2.1 Block System

The block system is the most common and appropriate system proposed for Putrajaya application. The block system is simply a branch with several sprinklers or drippers and is controlled by a valve. Figure F1 illustrates the schematic diagram of a block system.

Advantage of block system includes less usage of individual valves and control lines. However, it is realised that the block system applied in vast areas is impractical due to the large components required. Large valves are often not available or extremely expensive.

Considering the cost and availability of spares, the 50 mm diameter is preferred as the optimum size of the system. The favoured size is sufficient for most application unless highlighted for special applications.

2.2 Valve-In-Head System (VIH)

The Valve-In-Head (VIH) system is a special technique used primarily in large area irrigation which originated with the placement of a remote control valve in the riser assembly below each large rotary sprinkler to allow individual automatic control. Using one valve per sprinkler, the maximum flexibility can be achieved. The pipes and fittings size can be standardised and dispensation of large, unwieldy and expensive valves. However, the system requires many additional control stations and control lines. Moreover, each extra valve represents some level of future maintenance and repair. Figure F2 shows the schematic diagram of VIH system.

2.3 Quick Coupling System

The quick coupling system refers to the system that consists of several tapping points or coupler valves which can be coupled on with relative ease with a hose or sprinkler. This system requires manpower to move hoses or sprinklers from locations to locations. The matching coupler or sprinkler is forced into the coupler valve, opening it and allowing water to flow through the coupler valve. The system is not recommended as a main system but shall be used extensively to complement the block or VIH system.

The system is used frequently as a temporary mean of watering areas such as areas to be re-developed at a later date. The system also fits into areas where supplemental watering is required. Besides, the system is installed on pressure mains of a system to provide water for a myriad of uses other than normal sprinkling. For instance, deep-watering for newly planted trees.

3. Irrigation Centralised Control System

3.1 System Overview

Irrigation Centralised Control (ICC) system proposed for Putrajaya is a computer driven central management and control system for irrigation water management.

Irrigation Centralised Control (ICC) is a driven central management and control system for irrigation water management. ICC is capable of monitoring as well as controlling irrigation scheduling according to data received by external sensing devices. ICC mainly consists of, in control descending order:

- **Central Computer** – This is a software based controller used to monitor and control the entire irrigation system.
- **Field Controller** – Executes field device by sending out high signals upon receiving directives from ICC.
- **Field Devices**
 - Sub-Controllers provides signals for control outputs for valve station monitoring.
 - Valve Actuators provides hardwire or wireless Command only receiver for irrigation valve actuating.
 - Valve Station refers to signal operated valves.

Two transmission path options are proposed for the ICC system. Radio communication allows data transmission through radio frequencies; while hardwire communication provides data transmission through wireline.

3.2 System Configuration Layout

Irrigation Centralised Control (ICC) system shall offer a “two layer” design, one layer links a central computer to one or more Field Controller, the other layer links a Field Controller to Field Devices i.e. Sub-Controller, Valve-Actuator and Valve-Station. System may be installed with just Field Controller communicating with Field Devices as a first step, later on

adding the central computer control. This provides a maximum flexibility for staged development of Putrajaya. The system shall have an adequate capacity to meet the demand of Putrajaya.

Figure F3 illustrates the layout of Irrigation Centralised Control System.

3.3 Typical ICC Scheme Within The Field Controller And Field Devices

The master central computer monitors and controls the slave field controller units. The central computer allows upload, change and download irrigation programs to any linked field controller unit. Signals received from the central computer will be used to perform subsequent irrigation cycles by the field controller. Similar as above, data will be transferred to begin or stalled certain irrigation cycle. The field controller unit is capable of controlling various field devices distributed over a specific area. Data or high signal will instruct the Field Devices to begin irrigation cycle.

3.4 Typical ICC Scheme Within The Central Computer

Data acquired from Decision Support System (DSS) will be taken into account for the rescheduling of all irrigation cycle. Watering window for all cycles will be reschedule to suit the site condition. Depending on the weather condition received from DSS, certain irrigation cycle will not be carried out. Water conservation too shall be determined from the DSS input.

3.5 Data Acquisition from Decision Support System (DSS)

DSS is proposed to gather relevant information namely soil moisture, rainfall, evaporation etc. All data acquired shall be in the form of software to be interfaced with the ICC. A minor SCADA working platform forms the element for DSS-ICC. ICC will gather all information obtained from DSS and reschedule the necessary to suit the present condition of data acquisition.

3.6 Irrigation Watering Windows

“Watering windows” refers to the time frame allows for irrigation watering. It is one of the major design considerations for the sizing of pipe and pump capacity, and scheduling of water management. The allowable watering windows is proposed as follows:

- i) Drip system - 24 hours

- ii) Spray system
 - Public access area - 8 hours (10pm – 6 am)
 - Non-public access area - 12 hours (7pm – 7 am)

Table F1 Application System for Each Plant Group

Group of Plant	Application System
Tree	Drip system
Palm	Drip System
Shrub - less than 0.3m high - more than 0.3m high	Spray System Drip System
Groundcover and Lawn	Spray System

Table F2 Adjustment in Head Spacing for Wind Conditions

Wind Velocities	Maximum Spacings
0 to 3 m/hr	60% of diameter
4 to 7 m/hr	55% of diameter
8 to 12 m/hr	50% of diameter

Table F3 Maximum Precipitation Rate Based on Soil and Slope Type

Soil texture	0 to 5% slope	5 to 8% slope	8 to 12% slope	12%+ slope
Coarse sandy soils	2.00	2.00	1.50	1.00
Coarse sandy soils over compact subsoils	1.75	1.25	1.00	0.75
Light sandy loams uniform	1.75	1.25	1.00	0.75
Light sandy loams over compact subsoils	1.25	1.00	0.75	0.50
Uniform silt loams	1.00	0.80	0.60	0.40
Silt loams over compact subsoil	0.60	0.50	0.40	0.30
Heavy clay or clay loam	0.20	0.15	0.12	0.10

Table F4 Emitter Flow Rate with Proper Emitter and Lateral Spacing for Different Soil and Plant Types

Soil And Plant Type	Emitter Flow	Emitter Spacing	Row Spacing
Medium Sand - Trees or Shrubs	3.8 l/h (1.0 USg/h)	300mm (12")	450mm (18")
Loam - Trees or Shrubs	3.8 l/h (1.0 USg/h)	450mm (18")	450mm (18")
Clay - Trees or Shrubs	1.9 l/h (0.5 USg/h)	600mm (24")	600mm (24")

Source: *TORO Inc.*

Table F5 **Recommended Maximum Concentrations of Trace Element in Irrigation Water**

Element	Maximum concentrations In irrigation water, mg/L
Aluminium	5.000
Arsenic	0.100
Beryllium	0.100
Boron	0.750
Cadmium	0.010
Chromium	0.100
Cobalt	0.050
Copper	0.200
Fluoride	1.000
Iron	5.000
Lead	5.000
Lithium	0.075
Manganese	0.200
Molybdenum	0.010
Nickel	0.200
Selenium	0.020
Vanadium	0.100
Zinc	2.000

Source: *The Nalco Water Handbook*

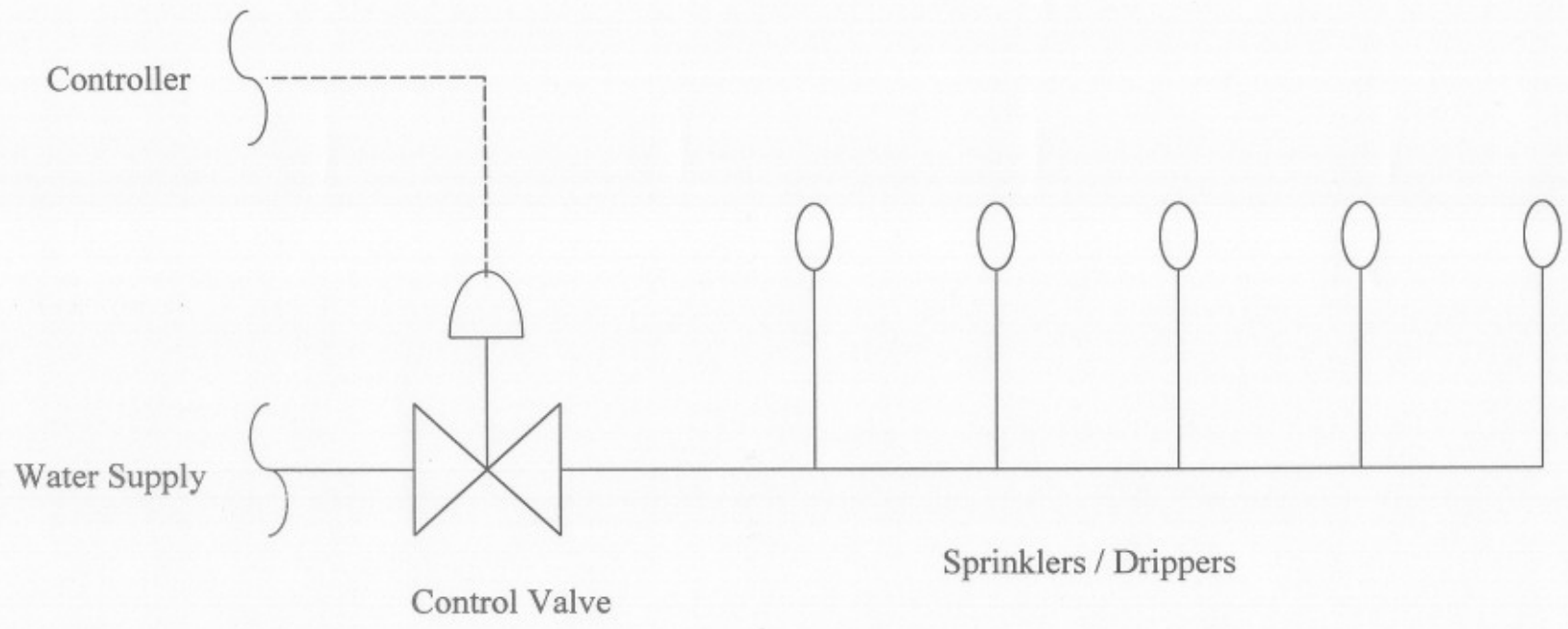


Figure F1 Schematic Diagram of Block System

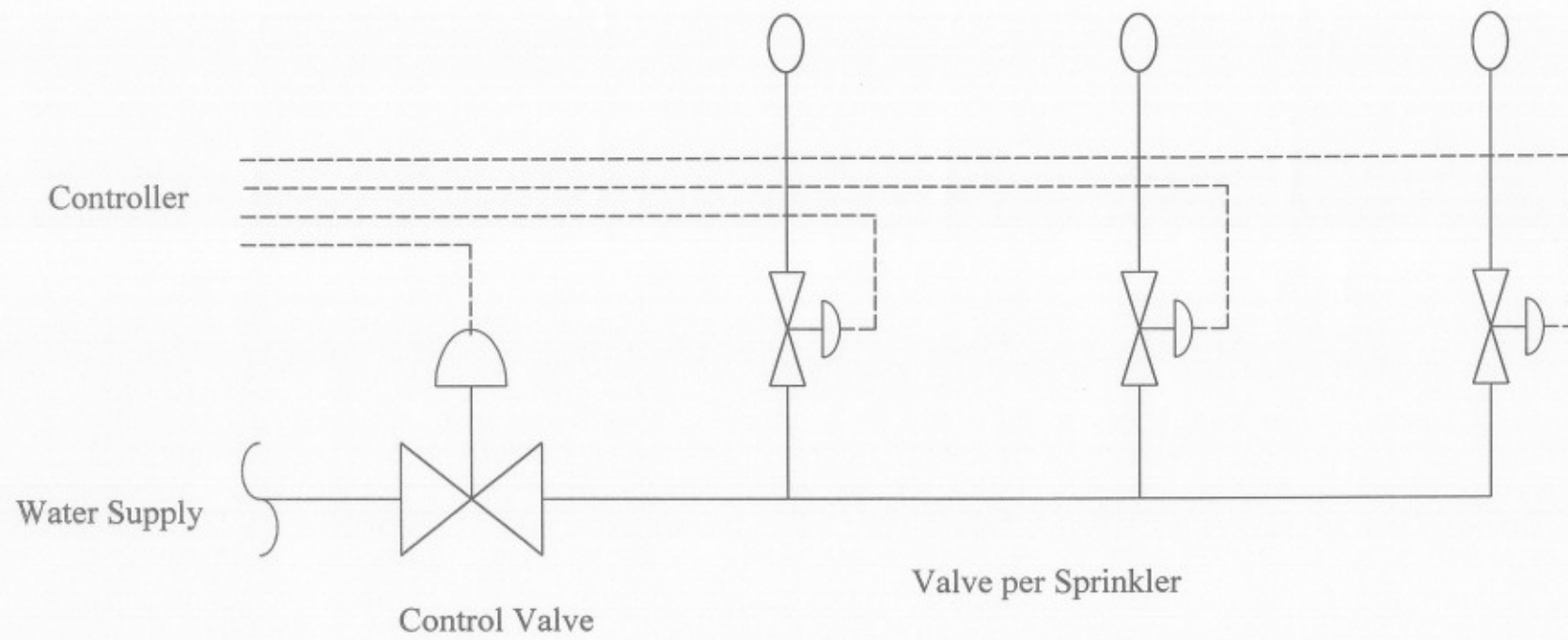


Figure F2 Schematic Diagram of Valve-In-Head System

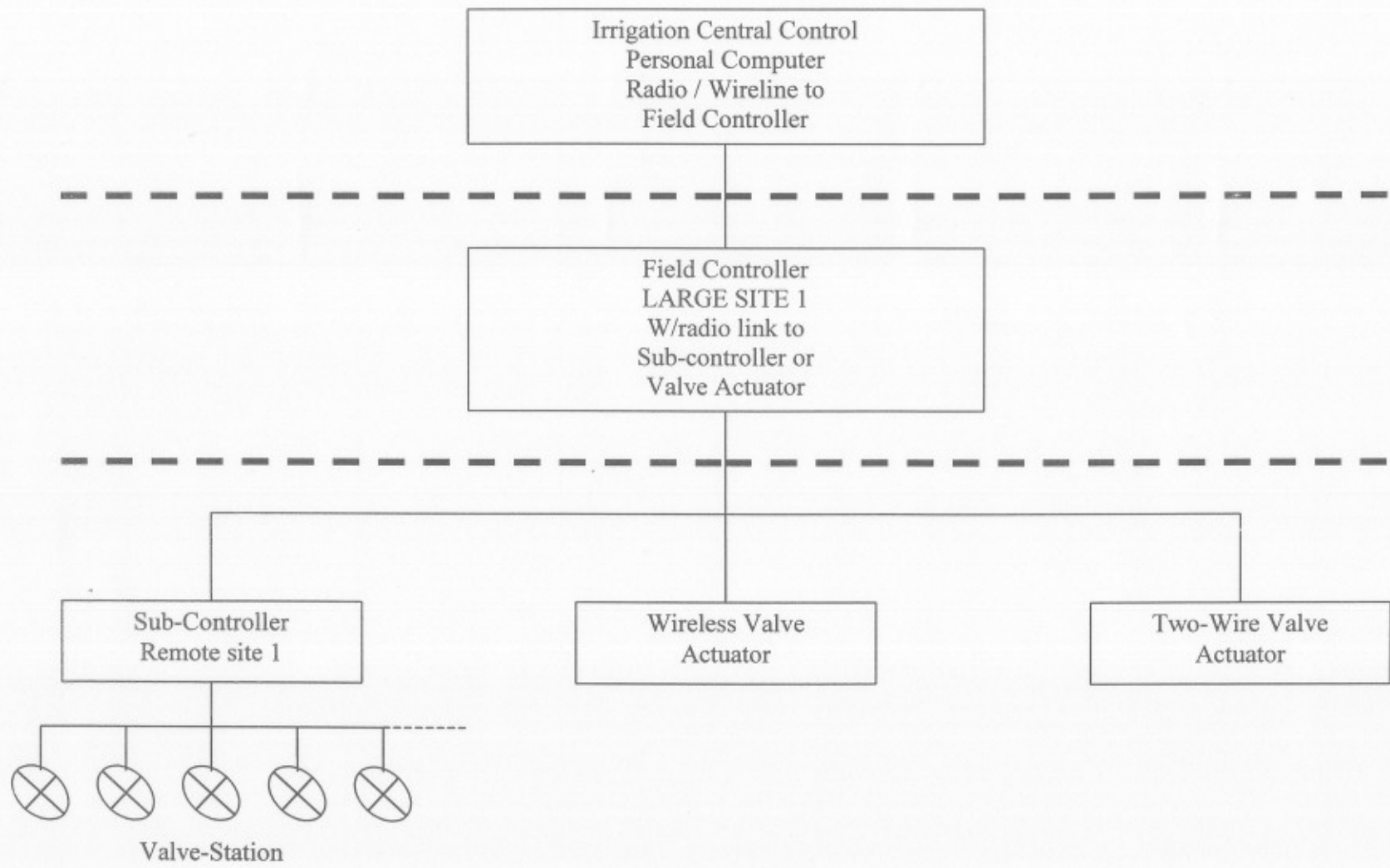


Figure F3 Irrigation Centralised Control System Layout

APPENDIX G

PROVISION UNDER WATERS ACT, 1920 (REVISED 1989)

- 1 Introduction
- 2 Interpretation of "river" includes
- 3 Property in rivers
- 4 Restoration of a river banks
- 5 Prohibition of acts affecting rivers, except under license
- 6 Prohibition of diversion of water from rivers, except under license
- 7 Prohibition of pollution of rivers
- 8 License to divert water may authorise interference with State land or alienated land
- 9 Fees Licensing

PROVISION UNDER WATERS ACT, 1920 (Revised 1989)

1. Introduction

It is expected that the provisions under the Waters Act will be the key factor during the implementation of the Irrigation Master Plan. Key Provisions of the Waters Act are reported as follows:

2. Interpretation of "river" includes

- (a) a tributary of a river and any other stream or natural water course; and
- (b) any canal declared by the State Authority of the State in which such canal is situated by notification in the Gazette to be subject to this Act;

3. Property in rivers

Subject to the terms of any express grant made by or on behalf of the Ruler of a State; the entire property in and control of all rivers in any State is and shall be vested solely in the Ruler of such State; provided that in the case of lands by the Government under grant or lease or reserved for a public purpose and maintained by a Government Department, such control may be exercised by the Head of such Department, under the direction of the State Authority.

4. Restoration of a river banks

Any person who shall in any State interfere with the bank of any river may by order of the State Authority be required to restore the same to the condition in which it was immediately prior to such interference or to remake the same in such manner as may be specified in such order.

5. Prohibition of acts affecting rivers, except under license

No person shall, except under and in all accordance with the terms of a license under this Act;

- (a) fell any tree so that it falls into a river;
- (b) in any manner obstruct or interfere with any river;
- (c) build any bridge, jetty, or landing stage (other than a bath-house) over or beside any river at a point where the width of such river exceeds twenty feet.

Licenses to do in any district any of the acts specified may be issued by the District Officer of such district with the approval, in each case, of the State Authority, any such license may be subject to such conditions and restrictions as the State Authority approves; all such conditions and restrictions shall be set out in the license.

6. Prohibition of diversion of water from rivers, except under license

Save as may be expressly authorised under the provisions of any other law no person shall, except under and in accordance with the terms of a license under this act, by means of any ditch, drain, channel, pipe, or otherwise divert water of any river from its natural course.

Whenever any such diversion shall have been made, the occupier or occupiers of the lands (if any) benefited by such diversion shall, in the absence of proof to the contrary, be presumed to have made it.

Licenses to divert water from a river in any State for use in the generation of electricity may be granted by the State Authority of such State.

Licenses to divert water from a river in any district for use:

- (a) for private or domestic purposes;
- (b) in the cultivation of rice;
- (c) for industrial and other purposes,

maybe granted by the District Officer of such district with the approval, in each case of this subsection, of the State Authority.

Every license granted under this section shall set out the purpose for which the same is granted and shall be for such period and subject to such conditions and restrictions as may be stated therein.

7. Prohibition of pollution of rivers

Save as may be expressly authorized under any written law or the terms of any express grant made by or on behalf of the State Authority no person shall except under and in accordance with the terms and conditions of license issued under this section cause to enter or discharge into any river:-

- (a) any poisonous, noxious or polluting matter that will render or is likely to render or contribute to rendering such river or part thereof harmful or detrimental or injurious to public health, safety or welfare, or to animal or vegetable life or health or to other beneficial uses of such river;
- (b) any matter which by virtue of its temperature, chemical or biological content or its effect in discolouring the waters makes or contributes to making such river or part thereof a potential danger to public health, safety or welfare or to animal or vegetable life or health, or affects other beneficial uses of such river;
- (c) any matter which by virtue of its physical nature, or its effect in discolouring waters, makes or contributes to making such water, difficult to treat; or
- (d) oil of any nature, used, waste or otherwise.

For purpose of this section the word "river" shall without prejudice to be deemed to further include-

- (a) any inland waters whether or not such inland waters fall within the definition of "river" in section 2;
- (b) any subterranean water resources; and
- (c) any water in an estuary or sea adjacent to the coast of the State.

Whenever any such entry or discharge shall have been made, the owner or occupier of the property from which such entry or discharge originates shall, in the absence of proof to the contrary, be presumed to have made it.

- (1) License to enter or discharge into a river any of the matter described of this section may be granted by the State Secretary in which the river or part thereof is located.

- (2) Every license granted under this section shall set out the purpose for which the same is granted and shall be for such period and such conditions and restrictions as may be laid down in the license.

8. License to divert water may authorise interference with State land or alienated land

- (1) A license under this Act to divert water from a river in any State may extend to authorising the licensee to erect, cut, or construct and maintain upon or through any State lands or alienated lands specified in that behalf in the license any pump, line of pipes, flume, race, drain, dam, or reservoir and, subject to such conditions and restrictions as may be specified in the license, to take and use the water therefrom in such quantities and in such manner as in the opinion of the State Authority of such State may be necessary for carrying out the purpose of the license.
- (2) A license so authorised as aforesaid may enter upon the State lands or alienated lands so specified as aforesaid for the purposes expressed in such license and carry out all or any of the works thereby sanctioned and exercise all or any of the rights thereby granted; provided that he shall be liable to make compensation to the owner or lawful occupier of any alienated land upon which such work shall be carried out or such rights exercised.

9. Fees Licensing

There shall be payable in respect of every license under this Act in any State such annual fee as may be prescribed, or if no such annual fee be prescribed then, such annual fee as the State Authority may impose.

APPENDIX H

Checklist for Development Approval

- Form SA (Pindaan 1)
- Form SA1 (Pindaan 1)
- Form PB (Pindaan 1)
- Form PB1 (Pindaan 1)
- Form PBS1 (Pindaan 1)
- Lampiran B(i) (Pindaan 1)
- Lampiran B(i) (Pindaan 1)

FORM SA (Pindaan 1)

**Senarai Semakan Permohonan untuk Permohonan Kebenaran Merancang Bagi Kelulusan
Susun Atur (Seksyen 21, Akta Perancangan Bandar dan Desa, 1976)**



PERBADANAN PUTRAJAYA

PERMOHONAN KEBENARAN MERANCANG BAGI PENDIRIAN BANGUNAN SEMENTARA
{Seksyen 21(3) Mengenai Pendirian Bangunan, Akta Perancangan Bandar dan Desa, 1976}

Tajuk Projek :

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.....
.....

Tarikh Penerimaan

SENARAI SEMAKAN PERMOHONAN

NAMA FAIL

1. Permohonan hendaklah disertakan dengan surat rasmi (cover letter) daripada Jururancang/Arkitek Bertauliah

SA_SURAT_
RASMI.TIF

2. Melengkapkan Borang A yang diisi dengan lengkap (Jadual Pertama Kaedah Kawalan Perancangan Am)

SA_BORANG_A.
TIF

3. Satu (1) salinan suratan hak milik.

SA_HAK_MILIK.
TIF

4. Satu (1) salinan Surat Perlantikan perunding.

SA_LANTIK_
RUNDING.TIF

5. Satu (1) salinan profil syarikat perunding.

SA_PROFIL_SYKT.
TIF

6. Mengemukakan dua (2) salinan Laporan Cadangan Pemajuan ketika mengemukakan permohonan.

Mengemukakan lapan (8) salinan untuk pengesahan (endorsement) apabila diarahkan oleh Perbadanan.

(Kandungan serta format laporan yang dikemukakan hendaklah mengikut format Senarai Semakan SA2)

(Laporan Cadangan Pemajuan perlu disediakan dan disahkan oleh Jururancang Bandar Bertauliah)

7. Mengemukakan dua (2) salinan termasuk satu (1) linen pelan-pelan berikut ketika mengemukakan permohonan.

Mengemukakan lapan (8) salinan termasuk satu (1) linen untuk pengesahan (endorsement) apabila diarah oleh Perbadanan.

(Pelan-pelan yang dikemukakan hendaklah mengikut format berikut:-)

- a) *Sempadan Presint bagi semua Pelan hendaklah berdasarkan bacaan koordinat, 'bearing' dan jarak.*
- b) *Sempadan lot (berdasarkan nombor PT) hendaklah ditunjukkan.*
- c) *Skala : 1:2000*
- d) *Pelan-pelan/ lukisan hendaklah disahkan oleh ahli profesional yang berkaitan.*
- e) *Pelan-pelan tersebut perlu diwarnakan dan dijilid bersama.*
- f) *Lukisan perspektif seperti di para 12 (bersaiz A3) perlu ditampal di atas kertas bersaiz A1/A0 berserta tajuk projek sebagai kulit luar Pelan-pelan yang dijilid bersama).*

7.1 Pelan Susun Atur

Pelan tersebut perlu mempamerkan Pelan Kunci (keseluruhan Putrajaya), Pelan Lokasi (Presint berkenaan dan Presint bersebelahan), Pelan Susun Atur dan Jadual Cadangan Gunatanah (Pelan-pelan perlu disahkan oleh Jururancang Bertauliah)

SA_SUSUN_ATUR.
DXF

7.2 Pelan Analisa Kecerunan

Merangkumi perkara seperti Senarai Semakan SA1, para 3.11. (Pelan perlu disahkan oleh Jurutera Bertauliah)

SA_KECERUNAN.DXF

7.3 Pelan Kerja Tanah

Merangkumi perkara seperti Senarai Semakan SA1, para 5.2. (Pelan perlu disahkan oleh Jurutera Bertauliah).

SA_KERJA_TANAH.
DXF

7.4 Pelan Infrastruktur dan Utiliti (Pelan Jajaran)

7.4.1 Pelan Pengangkutan/ Sistem Sirkulasi (Trafik, Laluan Basikal & Pejalan Kaki dan Pengangkutan Awam)

SA_PENGGANGKUTAN.
DXF

7.4.2 Pelan Saliran & Perparitan

SA_SALIRAN.DXF

7.4.3 Pelan Pembetulan

SA_PEMBETUNGAN.
DXF

7.4.4 Pelan Bekalan Elektrik

SA_BEKALAN_
ELEKTRIK.DXF

7.4.5	Pelan Bekalan Air	SA_BEKALAN_AIR.DXF
7.4.6	Pelan Telekomunikasi	SA_TELEKOM.DXF
7.4.7	Pelan Bekalan Gas	SA_BEKALAN_GAS.DXF
7.4.8	Pelan 'Gas District Cooling' (GDC)	SA_GDC.DXF
7.4.9	Pelan Kemudahan Sisa Pepejal	SA_SISA_PEPEJAL.DXF
7.4.10	Pelan Utiliti Hub	SA_HUB.DXF
7.4.11	Pelan 'Common Utiliti Trench' (CUT)	SA_CUT.DXF
7.4.12	Pelan Pengairan	SA_PENGAIRAN.DXF
7.6	Pelan Konsep Landskap (<i>Pelan perlu disahkan oleh Arkitek Landskap Bertauliah</i>)	
7.6.1	<i>Taman dan Kawasan Lapang</i>	
i.	Pelan Landskap Lembang	SA_LSKP_LEMBUT.DXF
ii.	Pelan Landskap Pejal (Perabut Kelengkapan Landskap, Papan Tanda, Pagar, Kemudahan Rekreasi, Landskap Berciri Air, Sirkulasi Pejalan Kaki & Basikal)	SA_LSKP_PEJAL.DXF
iii.	Pelan Landskap Pencahayaan	SA_LSKP_PENCAHAYAAN.DXF
iv.	Pelan Pengairan	SA_LSKP_PENGAIRAN.DXF
7.6.2	Koridor/ Rangkaian Hijau	SA_LSKP_KORIDOR_HIJAU.DXF
7.6.3	Jalanan Pejalan Kaki	SA_LSKP_JALAN_KAKI.DXF
8.	Satu (1) salinan lukisan perspektif (bird's eye view) (<i>format penyerahan rujuk lampiran A</i>)	SA_PERSPEKTIF.TIF

9. Model cadangan pembangunan, sila kemukakan salah satu dari berikut:

9.1 Model susun atur
(format penyerahan rujuk Lampiran B)

PBS_SENIBINA.DOC

9.2 Model berkomputer (3D simulation ataupun virtual reality)

SA_MODEL_3D.DXF

10. Surat-surat dan ulasan berserta pelan-pelan pengesahan agensi/ syarikat utiliti berkaitan:-

10.1 Bekalan Air (Jabatan Bekalan Air Selangor)

SA_SURAT_AIR.TIF

10.2 Telekomunikasi (Telekom Malaysia Berhad)

SA_SURAT_TELEKOM
.TIF

10.3 Chilled Water (GDC) - P1, P2, P3, P4, P5, P7 & P8 (Sub Commercial Centre)

SA_SURAT_GDC.TIF

10.4 Sisa Pepejal (Alam Flora Sdn. Bhd.)

SA_SURAT_SISA_
PEJAL.TIF

10.5 Pembedungan (Jabatan Perkhidmatan Pembedungan)

SA_SURAT_
PEMBETUNGAN.TIF

10.6 Bekalan Gas (Gas Malaysia)

SA_SURAT_GAS.TIF

10.7 Bekalan Elektrik (Tenaga Nasional Berhad)

SA_SURAT_TNB.TIF

10.8 Bomba dan Penyelamat (Jabatan Bomba, Ibu Pejabat)

SA_SURAT_BOMBA.
TIF

10.9 Syarikat Konsesi 'Common Utility Trench'

SA_SURAT_CUT.TIF

11. Mengemukakan dua (2) salinan Laporan Ringkas Cadangan Pemajuan bersaiz A3 ketika mengemukakan permohonan

SA_RINGKAS_LCP.
DOC

Mengemukakan Lima Belas (15) salinan (10 salinan berwarna dan 5 salinan hitam/putih), sekurang-kurangnya tiga(3) hari sebelum Mesyuarat JKPP.

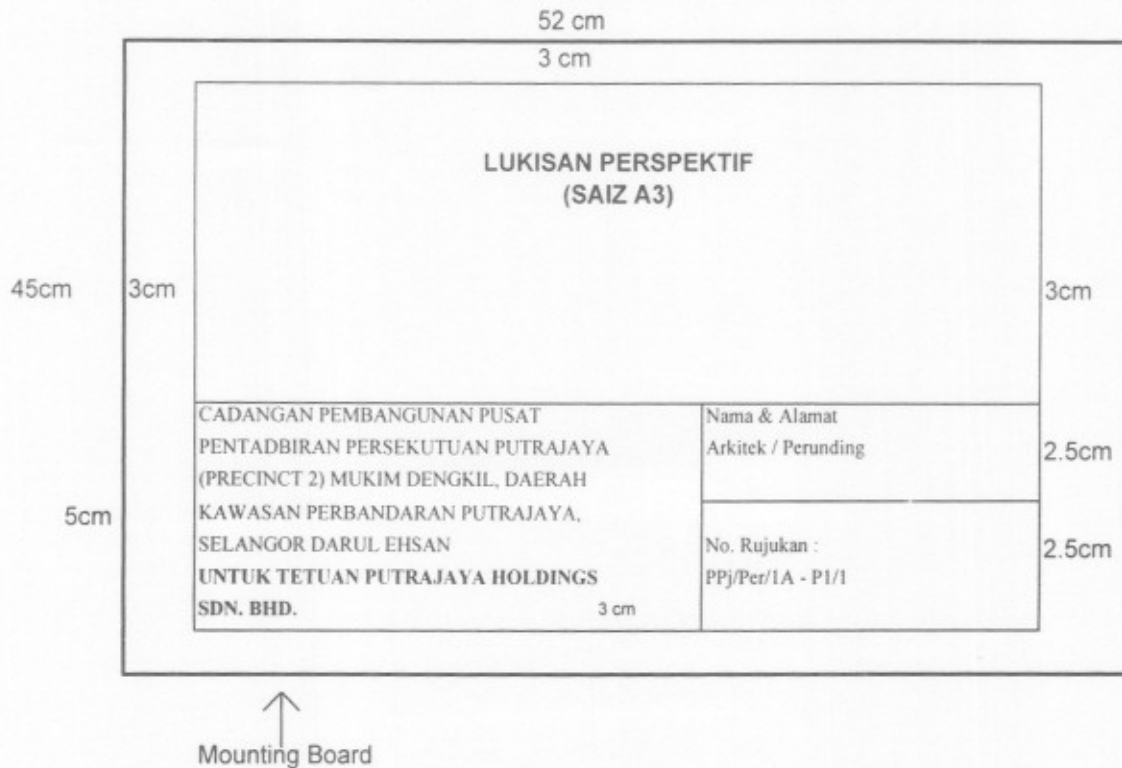
12. Satu (1) salinan Pelan Susun Atur dan Satu Salinan Lukisan Perspektif (bird's eye view) ditampal di atas 'mounting board' dan menggunakan saiz yang bersesuaian untuk taklimat semasa mesyuarat JKPP.

Nota:

 - Amendment

JABATAN PERANCANGAN B ANDAR
Perbadanan Putrajaya

Panduan Penyediaan Lukisan Perspektif Untuk
Permohonan Kelulusan Kebenaran Merancang



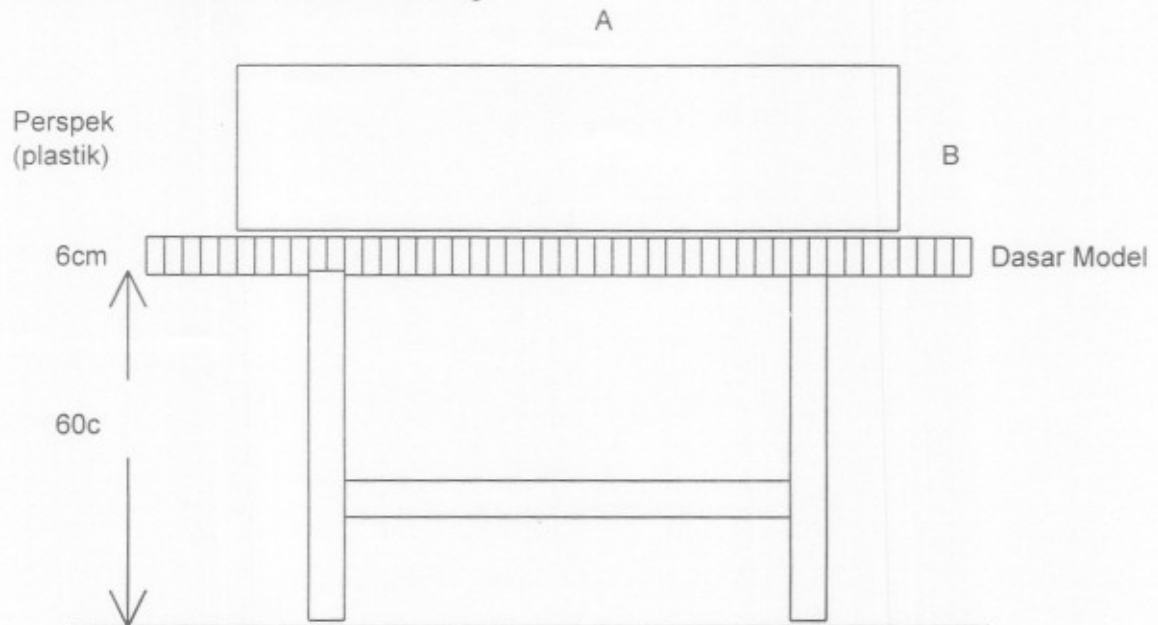
Syarat-syarat Am

1. Lukisan perspektif hendaklah diwarnakan dan disediakan di dalam saiz A3 (1 salinan).
2. Tajuk perspektif hendaklah mengandungi :-
 - i. Jenis cadangan pembangunan
 - ii. Alamat tapak cadangan
 - iii. Nama pemilik
3. Lukisan perspektif hendaklah disertakan nama dan alamat perunding dan nombor rujukan Perbadanan Putrajaya.
4. Ruangan tajuk lukisan perspektif hendaklah ditulis dengan tulisan hitam dan latarbelakang putih.
5. Lukisan perspektif hendaklah dilekatkan di atas 'mounting board' hitam dan ukuran sisi kelilingnya ialah 3cm lebar.
6. Setiap lukisan yang digunakan pada tajuk ialah 1cm dan hendaklah lebih besar daripada nama dan alamat perunding.
7. Lukisan perspektif yang dikemukakan adalah hak milik Perbadanan Putrajaya.

JABATAN PERANCANGAN BANDAR

PERBADANAN PUTRAJAYA

Panduan Penyediaan Model Untuk
Permohonan Kelulusan Kebenaran Merancang



A & B - Lebar dan tinggi perspek bergantung kepada skil model bangunan

Syarat-Syarat Am (Model)

1. Skala 1:3,000
2. Ikut sempadan Precinct
3. Model & dasar mesti boleh ditanggalkan (mudah alih)
4. Model tersebut hendaklah menunjukkan semua perkara yang dicadang berdasarkan pelan lulus termasuk pelan susun atur, landskap, 'footprint' bangunan, senitaman, kontor, perparitan dan infrastruktur.
5. Perspektif yang diperbuat dari plastik hendaklah dari jenis mudah alih.
6. Dasar model hendaklah diperbuat daripada kayu.
7. Model hendaklah disediakan oleh pembuat model yang dilantik oleh Perbadanan bagi tujuan penyeragaman pengkelasan penggunaan warna, bahan & reka bentuk supaya boleh dicantum-cantumkan.
8. Model yang diserahkan adalah hakmilik Perbadanan Putrajaya.

FORM SA 1 (Pindaan1)

**Senarai Semakan Permohonan untuk Permohonan Kebenaran Merancang Bagi Keluasan
Susun Atur (Seksyen 21(3), Akta Perancangan Bandar dan Desa, 1976)**

SA1 (Pindaan 1)



PERBADANAN PUTRAJAYA

PERMOHONAN KEBENARAN MERANCANG BAGI PENDIRIAN BANGUNAN SEMENTARA
{Seksyen 21(3) Mengenai Pendirian Bangunan, Akta Perancangan Bandar dan Desa, 1976}

Tajuk Projek :
.....
.....
.....

Tarikh Penerimaan

SENARAI SEMAKAN PERMOHONAN

(For Manual Submission)

KANDUNGAN LAPORAN CADANGAN PEMAJUAN

Laporan Cadangan Pemajuan hendaklah dikemukakan sebanyak dua(2) salinan ketika mengemukakan permohonan dan lapan (8) salinan untuk pengesahan (endorsement) apabila diarahkan oleh Perbadanan.

Laporan Cadangan Pemajuan perlulah mengikut format seperti berikut:

- Saiz laporan : A4
- Saiz pelan : A3
- Binding : Fail berkulit tebal serta bernombor siri.
- Pengesahan Professional : Bagi perkara 1 hingga 4 hendaklah disediakan dan disahkan oleh Jururancang Bertauliah dan perkara 5 hendaklah disediakan dan disahkan oleh profesional berkaitan.
- Kandungan setiap perkara perlu menerangkan dengan ringkas mengenai pematuhan dengan kehendak Garis Panduan Reka Bentuk Bandar.

NAMA FAIL

1. Tajuk permohonan / pengenalan

SA1_SURAT_
PENGENALAN.DOC

2. Perihal Tapak
(penerangan hendaklah dikecilkan skopnya kepada Kawasan Putrajaya sahaja)

3.1.9 Flora (Perintah Pemeliharaan Pokok)

Penerangan berdasarkan perkara-perkara berikut:

- a. Spesis Pokok
- b. Kategori Pokok
- c. Spesifikasi Pokok
- d. Kuantiti Pokok
- e. Lokasi dan Umur Pokok
- f. Nilai Estetika Pokok
- g. Kaedah Pengekalan/Penebangan/Pengalihan-Tanam Semula Pokok
- h. Foto-foto Digital Pokok Sedia ada

3.1.10 Pemandangan dan Vista

3.1.11 Analisa Kecerunan

Menerangkan kecerunan berdasarkan kelas berikut:

- Less than 10°
- 10° - 15°
- 15° - 20°
- >above 20°

3.1.12 Analisa Gunatanah Kawasan Berhampiran Samada Precint Bersebelahan atau Luar Perbadanan Putrajaya.

3.1.13 Analisa Kualiti Alam Sekitar Semasa

- a. Kualiti Air
- b. Kualiti Udara
- c. Kebisingan

3.1.14 Sosio ekonomi Meliputi Tapak dan Kawasan Sekitar

3.1.15 Analisis Potensi dan Halangan Pembangunan

- a. Kawasan yang boleh dibangunkan
- b. Kawasan halangan pembangunan

3.2 Pelan Keadaan Semasa dan Analisa Tapak

3.2.1 Pelan Topografi dan Rupa Bumi

SA1_KS_TOPO.TIF

3.2.2 Pelan Gunatanah Sedia Ada

SA1_KS_GUNATANAH.TIF

3.2.3 Pelan Faktor Iklim

SA1_KS_FAKTOR_IKLIM.TIF

3.2.4 Pelan Saliran Air, Badan Air dan Tadahan Semujadi

SA1_KS_SALIRAN_AIR.TIF

3.2.5 Pelan Jalan Keluar Masuk (aksesibiliti ke tapak sedia ada)

SA1_KS_AKSES.TIF

3.2.6 Pelan Jenis Tanah	SA1_KS_JENIS_TANAH.TIF
3.2.7 Pelan Geologi & Air Bawah Tanah	SA1_KS_GEOLOGI.TIF
3.2.8 Fauna	SA1_KS_FAUNA.TIF
3.2.9 Flora (Pelan Inventori Pokok)	SA1_KS_INV_POKOK.TIF
3.2.10 Pelan Pemandangan dan Vista	SA1_KS_VISTA.TIF
3.2.11 Pelan Analisis Kecerunan	SA1_KS_KECERUNAN.TIF
<p>Menerangkan kecerunan berdasarkan kelas berikut:</p> <ul style="list-style-type: none"> • Less than 10° • 10° - 15° • 15° - 20° • >above 20° 	
3.2.12 Pelan analisa gunatanah kawasan berhampiran samada precinct bersebelahan atau kawasan luar Perbadanan Putrajaya	SA1_KS_GTANAH_SEBELAH.TIF
3.2.13 Pelan Sosio-ekonomi meliputi kawasan sekitar	SA1_KS_SOCIO_EKONOMI.TIF
3.2.14 Pelan Analisis Kualiti Alam Sekitar Semasa	SA1_KS_ALAM_SEKITAR.TIF
<ul style="list-style-type: none"> i. Kualiti Air ii. Kualiti Udara iii. Kebisingan 	
3.2.15 Pelan Analisis Potensi dan Halangan Pembangunan	SA1_KS_POTENSI_HALANGAN.TIF
4. Cadangan Pembangunan	
4.1 Laporan Cadangan Pembangunan	SA1_CDG_PEMBANGUNAN.DOC

4.1.1 Matlamat, Objektif, Strategi Pembangunan Precint

4.1.2 Konsep dan Justifikasi Pembangunan Precint

Menerangkan rangkakerja pembangunan dari aspek:

- i. Pelan Pengezonan
- ii. Konsep Zon Kepadatan
- iii. Konsep Reka Bentuk Bandar
 - Identiti Tempatan
 - 'Organisation'
 - 'Access Point'
 - 'Vertical Treatment'
 - 'Horizontal Treatment'
 - Tarikan Pelancong
 - 'Public Realm'
- iv. Rangkaian Utiliti
- v. Rangkaian Pengangkutan
 - Sirkulasi Kenderaan
 - Sirkulasi bukan Kenderaan
 - Pengangkutan Awam
 - Tempat Letak Kenderaan
- vi. Kordinasi Ruang Landskap
- vii. Saliran/ Hidrologi
- viii. Perancangan Alam Sekitar (Pematuhan Syarat EIA)
- ix. Kesan Cadangan Pembangunan kepada Gunatanah Kawasan bersebelahan samada Precint Bersebelahan atau Kawasan Luar Putrajaya

4.1.3 Cadangan Pelan Susun Atur

Menerangkan butiran terperinci berikut:

- i. Pecahan guna tanah (pecahan guna tanah yang seperti perumahan, perdagangan, kerajaan, kemudahan kawasan lapang, kemudahan ameniti, kemudahan utiliti dan kemudahan infrastruktur)
- ii. Aspek-aspek densiti (kepadatan), nisbah plot, 'plinth area', ketinggian bangunan, garisan anjakan;
- iii. Langkah-langkah bagi melindungi dan memperelok alam sekitar dari segi fizikal.
- iv. Langkah- langkah bagi melindungi topografi semulajadi
- v. Langkah-langkah bagi memperelok landskap
- vi. Langkah-langkah bagi memelihara dan menanam pokok-pokok.

4.2 Pelan-pelan Cadangan Pembangunan

4.2.1 Pelan Pengezonan

SA1_CP_ZON.TIF

4.2.2 Pelan Konsep Reka Bentuk Bandar

SA1_CP_REKA_
BANDAR.TIF

4.2.3 Pelan Konsep Rangkaian Utiliti

SA1_CP_UTILITI.TIF

4.2.4	Pelan Konsep Rangkaian Pengangkutan	SA1_CP_PENGANGKUTAN.TIF
4.2.5	Pelan Kordinasi Ruang Landskap	SA1_CP_LANDSKAP.TIF
4.2.6	Pelan Konsep Saliran / Hidrologi	SA1_CP_SALIRAN_HIDROLOGI.TIF
4.2.7	Pelan Kesan Cadangan Pembangunan Terhadap Guna Tanah Kawasan Bersebelahan	SA1_CP_KESAN_GTANAH_SEBELAH.TIF
4.2.8	Pelan Susun Atur Terperinci	SA1_CP_SUSUN_ATUR.TIF
4.2.9	Jadual Pecahan Gunatanah	SA1_CP_JADUAL_GTANAH.TIF
4.2.10	Pelan Densiti	SA1_CP_DENSITI.TIF
4.3	Pandangan Perspektif Cadangan Susun Atur (Bird's Eye View)	SA1_CP_PERSPEKTIF.TIF
4.4	Gambarajah / Ilustrasi Cadangan Pembangunan Lain	SA1_CP_LAIN.TIF
5.	Laporan-laporan sokongan - impak dan implikasi aspek-aspek berikut:	
5.1	Geoteknikal (perlu disahkan oleh Jurutera Bertauliah)	
5.1.1	Laporan Geoteknikal	SA1_LS_GEOTEKNIKAL.DOC
	<ul style="list-style-type: none"> i. Geologi Tanah ii. Kerja-kerja Penyiasatan Tanah iii. Keadaan Sub-permukaan dan Penerangan Lubang Gerek iv. Analisis Kestabilan Cerun 	
5.1.2	Pelan Geoteknikal yang mengandungi:-	SA1_LS_GT_PELAN.TIF
	<ul style="list-style-type: none"> i. Nod Lubang Gerek ii. Kontur sedia ada & Cadangan iii. Profil Tanah (Perkawasan) 	
5.1.3	Keratan Rentas Lubang Gerek & Profil Tanah	SA1_LS_GT_KERATAN.TIF

5.1.4	Gambarajah/ Ilustrasi Geoteknikal Lain	SA1_LS_GT_LAIN.TIF
5.2	Kerja Tanah <i>(perlu disahkan oleh Jurutera Bertauliah)</i>	
5.2.1	Laporan Kerja Tanah	SA1_LS_KERJA_TANAH.DOC
5.2.2	Pelan Kerja Tanah	SA1_LS_KT_PELAN.TIF
	<ul style="list-style-type: none"> i. Kontur sedia ada ii. Cadangan awal pemotongan dan penambakan iii. Aras muktamad iv. Cerun muktamad v. Kontur Cadangan vi. Punca Tanah Penambakan vii. Isipadu Pemotongan dan Penambakan viii. Lokasi stockpile ix. Saliran Sementara x. 'Silt trap' 	
5.2.3	Keratan Rentas Tapak dan Aras (sekurang-kurangnya 3)	SA1_LS_KT_KERATAN.TIF
5.2.4	Rajah/ Ilustrasi Kerja Tanah Lain	SA1_LS_KT_LAIN.TIF
5.3	Penilaian Kesan Lalulintas (TIA) <i>(perlu disahkan oleh Jurutera/ Jururancang Pengangkutan Bertauliah)</i>	
5.3.1	Laporan Penilaian Kesan Lalulintas (TIA)	SA1_LS_TIA.DOC
	<ul style="list-style-type: none"> i. Penjanaan Lalulintas ii. Analisa impak lalulintas (keselamatan & keselesaan) iii. Cadangan sirkulasi trafik, sistem pejalan kaki, laluan basikal, sistem pengangkutan awam dsb. iv. Cadangan Tempak Letak Kenderaan 	
5.3.2	Pelan Sistem Pengangkutan	SA1_LS_ANGKUT_PELAN.TIF
5.3.3	Keratan Rentas Pengangkutan	SA1_LS_ANGKUT_KERATAN.TIF
5.3.4	Gambarajah/ Ilustrasi Pengangkutan Lain	SA1_LS_ANGKUT_LAIN.TIF
5.4	Saliran	

- i. Keperluan Maklumat Hidrologi
 - Saliran Utama
 - Saliran Sederhana/ Kecil
 - Lengkung IDF bagi Putrajaya untuk 'basis' pengiraan rekabentuk saliran
- ii. Pengiraan rekabentuk saliran (saiz, bentuk saliran dan sebagainya)

5.4.2 Pelan Saliran

SA1_LS_SL_PELAN.TIF

5.4.3 Keratan Rentas Saliran

SA1_LS_SL_KERATAN.TIF

5.4.4 Rajah / Ilustrasi Saliran Lain

SA1_LS_SL_LAIN.TIF

5.5 Kemudahan Utiliti

(perlu disahkan oleh Jurutera Bertauliah)

5.5.1 Laporan Kemudahan Utiliti

SA1_LS_UTILITI.DOC

- i. Pembedungan
- ii. Bekalan Air
- iii. Bekalan Elektrik
- iv. Telekomunikasi
- v. Bekalan Gas
- vi. Bekalan 'Gas District Cooling (GDC)
- vii. Kemudahan Sisa Pepejal
- viii. 'Common Utility Trench (CUT)

5.5.2 Pelan Kemudahan Utiliti

i. Pelan Pembedungan

SA1_LS_UT_PEMBETUNGAN.TIF

ii. Pelan Bekalan Air

SA1_LS_UT_AIR.TIF

iii. Pelan Bekalan Elektrik

SA1_LS_UT_ELEKTRIK.TIF

iv. Pelan Telekomunikasi

SA1_LS_UT_TELEKOM.TIF

v. Pelan Bekalan Gas

SA1_LS_UT_GAS.TIF

vi. Pelan Bekalan GDC

SA1_LS_UT_GDC.TIF

vii. Pelan Kemudahan Sisa Pepejal

SA1_LS_UT_SISA_
PEPEJAL.TIF

viii. Pelan 'Common Utility Trench'

SA1_LS_UT_CUT_TIF

5.5.3 Keratan Rentas 'Common Utility Trench'

SA1_LS_UT_CUT_
KERATAN.TIF

5.6 Landskap

(perlu disahkan oleh Arkitek Landskap Bertauliah)

5.6.1 Laporan Konsep Landskap

SA1_LS_LANDSKAP.
DOC

- a) Hirarki Taman dan Kawasan Lapang
- b) Katergori Landskap
- c) Matlamat dan Objektif
- d) Konsep Senireka Landskap
- e) Isu-isu Rekabentuk
Mengambilkira :
 - Pokok sedia ada
 - Kordinasi Ruang
- f) Program Implementasi
- g) Program Penyelenggaraan Landskap
- h) Pengurusan Operasi & Penyelenggaraan (O&M)

5.6.2 Pelan Konsep Landskap

Yang merangkumi konsep-konsep berikut:

i. Taman dan Kawasan Lapang

- Landskap Lembut
- 'Hard Landscape'
(Perabot Landskap, Papan Tanda, Pagar,
Kemudahan Rekreasi, Landskap Berciri Air,
Sirkulasi Pejalan Kaki & Basikal)
- Landskap Pencahayaan
- Pengairan

SA1_LS_LSKP_
LEMBUT.TIF

SA1_LS_LSKP_
PEJAL.TIF

SA1_LS_LSKP_
PENCAHAYAAN.TIF

SA1_LS_LSKP_
PENGAIRAN.TIF

ii. Koridor/ Rangkaian Hijau

SA1_LS_LSKP_KORI
DOR_HIJAU.TIF

iii. Jalinan Pejalan Kaki

SA1_LS_LSKP_
JALAN_KAKI.TIF

5.6.3 Keratan Rentas Landskap	SA1_LS_LSKP_KERATAN.TIF
5.6.4 Gambarajah/ Ilustrasi Landskap Lain	SA1_LS_LSKP_LAIN.TIF
5.7 Alam Sekitar (perlu disahkan oleh Perunding Alam Sekitar Bertauliah)	
5.7.1 Pelan Pengurusan Alam Sekitar (EMP)	SA1_LS_EMP.DOC
5.7.2 Lampiran yang mengandungi pelan-pelan bersaiz A3 seperti berikut:	
i. Pelan topografi bersama-sama dengan analisa kecerunan	SA1_LS_AS_TOPO_CERUN.TIF
ii. Pelan lokasi sungai dan lain-lain badan air	SA1_LS_AS_BADAN_AIR.TIF
iii. Pelan jalan logistik dan kawasan penyimpanan "stockpile"	SA1_LS_AS_LOGISTIK.TIF
iv. Pelan pengezonan dan pengfasaan kerja tanah	SA1_LS_AS_KT_ZON_FASA.TIF
v. Pelan pemotongan dan penambakan kerja tanah	SA1_LS_AS_KT_POTONG_TAMBAK.TIF
vi. Pelan lokasi	
a) 'silt trap'	SA1_LS_AS_SILT_TRAP.TIF
b) 'silt fence'	SA1_LS_AS_SILT_FENCE.TIF
c) 'kolam takungan'	SA1_LS_AS_KOLAM.TIF
d) sistem perparitan sementara dan kekal	SA1_LS_AS_PARIT.TIF
e) kawasan yang akan ditanam dengan rumput/ 'hydroseed'	SA1_LS_AS_HYDROSEED.TIF
f) perangkap minyak dan gris	SA1_LS_AS_MINYAK_GRIS.TIF

vii. Pelan analisis sedimen dan kawasan hakisan	SA1_LS_AS_SEDIMEN.TIF
viii. Pelan kawasan servis dan tempat penyimpanan minyak diesel	SA1_LS_AS_DIESEL.TIF
ix. Pelan lokasi stesen pengawasan air, udara dan bunyi bising	SA1_LS_AS_STESEN_AWASAN.TIF
x. CV dan Sijil Pendaftaran Perunding Alam Sekitar	SA1_LS_AS_CV.TIF
5.7.3 Surat-surat kelulusan dari agensi-agensi yang berkaitan seperti:	
i. Jabatan Alam Sekitar	
a. Kelulusan untuk pembinaan bagi pelepasan effluent/ kumbahan baru	SA1_LS_AS_SURAT_EFFLUEN.TIF
b. Kelulusan mendirikan 'batching plant'	SA1_LS_AS_SURAT_BPLANT.TIF
c. Kelulusan EIA tambahan	SA1_LS_AS_SURAT_EIA_TAMBAH.TIF
ii. Lain - lain kelulusan berkaitan	SA1_LS_AS_SURAT_LAIN.TIF

5.8 Pengairan
(*perlu disahkan oleh Jurutera Bertauliah*)

5.8.1 Laporan Pengairan

SA1_LS_PENGAIRAN.DOC

- i. Konsep Pengairan
- ii. Kualiti Air dan Implikasi Kos
- iii. Kriteria Rekabentuk
- iv. Inner/ Outer Reticulation System
- v. Punca Air/ Keperluan
- vi. Sistem Pengairan (Manual)
 - Tap/ Tap Point/ Quick Coupling/ Standpipe
 - Mobile Tanker
 - Rainwater Harvesting Tank
- vii. Sistem Pengairan Separuh Automatik/ Automatik
 - Movable Pulsator/ Rotary Sprinkler Standpipe
 - Sprinkler System (Pop-up Spray, Misting, Bubble Spray)
 - Drip Irrigation (Drip Emitter, Dripper Line)
 - Programmable Logic Controller (PLC)/ Control Panel
 - Rain Sensor/ Lighting Arrestor
 - Cabling Work (M&E)
 - Tapping Point from Irrigation Main
 - Pump House

5.8.2 Pelan Pengairan

SA1_LS_PENGAIRAN
PELAN.TIF

- i. Petunjuk
- ii. Sistem Pengairan (Manual)
 - Tap/ Tap Point/ Quick Coupling/ Standpipe
 - Mobile Tanker
 - Rainwater Harvesting Tank
- iii. Sistem Pengairan Separuh Automatik/ Automatik
 - Movable Pulsator/ Rotary Sprinkler Standpipe
 - Sprinkler System (Pop-up Spray, Misting, Bubble Spray)
 - Drip Irrigation (Drip Emitter, Dripper Line)
 - Programmable Logic Controller (PLC)/ Control Panel
 - Rain Sensor/ Lighting Arrestor
 - Cabling Work (M&E)
 - Tapping Point from Irrigation Main
 - Pump House

5.8.3 Keratan Bujur Saliran

SA1_LS_PENGAIRAN
KERATAN.TIF

6. Fasa Pembangunan

6.1 Laporan Fasa Pembangunan

SA1_FASA_
PEMBANGUNAN.DOC

6.2 Jadual Fasa Pembangunan

SA1_JAD_FASA_
PEMBANGUNAN. TIF

7. Anggaran Harga Jualan Premis

7.1 Laporan Anggaran Harga Jualan Premis

SA1_HARGA_
JUALAN.DOC

7.2 Jadual Anggaran Harga Jualan Premis

SA1_JAD_HARGA_
JUALAN.TIF

Nota:



- Amendment

FORM PB (Pindaan 1)

Senarai Semakan Permohonan Untuk Permohonan Kebenaran Merancang Bagi Pendirian Bangunan (Seksyen 21(3) Mengenai Pendirian Bangunan, Akta Perancangan Bandar dan Desa, 1976)

PB (Pindaan 1)



PERBADANAN PUTRAJAYA

PERMOHONAN KEBENARAN MERANCANG BAGI PENDIRIAN BANGUNAN
{Seksyen 21(3) Mengenai Pendirian Bangunan, Akta Perancangan Bandar dan Desa 1976}

Tajuk Projek :

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Tarikh Penerimaan

SENARAI SEMAKAN PERMOHONAN

	NAMA FAIL
1. Permohonan hendaklah disertakan dengan surat rasmi (cover letter) daripada Jururancang Bertauliah	PB_SURAT_RASMI.TIF
2. Melengkapkan Borang A (Jadual Pertama Kaedah Kawalan Perancangan Am)	PB_BORANG_A.TIF
3. Satu (1) salinan suratan hak milik	PB_HAK_MILIK.TIF
4. Satu (1) salinan surat perlantikan perunding.	PB_LANTIK_RUNDING.TIF
5. Satu (1) salinan profil syarikat perunding.	PB_PROFIL_SYKT.TIF
6. Satu (1) salinan Surat Kelulusan Kebenaran Merancang untuk Pelan Susun Atur Precint berkaitan.	PB_KELULUSAN_SA.TIF
7. Mengemukakan dua (2) salinan pelan-pelan dan lukisan-lukisan termasuk satu (1) linen ketika mengemukakan permohonan.	

Mengemukakan lapan (8) salinan pelan-pelan dan lukisan-lukisan termasuk satu (1) linen untuk pengesahan (endorsement) apabila diarah oleh Perbadanan.

(Pelan-pelan yang dikemukakan hendaklah berdasarkan kepada format seperti berikut:

- a) Kesemua pelan kecuali Pelan-pelan Bangunan hendaklah berdasarkan kepada Pelan Pra-Hitungan (pre-comp plan) yang mengandungi bacaan koordinat, jarak, "bearing" dan menunjukkan aras platform.
- b) Saiz pelan : A1
- c) Pelan-pelan / lukisan hendaklah disahkan oleh ahli profesional yang berkaitan
- d) Pelan-pelan hendaklah diwarnakan dan dijilid bersama
- e) Lukisan perspektif seperti di para 7.2.5 (bersaiz A3) perlu ditampal di atas kertas bersaiz A1 berserta tajuk projek sebagai kulit luar Pelan-pelan/ lukisan yang dijilid bersama)

7.1 PELAN TAPAK

(Pelan-pelan perlu disahkan oleh Jururancang Bertauliah)

PB_TAPAK.DXF

- i. Pelan kunci (menunjukkan tapak cadangan dalam keseluruhan Putrajaya)
- ii. Pelan lokasi (menunjukkan tapak cadangan dan pembangunan di sekitarnya)
- iii. Pelan tapak yang berdasarkan pelan pra-hitungan.
- iv. Maklumat dan jadual kawalan pembangunan.

7.2 PELAN DAN LUKISAN SENIBINA

(Pelan-pelan perlu disahkan oleh Arkitek Bertauliah)

7.2.1 Pelan Lantai

PB_SB_LANTAI.TIF

7.2.2 Pelan Bumbung

PB_SB_BUMBUNG.
TIF

7.2.3 Pandangan Tampak mengikut skim warna sebenar (sekurang-kurangnya 4 pandangan Tampak)

PB_SB_TAMPAK.TIF

7.2.4 Keratan Rentas (sekurang-kurangnya 2 keratan rentas)

PB_SB_KERATAN.TIF

7.2.5 Lukisan Perspektif berukuran minimum A3

PB_SB_PERSPEKTIF.
TIF

7.3 PELAN KERJA TANAH

(Pelan perlu disahkan oleh Jurutera Bertauliah yang mengandungi perkara-perkara berikut:

- a. Kontor sedia ada
- b. Cadangan awal pemotongan dan penambakan
- c. Aras Muktamad

- d. Cerun Muktamad
- e. Kontor Cadangan
- f. Punca Tanah Penambakan
- g. Isipadu Pemetongan dan Penambakan
- h. Lokasi Stockpile
- i. Saliran Sementara
- j. 'Silt Trap'
- k. Keratan tapak dan aras
(sekurang-kurangnya 3)

7.4 PELAN-PELAN TAPAK INFRASTRUKTUR DAN UTILITI.
(Pelan-pelan perlu disahkan oleh Jurutera Bertauliah)

7.4.1 Pelan Jalan (Pengangkutan)	PB_JALAN.DXF
7.4.2 Pelan Perparitan (Saliran)	PB_SALIRAN.DXF
7.4.3 Pelan Pembetulan	PB_PEMBETUNGAN. DXF
7.4.4 Pelan Bekalan Air	PB_BEKALAN_AIR. DXF
7.4.5 Pelan Bekalan Elektrik	PB_BEKALAN_ ELEKTRIK.DXF
7.4.6 Pelan Telekomunikasi	PB_TELEKOM.DXF
7.4.7 Pelan Bekalan Gas	PB_BEKALAN_GAS. DXF
7.4.8 Pelan Sisa Pepejal	PB_SISA_PEPEJAL. DXF
7.4.9 Pelan Gas District Cooling (GDC)	PB_GDC.DXF
7.4.10 Pelan Common Utility Trench (CUT)	PB_CUT.DXF
7.4.11 Pengairan	PB_PENGAIRAN.DXF

7.5 PELAN DAN LUKISAN LANDSKAP
(Pelan-pelan perlu disahkan oleh Arkitek Landskap Bertauliah)

- 7.5.1 Pelan Induk Landskap yang mengandungi perkara-perkara berikut:
- a. Pelan dan Jadual Senireka Tanaman
 - b. Pelan Landskap Pejal

PB_LSKP_TANAMAN.
DXF

i. Pelan dan Jadual Perabut Kelengkapan Landskap	PB_LSKP_PERABUT. DXF
ii. Pelan dan Jadual Sistem Papan Tanda & Pengiklanan	PB_LSKP_PTANDA. DXF
iii. Pelan dan Jadual Pagar	PB_LSKP_PAGAR. DXF
iv. Pelan dan Jadual Kemudahan Rekreasi	PB_LSKP_REKREASI. DXF
v. Pelan dan Jadual Lanskap Berciri Air	PB_LSKP_AIR.DXF
vi. Pelan dan Jadual Sirkulasi Pejalan Kaki/ Basikal	PB_LSKP_SIRKULASI .DXF
c. Pelan dan Jadual Landskap Pencahayaan	PB_LSKP_ PENCAHAYAAN.DXF
d. Pelan dan Jadual Pengairan	PB_LSKP_ PENGAIRAN.DXF
7.5.2 Jadual Penyerenggaan Landskap (Tempoh 24 Bulan) dan Skop Kerja	PB_LSKP_JAD_ SENGGARA.TIF
7.5.3 Foto, Imej dan Lakaran setiap komponen/ elemen landskap	
a) Senireka Tanaman	PB_LSKP_IMEJ_ TANAMAN.TIF
b) Landskap Pejal	
i. Perabut Kelengkapan Landskap	PB_LSKP_IMEJ_ PERABUT.TIF
ii. Sistem Papan Tanda & Pengiklanan	PB_LSKP_IMEJ_ PTANDA.TIF
iii. Pagar	PB_LSKP_IMEJ_ PAGAR.TIF
iv. Kemudahan Rekreasi	PB_LSKP_IMEJ_ REKREASI.TIF

c) Landskap Pencahayaan

PB_LSKP_IMEJ_
PENCAHAYAAN.TIF

d) Pengairan

PB_LSKP_IMEJ_
PENGAIARAN.TIF

7.5.4 Dua (2) Keratan Rentas Keseluruhan Tapak
Pembangunan

PB_LSKP_KERATAN.
DXF

7.5.5 Tampak Sisi /Hadapan setiap Komponen / elemen
landskap

a) Landskap Pejal

i. Perabut Kelengkapan Landskap

PB_LSKP_TAMPAK_
PERABUT.DXF

ii. Sistem Papan Tanda & Pengiklanan

PB_LSKP_TAMPAK_
PTANDA.DXF

iii. Pagar

PB_LSKP_TAMPAK_
PAGAR.DXF

iv. Kemudahan Rekreasi

PB_LSKP_TAMPAK_R
EKREASI.DXF

v. Landskap Berciri Air

PB_LSKP_TAMPAK_
AIR.DXF

b) Landskap Pencahayaan

PB_LSKP_TAMPAK_
PENCAHAYAAN.DXF

c) Pengairan

PB_LSKP_TAMPAK_
PENGAIARAN.DXF

8. Mengemukakan dua(2) salinan Laporan Ringkas Cadangan
Pemajuan Berukuran A3 ketika Mengemukakan Permohonan

Mengemukakan lima belas (15) salinan Laporan Ringkas Cadangan
Pemajuan berukuran A3 (10 salinan berwarna dan 5 salinan
hitam/putih) sekurang-kurangnya tiga(3) hari sebelum mesyuarat
JKPP.

(Kandungan serta format laporan yang dikemukakan hendaklah
mengikut format Senarai Semakan PB1)

9. Surat-surat ulasan berserta pelan-pelan pengesahan agensi/syarikat
utiliti berkaitan:-

- | | |
|---|---------------------------|
| 9.1 Bekalan Air (Jabatan Bekalan Air Selangor) | PB_SURAT_AIR.TIF |
| 9.2 Telekomunikasi (Telekom Malaysia Berhad) | PB_SURAT_TELEKOM.TIF |
| 9.3 Chilled Water (GDC) - P1, P2, P3, P4, P5, P7 & P8 (Sub Commercial Centre) | PB_SURAT_GDC.TIF |
| 9.4 Sisa Pepejal (Alam Flora Sdn. Bhd.) | PB_SURAT_SISA_PEPEJAL.TIF |
| 9.5 Pembedungan (Jabatan Perkhidmatan Pembedungan Pembinaan Jaya Bumi Sdn. Bhd.) | PB_SURAT_PEMBEDUNGAN.TIF |
| 9.6 Bekalan Gas (Gas Malaysia) | PB_SURAT_GAS.TIF |
| 9.7 Bekalan Elektrik (Tenaga Nasional Berhad) | PB_SURAT_TNB.TIF |
| 9.8 Bomba (Jabatan Bomba, Ibu Pejabat) | PB_SURAT_BOMBA.TIF |
| 9.9 Syarikat Konsesi 'Common Utility Trench' | PB_SURAT_CUT.TIF |
| 10. Satu (1) salinan Pelan Tapak dan satu salinan lukisan perspektif yang ditampal di atas 'mounting board' berukuran A1 untuk taklimat semasa mesyuarat. | |
| 11. Model cadangan pembangunan, salah satu dari berikut:- | |
| 11.1 Model Bangunan | |
| a. Mengikut skim warna yang dicadangkan dan hendaklah selaras dengan Pelan Tapak, Pelan Senibina dan Pelan Landskap. | |
| b. Menggunakan skala yang bersesuaian berserta tajuk projek, bar sekil, arah utara dan arah kiblat. | |
| c. Hendaklah disertakan kaki (2 kaki 6 inci tinggi) dan bertutup dengan perspek jernih. | |
| 11.2 Model berkomputer (3D simulation ataupun virtual reality) | PB_MODEL_3D.DXF |

Nota:

 - Amendment

FORM PB1 (Pindaan 1)

Senarai Semakan Permohonan Untuk Permohonan Kebenaran Merancang Bagi Pendirian Bangunan (Seksyen 21(3) Mengenai Pendirian Bangunan, Akta Perancangan Bandar dan Desa, 1976)

- Kandungan Laporan Ringkas Cadangan Pemajuan

PB1 (Pindaan 1)



PERBADANAN PUTRAJAYA

PERMOHONAN KEBENARAN MERANCANG BAGI PENDIRIAN BANGUNAN
{Seksyen 21(3) Mengenai Pendirian Bangunan, Akta Perancangan Bandar dan Desa 1976}

Tajuk Projek :

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Tarikh Penerimaan

SENARAI SEMAKAN PERMOHONAN

KANDUNGAN LAPORAN RINGKAS CADANGAN PEMAJUAN

Laporan Ringkas Cadangan Pemajuan hendaklah dikemukakan sebanyak dua(2) salinan ketika mengemukakan permohonan dan lima belas(15) salinan (10 salinan berwarna dan 5 salinan hitam/putih) sekurang-kurangnya tiga(3) hari sebelum Mesyuarat JKPP dan hendaklah mengikut format seperti berikut:-

- a) Saiz Laporan : A3
- b) Saiz Pelan A3 dan berwarna
- c) Pengesahan Profesional : Disahkan oleh ahli professional berkaitan
- d) Kandungan setiap perkara perlu menerangkan dengan ringkas mengenai pematuhan dengan kehendak Garis Panduan Reka Bentuk Bandar.

NAMA FAIL

1. CADANGAN PEMBANGUNAN
(perlu disahkan oleh Jururancang Bertauliah)

- 1.1 Laporan Cadangan Pembangunan

PB1_CDG_
PEMBANGUNAN.DOC

- 1.1.1 Matlamat dan Objektif

- 1.1.2 Perihal & Analisis Tapak

- i. Pelan Kunci
- ii. Pelan Lokasi
- iii. Foto Tapak Sedia Ada
- iv. Analisis Tapak

- 1.1.3 Konsep Cadangan Pembangunan

- 1.1.4 Isu-isu dan Pertimbangan

1.1.5	Cadangan Pelan Pembangunan (Pelan Tapak yang merangkumi perkara seperti Senarai Semakan PB para 7.1)	
1.1.6	Maklumat Cadangan Pembangunan Maklumat Ringkasan Projek dengan mematuhi kehendak-kehendak Garis Panduan Rekabentuk Bandar Putrajaya (UDG) dan Pelan Susun Atur presint berkenaan.	
1.1.7	Program Implementasi serta Skop Kerja.	
1.2	Pelan-pelan dan Ilustrasi bagi Cadangan Pembangunan	
1.2.1	Pelan Kunci	PB1_CP_KUNCI.TIF
1.2.2	Pelan Lokasi	PB1_CP_LOKASI.TIF
1.2.3	Foto Tapak Sedia Ada	PB1_CP_FOTO.TIF
1.2.4	Analisa Tapak	PB1_CP_ANALISA_TAPAK.TIF
1.2.5	Pelan Konsep Cadangan Pembangunan	PB1_CP_KONSEP.TIF
1.2.6	Ilustrasi Pelan Konsep Cadangan Pembangunan Lain	PB1_CP_KONSEP_LAIN.TIF
1.2.7	Pelan tapak yang merangkumi perkara seperti dipara 7.1	PB1_CP_TAPAK.TIF
1.2.8	Gambarajah/ Ilustrasi Cadangan Pembangunan Lain	PB1_CP_TAPAK_LAIN.TIF
1.2.9	Jadual Maklumat Cadangan Pembangunan Maklumat Ringkasan Projek (dalam bentuk jadual perbandingan) dengan mematuhi kehendak-kehendak Garis Panduan Rekabentuk Bandar Putrajaya.	PB1_CP_JADUAL.TIF
1.2.10	Jadual dan Program Implementasi serta Skop Kerja Cadangan Pembangunan.	PB1_CP_JAD_PROGRAM.TIF
2.	PELAN DAN LUKISAN SENIBINA (perlu disahkan oleh Arkitek Bertauliah)	
2.1	Laporan Senibina	PB1_SENIBINA.DOC
2.1.1	Matlamat dan Objektif	
2.1.2	Konsep Senibina	
2.1.3	Isu-isu Pertimbangan	

2.2 Pelan-pelan dan Lukisan Senibina

2.2.1 Pelan Lantai

PB1_SB_LANTAI.TIF

2.2.2 Pelan Bumbung

PB1_SB_BUMBUNG.
TIF

2.2.3 Pandangan Tampak

2.2.4 Keratan Rentas.

2.2.5 Lukisan Perspektif

Lukisan perspektif perlulah mengikut skim warna sebenar yang dicadangkan dan selaras dengan Pelan Tapak, Pelan Senibina dan Pelan Landskap.

2.2.6 Gambarajah / Ilustrasi Senibina Lain.

2.3 Jadual dan Program Implementasi serta Skop Kerja.

3. CADANGAN KERJA TANAH

(Pelan perlu disahkan oleh Jurutera Bertauliah)

3.1 Laporan kerja tanah bagi perkara seperti Senarai Semakan PB, para 7.3

3.2 Pelan Kerja Tanah

3.3 Keratan Rentas Kerja Tanah

3.4 Gambarajah/ Ilustrasi Kerja Tanah Lain

3.5 Jadual dan Program Implementasi serta Skop Kerja

4. CADANGAN INFRASTRUKTUR & UTILITI

(perlu disahkan oleh Jurutera Bertauliah)

4.1 Laporan cadangan penyediaan infrastruktur dan utiliti

a. Cadangan penyediaan infrastruktur dan utiliti

- i. Jalan (Pengangkutan)
- ii. Perparitan (Saliran)
- iii. Pembedungan
- iv. Bekalan Air
- v. Bekalan Elektrik
- vi. Telekomunikasi
- vii. Bekalan Gas
- viii. Gas District Cooling (GDC)
- ix. Common Utiliti Trench (CUT)
- x. Pembuangan Sisa Pepejal
- xi. Pengairan (Kaedah-kaedah pengairan – paip, trak, rainwater harvesting tank dsb.)

b. Jadual dan Program Implementasi serta Skop Kerja

4.2 Pelan-pelan tapak Infrastruktur dan utiliti

4.2.1 Jalan (Pengangkutan)

i. Pelan Jalan (Pengangkutan)

PB1_IU_JLN_PELAN.
TIF

ii. Keratan Rentas Jalan (Pengangkutan)

PB_IU_JLN_
KERATAN.TIF

iii. Ilustrasi Jalan Lain

PB1_IU_JLN_LAIN.
TIF

iv. Jadual dan Program Implimentasi dan Skop Kerja

PB1_IU_JLN_JAD_
PROGRAM.TIF

4.2.2 Perparitan (Saliran)

i. Pelan Perparitan (Saliran)

PB1_IU_PRT_PELAN.
TIF

ii. Keratan Rentas Perparitan (Saliran)

PB1_IU_PRT_
KERATAN.TIF

iii. Gambarajah / Ilustrasi Saliran Lain

PB1_IU_PRT_LAIN.
TIF

iv. Jadual dan Program Implimentasi dan Skop Kerja

PB1_IU_PRT_JAD_
PROGRAM.TIF

4.2.3 Pembedungan

i. Pelan Pembedungan

PB1_IU_BETUNG_
PELAN.TIF

ii. Jadual dan Program Implimentasi dan Skop Kerja

PB1_IU_BETUNG_
JAD_PROGRAM.TIF

4.2.4 Bekalan Air

i. Pelan Bekalan Air

PB1_IU_AIR_PELAN.
TIF

ii. Jadual dan Program Implimentasi dan Skop Kerja

PB1_IU_ELEKTRIK_
PELAN.TIF

4.2.5 Bekalan Elektrik

i. Pelan Bekalan Elektrik

PB1_IU_ELEKTRIK_
PELAN.TIF

ii. Jadual dan Program Implimentasi dan Skop Kerja

PB1_IU_ELEKTRIK_
JAD_PROGRAM.TIF

4.2.6 Telekomunikasi

i. Pelan Telekomunikasi

PB1_IU_TELEKOM_
PELAN.TIF

ii. Jadual dan Program Implimentasi dan Skop Kerja

PB1_IU_TELEKOM_
JAD_PROGRAM.TIF

4.2.7 Bekalan Gas

i. Pelan Bekalan Gas

PB1_IU_GAS_PELAN.
TIF

ii. Jadual dan Program Implimentasi dan Skop Kerja

PB1_IU_GAS_JAD_
PROGRAM.TIF

4.2.8 Gas District Cooling (GDC)

i. Pelan Gas District Cooling (GDC)

PB1_IU_GDC_TIF

ii. Jadual dan Implimentasi dan Skop Kerja

PB1_IU_GAS_JAD_
PROGRAM.TIF

4.2.9 Pembuangan Sisa Pepejal

i. Pelan Sisa Pepejal

PB1_IU_PEPERJAL_
PELAN.TIF

ii. Jadual dan Implimentasi dan Skop Kerja

PB1_IU_PEPERJAL_
JAD_PROGRAM.TIF

4.2.10 Common Utiliti Trench (CUT)

i. Pelan Common Utiliti Trench (CUT)

PB1_IU_CUT_PELAN.
TIF

ii. Keratan Rentas Utiliti Trench

PB1_IU_CUT_
KERATAN.TIF

iii. Jadual dan Implimentasi dan Skop Kerja

PB1_IU_CUT_JAD_
PROGRAM.TIF

4.2.11 Pengairan

i. Pelan Pengairan

PB1_IU_PENGAIRAN
PELAN.TIF

ii. Keratan Bujur Pengairan

PB1_IU_PENGAIRAN
KERATAN.TIF

iii. Gambarajah/ Ilustrasi Pengairan Lain

PB1_IU_PENGAIFAN
LAIN.TIF

iv. Jadual dan Program Implimentasi dan Skop Kerja

PB1_IU_PENGAIRAN
_JAD_PROGRAM.TIF

5. CADANGAN LANDSKAP
(Perlu disahkan oleh Arkitek Landskap Bertauliah)

PB1_LSKP_JAD_
LENGKAP.TIF

5.1 Laporan Pelan Induk Landskap

PB1_LANDSKAP.DOC

- 5.1.1 Konsep Reka Bentuk
- 5.1.2 Matlamat dan Objektif
- 5.1.3 Isu-isu dan Pertimbangan
- 5.1.4 Jadual dan Program Implementasi serta Skop Kerja
- 5.1.5 Jadual dan Program Penyelenggaraan Landskap serta Skop Kerja.
- 5.1.6 Strategi Implementasi (Pengurusan Kontrak, Spesifikasi Kerja dan Bidang Tugas)
- 5.1.7 Strategi Penanaman (Impak Visual Pembangunan Persekitaran)

PB1_LSKP_JAD_
PAGAR.TIF

PB1_LSKP_JAD_
REKREASI.TIF

PB1_LSKP_JAD_AIR
TIF

PB1_LSKP_JAD_
SIRKULASI.TIF

5.2 Pelan Induk Landskap yang mengandungi:

- 5.2.1 Pelan Senireka Tanaman

PB1_LSKP_
TANAMAN.TIF

5.3 Pelan Landskap Pejal

- 5.3.1 Pelan Perabut Kelengkapan Landskap

PB1_LSKP_PERABUT
.TIF

- 5.3.2 Pelan Sistem Papan Tanda & Pengiklanan

PB1_LSKP_PTANDA.
TIF

- 5.3.3 Pelan Pagar

PB1_LSKP_PAGAR.
TIF

- 5.3.4 Pelan Kemudahan Rekreasi

PB1_LSKP_
REKREASI.TIF

- 5.3.5 Pelan Landskap Berciri Air

PB1_LSKP_AIR.TIF

- 5.3.6 Pelan Sirkulasi Pejalan Kaki/ Basikal

PB1_LSKP_
SIRKULASI.TIF

- 5.3.7 Pelan Landskap Pencahayaan

PB1_LSKP_
PENCAHAYAAN.TIF

5.4.1	Jadual Senireka Tanaman	PB1_LSK_JAD_TANAMAN.TIF
5.4.2	Jadual Perabut Kelengkapan Landskap	PB1_LSKP_JAD_LENGKAP.TIF
5.4.3	Jadual Papan Tanda & Pengiklanan	PB1_LSKP_JAD_PTANDA.TIF
5.4.4	Jadual Pagar	PB1_LSKP_JAD_PAGAR.TIF
5.4.5	Jadual Kemudahan Rekreasi	PB1_LSKP_JAD_REKREASI.TIF
5.4.6	Jadual Landskap Berciri Air	PB1_LSKP_JAD_AIR.TIF
5.4.7	Jadual Sistem Sirkulasi Pejalan Kaki/ Basikal	PB1_LSKP_JAD_SIRKULASI.TIF
5.4.8	Jadual Landskap Pencahayaan	PB1_LSKP_JAD_PENCAHAYAAN.TIF
5.4.9	Jadual Pengairan	PB1_LSKP_JAD_PENGAIRAN.TIF
5.5	Jadual Penyenggaraan Landskap (tempoh 24 bulan) dan Skop Kerja	PB1_LSKP_JAD_SENGGARA.TIF
5.6	Foto, imej dan Lakaran setiap Komponen/ Elemen Landskap	
5.6.1	Senireka Tanaman	PB1_LSKP_IMEJ_TANAMAN.TIF
5.6.2	Perabut Kelengkapan Landskap	PB1_LSKP_IMEJ_PERABUT.TIF
5.6.3	Papan Tanda dan Pengiklanan	PB1_LSKP_IMEJ_PTANDA.TIF
5.6.4	Pagar	PB1_LSKP_IMEJ_PAGAR.TIF
5.6.5	Kemudahan Rekreasi	PB1_LSKP_IMEJ_REKREASI.TIF
5.6.6	Landskap Berciri Air	PB1_LSKP_IMEJ_AIR.TIF
5.6.7	Jadual Sistem Sirkulasi Pejalan Kaki/ Basikal	PB1_LSKP_IMEJ_SIRKULASI.TIF

5.6.8 Landskap Pencahayaan	PB1_LSKP_IMEJ_PENCAHAYAAN.TIF
5.6.9 Pengairan	PB1_LSKP_IMEJ_PENGAIRAN.TIF
5.7 Dua(2) Keratan Rentas Keseluruhan Tapak Pembangunan	PB1_LSKP_KERATAN.TIF
5.8 Pelan Tampak Sisi/ Tampak Hadapan setiap Komponen/ Elemen Landskap	
5.8.1 Perabut Kelengkapan Landskap	PB1_LSKP_TAMPAK_TIF
5.8.2 Papan Tanda dan Pengiklanan	PB1_LSKP_TAMPAK_PTANDA.TIF
5.8.3 Pagar	PB1_LSKP_TAMPAK_PAGAR.TIF
5.8.4 Kemudahan Rekreasi	PB1_LSKP_TAMPAK_REKREASI.TIF
5.8.5 Landskap Berciri Air	PB1_LSKP_TAMPAK_AIR.TIF
5.8.6 Landskap Pencahayaan	PB1_LSKP_TAMPAK_PENCAHAYAAN.TIF
5.8.7 Pengairan	PB1_LSKP_TAMPAK_PENGAIRAN.TIF
6. PENGURUSAN ALAM SEKITAR	
6.1 Surat pengesahan dari Perbadanan Putrajaya sama ada pemaju perlu mengemukakan Pelan Pengurusan Alam Sekitar (EMP) atau Laporan Pengurusan Alam Sekitar (EMR)	PB1_AS_SURAT_TIF
6.2 Pelan Pengurusan Alam Sekitar (EMP) atau:-	PB1_EMP.DOC
6.3 Laporan Pengurusan Alam Sekitar (EMR)	PB1_EMR.DOC
6.4 Lampiran yang mengandungi pelan-pelan seperti berikut:	
i. Pelan topografi bersama-sama dengan analisa kecerunan.	PB1_AS_TOPO.TIF
ii. Pelan lokasi sungai dan lain-lain badan air.	PB1_AS_BADAN_AIR.TIF

iii. Pelan jalan logistik dan kawasan penyimpanan 'stockpile'	PB1_AS_LOGISTIK.TIF
iv. Pelan pengezonan dan pengfasaan kerja tanah	PB1_AS_KT_ZON_FASA.TIF
v. Pelan pemotongan dan penambakan kerja tanah	PB1_AS_KT_POTONG_TAMBAK.TIF
vi. Pelan Lokasi	
a. silt trap	PB1_AS_SILT_TRAP.TIF
b. silt fence	PB1_AS_SILT_FENCE.TIF
c. kolam takungan	PB1_AS_KOLAM.TIF
d. sistem perparitan sementara dan	PB1_AS_PARIT.TIF
e. kawasan yang akan ditanam dengan rumput/'hydroseed'	PB1_AS_HYDROSEED.TIF
f. perangkap minyak dan gris	PB1_AS_MINYAK_GRIS.TIF
vii. Pelan analisis sedimen dan kawasan hakisan	PB1_AS_SEDIMEN.TIF
viii. Pelan kawasan servis dan tempat penyimpanan minyak diesel	PB1_AS_DIESEL.TIF
ix. Pelan lokasi stesen pengawasan air, udara dan bunyi bising	PB1_AS_STESEN_AWASI.TIF

6.4 Surat-surat kelulusan dari agensi-agensi yang berkaitan seperti:

i. Jabatan Alam Sekitar	
a) Kelulusan janakuasa tunggu sedia	PB1_AS_SURAT_JKUASA.TIF
b) Kelulusan ketinggian cerobong	PB1_AS_SURAT_CEROBONG.TIF
c) Kelulusan untuk pembinaan bagi pelepasan effluen/ kumbahan baru	PB1_AS_SURAT_EFFLUEN.TIF
d) Kelulusan mendirikan 'batching plant'	PB1_AS_SURAT_BPLANT.TIF
e) Kelulusan EIA tambahan	PB1_AS_SURAT_EIA_TAMBAH.TIF
ii. Lain-lain kelulusan berkaitan	PB1_AS_SURAT_LAIN.TIF

FORM PBS1 (Pandaan 1)

Senarai Semakan Permohonan Untuk Permohonan Kebenaran Merancang Bagi Pendirian Bangunan Sementara (Seksyen 21(3) Mengenai Pendirian Bangunan, Akta Perancangan Bandar dan Desa, 1976)

PBS1 (Pindaan 1)



PERBADANAN PUTRAJAYA

PERMOHONAN KEBENARAN MERANCANG BAGI PENDIRIAN BANGUNAN SEMENTARA
{Seksyen 21(3) Mengenai Pendirian Bangunan, Akta Perancangan Bandar dan Desa, 1976}

Tajuk Projek :
.....
.....
.....

Tarikh Penerimaan

SENARAI SEMAKAN PERMOHONAN

NAMA FAIL

- | | |
|--|---------------------------|
| 1. Permohonan hendaklah disertakan dengan surat rasmi (cover letter) daripada Jururancang/Arkitek Bertauliah | PBS1_SURAT_RA
SMI.TIF |
| 2. Melengkapkan Borang A (Jadual Pertama Kaedah Kawalan Perancangan Am) | PBS1_BORANG_A.
TIF |
| 3. Mengemukakan satu (1) salinan suratan hak milik. | PBS1_HAK_MILIK.
TIF |
| 4. Mengemukakan satu (1) salinan Surat Kelulusan Kebenaran Merancang Pelan Susun Atur (jika berkaitan). | PBS1_Kelulusan_
KM.TIF |

5. Mengemukakan dua (2) salinan pelan-pelan dan lukisan-lukisan termasuk 1(satu) linen ketika mengemukakan permohonan.

Mengemukakan 5 salinan pelan-pelan termasuk satu(1) linen untuk pengesahan (endorsement) apabila diarah oleh Perbadanan.

(Pelan-pelan yang dikemukakan hendaklah berdasarkan kepada format seperti berikut :-)

1. Kesemua pelan hendaklah berdasarkan kepada Pelan Pra-Hitungan (pre comp plan) yang mengandungi bacaan koordinat, jarak, bering dan aras platform.
2. Saiz pelan : A1

3. Pelan-pelan/lukisan hendaklah disahkan oleh ahli profesional yang berkaitan
4. Pelan-pelan/lukisan hendaklah diwarnakan dan dijilid bersarna.
5. Lukisan perspektif seperti di para 5.2.5 (bersaiz A3) perlu ditampal di atas kertas bersaiz A1 berserta tajuk projek sebagai kulit luar pelan-pelan/lukisan yang dijilid bersama).

5.1 PELAN TAPAK

(Pelan-pelan perlu disahkan oleh Jururancang Bertauliah jika berkenaan)

PBS1_TAPAK.DXF

5.1.1 Pelan tapak

Pelan tapak perlu mengandungi pelan kunci pelan lokasi, garis kontor rupabumi dan pelan tapak cadangan pembangunan.

5.1.2 Jadual Maklumat Pembangunan

(Maklumat Ringkasan Projek (dalam bentuk jadual perbandingan) dengan mematuhi kehendak-kehendak Garis Panduan Rekabentuk Bandar Putrajaya (UDG) dan Pelan Susun Atur precinct berkenaan yang telah diluluskan yang merangkumi perkara-perkara berikut:

- a) Keluasan Tapak / Saiz Plot
- b) Keluasan Lantai Kasar (GFA) dan kegunaannya
- c) Kawasan Plinth
- d) Nisbah Plot
- e) Bilangan Tempat Meletak Kenderaan
- f) Kemudahan-kemudahan yang disediakan

5.2 PELAN BANGUNAN DAN LUKISAN SENIBINA

(Pelan-pelan perlu disahkan oleh Arkitek Berdaftar)

5.2.1 Pelan Lantai

PBS1_SB_LANTAI.TIF

5.2.2 Pelan Bumbung

PBS1_SB_BUMBUNG.
TIF

5.2.3 Pandangan Tampak mengikut skim warna sebenar (sekurang-kurangnya 4 pandangan tampak).

PBS1_SB_TAMPAK.
TIF

5.2.4 Keratan Rentas (sekurang-kurangnya 2 keratan rentas).

PBS1_SB_KERATAN.
TIF

5.2.5 Lukisan Perspektif (Bird's Eye View)

PBS1_SB_PERSPEKTI
F.TIF

5.3 PELAN-PELAN INFRASTRUKTUR DAN UTILITI

(Pelan-pelan perlu disahkan oleh Jurutera Bertauliah).

5.3.1 Pelan Jalan (Pengangkutan)	PBS1_JALAN.DXF
5.3.2 Pelan Perparitan (Saliran)	PBS1_SALIRAN.DXF
5.3.3 Pelan Pembedungan	PBS1_PEMBETUNGAN.DXF
5.3.4 Pelan Bekalan Air	PBS1_BEKALAN_AIR.DXF
5.3.5 Pelan Bekalan Elektrik	PBS1_BEKALAN_ELEKTRIK.DXF
5.3.6 Pelan Telekomunikasi	PBS1_TELEKOM.DXF
5.3.7 Pelan Pembuangan Sisa Pepejal	PBS1_SISA_PEPEJAL.DXF
5.3.8 Pelan Pengairan (Kaedah-kaedah pengairan – paip, trak, rainwater harvesting tank dsb.)	PBS1_PENGAIRAN.DXF
5.4 PELAN KERJA TANAH (sekiranya berkaitan) (Pelan perlu disahkan oleh Jurutera Bertauliah)	PBS1_KERJA_TANAH.DXF
5.5 PELAN INDUK LANDSKAP (Pelan-pelan perlu disahkan oleh Arkitek Landskap Bertauliah)	
5.5.1 Pelan dan Jadual inventori pokok sedia ada	PBS1_LSKP_POKOK.DXF
5.5.2 Pelan dan Jadual Senireka Tanaman	PBS1_LSKP_PTAN.DXF
5.5.3 Pelan Landskap Pejal	
a. Perabut dan Jadual Kelengkapan Lanskap	PBS1_LSKP_PERABUT.DXF
b. Pelan dan Jadual Sistem Papan Tanda & Pengiklanan	PBS1_LSKP_PTANDA.DXF
c. Pelan dan Jadual Pagar	PBS1_LSKP_PAGAR.DXF
d. Pelan dan Jadual Kemudahan Rekreasi	PBS1_LSKP_REKREASI.DXF
e. Pelan dan Jadual Landskap Berciri Air	PBS1_LSKP_AIR.DXF

f. Pelan dan Jadual Sirkulasi Pejalan Kaki/ Basikal	PBS1_LSKP_ SIRKULASI.DXF
5.5.4 Pelan dan Jadual Pelan Lanskap Pencahayaan	PBS1_LSKP_ PENCAHAYAAN.DXF
5.5.5 Pelan dan Jadual Pelan Pengairan	PBS1_LSKP_ PENGAIRAN.DXF
5.5.6 Jadual Penyenggaraan Landskap	PBS1_LSKP_JAD_ SENGGARA.DXF
5.5.7 Foto, imej dan Lakaran setiap komponen/ elemen landskap	
a. Inventori Pokok Sedia Ada	PBS1_LSKP_IMEJ_IN V_POKOK.TIF
b. Senireka Taman	PBS1_LSKP_IMEJ_ TANAMAN.TIF
c. Perabut Kelengkapan Landskap	PBS1_LSKP_IMEJ_ PERABUT.TIF
d. Papan Tanda dan Pengiklanan	PBS1_LSKP_IMEJ_ PTANDA.TIF
e. Pagar	PBS1_LSKP_IMEJ_ PAGAR.TIF
f. Kemudahan Rekreasi	PBS1_LSKP_IMEJ_ REKREASI.TIF
g. Landskap Berciri Air	PBS1_LSKP_IMEJ_ AIR.TIF
h. Sistem Sirkulasi Pejalan Kaki/ Basikal	PBS1_LSKP_IMEJ_ SIRKULASI.TIF
i. Landskap Pencahayaan	PBS1_LSKP_IMEJ_ PENCAHAYAAN.TIF
j. Pengairan	PBS1_LSKP_IMEJ_ PENGAIRAN.TIF
5.5.8 Dua(2) Keratan Rentas Keseluruhan Tapak Pembangunan	PBS1_LSKP_KERATA N.DXF
5.5.9 Tampak Sisi/ Hadapan setiap komponen/ elemen landskap	
a. Perabut Kelengkapan Landskap	PBS1_LSKP_TAMPAK _PERABUT.DXF

b. Sistem Papan Tanda & Pengiklanan

PBS1_LSKP_TAMPAK_PTANDA.DXF

c. Pagar

PBS1_LSKP_TAMPAK_PAGAR.DXF

d. Kemudahan rekreasi

PBS1_LSKP_TAMPAK_REKREASI.DXF

e. Landskap Berciri Air

PBS1_LSKP_TAMPAK_AIR.DXF

f. Pencahayaan

PBS1_LSKP_TAMPAK_PENCAHAYAAN.DXF

g. Pengairan

PBS1_LSKP_TAMPAK_PENGAIRAN.DXF

6. Mengemukakan dua(2) salinan Laporan Ringkas Cadangan Pemajuan (jika berkaitan) ketika mengemukakan permohonan.

Mengemukakan lima belas (15) salinan Laporan Ringkas Cadangan Pemajuan (jika berkaitan) berukuran A3 (10 salinan berwarna dan 5 salinan hitam/putih) sekurang-kurangnya tiga(3) dari sebelum Mesyuarat JKPP.

(Laporan yang dikemukakan hendaklah mengikut format berikut:)

- a) Saiz laporan : A3 dan dijilid
- b) Saiz Pelan : A3 dan perlu diwarnakan
- c) Pengesahan Profesional : Pelan-pelan hendaklah disediakan dan disahkan oleh profesional berkaitan yang bertauliah.

6.1 Cadangan Pembangunan

6.1.1 Laporan Cadangan Pelan Tapak

PBS1_CDG_PEMBANGUNAN.DOC

- a. Matlamat dan Objektif
- b. Perihal Tapak dan Analisa Tapak
- c. Konsep Pembangunan
- d. Isu-isu dan Pertimbangan
- e. Cadangan Pelan Pembangunan
- f. Jadual Cadangan Gunatanah
- g. Jadual dan Program Implimentasi serta Skop Kerja

6.1.2 Pelan-pelan dan Illustrasi bagi Cadangan pembangunan

iv. Pelan Tapak

PBS1_CP_TAPAK.TIF

v. Jadual Cadangan Pembangunan

PBS1_CP_JADUAL.
TIF

vi. Jadual dan Program Implementasi dan Skop Kerja

PBS1_CP_JAD_
PROGRAM.TIF

6.2 Pelan dan Lukisan Senibina

6.2.1 Laporan Cadangan

PBS1_SENIBINA.DOC

a. Matlamat dan Objektif

b. Konsep Senibina

c. Isu-isu dan Pertimbangan

d. Pelan-pelan dan Lukisan Senibina

e. Jadual dan Program Implimentasi serta Skop Kerja

6.2.2 Pelan dan Lukisan Senibina

i. Pelan Lantai

PBS1_SB_LANTAI.
TIF

ii. Pelan Bumbung

PBS1_SB_BUMBUNG.
TIF

iii. Pandangan Tampak

PBS1_SB_TAMPAK.
TIF

iv. Keratan Rentas

PBS1_SB_KERATAN.T
IF

v. Lukisan Perspektif

PBS1_SB_
PERSPEKTIF.TIF

vi. Jadual dan Program Implementasi

PBS1_SB_JAD_
PROGRAM.TIF

6.3 Infrastruktur dan Utiliti

6.3.1 Laporan Cadangan

PBS1_INFRA_UTILITI.
DOC

6.3.2 Pelan-pelan Tapak dan Ilustrasi Infrastruktur dan Utiliti

6.3.2.1 Pelan Jalan (Pengangkutan)

i. Pelan Jalan (Pengangkutan)	PBS1_IU_JLN_PELAN .TIF
ii. Keratan Rentas Jalan	PBS1_IU_JLN_ KERATAN.TIF
iii. Jadual dan Program Implimentasi dan Skop Kerja Jalan	PBS1_IU_JLN_JAD_ PROGRAM.TIF
 6.3.2.3 Perparitan (Saliran)	
i. Pelan Perparitan (Saliran)	PBS1_IU_PRT_PELAN .TIF
ii. Keratan Rentas Saliran	PBS1_IU_PRT_ KERATAN.TIF
iii. Jadual dan Program Implimentasi dan Skop Kerja Saliran	PBS1_IU_PRT_JAD_ PROGRAM.TIF
 6.3.2.3 Pembedungan	
i. Pelan Pembedungan	PBS1_IU_BENTUNG_ PELAN.TIF
ii. Jadual dan Program Implimentasi dan Skop Kerja Pembedungan	PBS1_IU_BENTUNG_J AD_PROGRAM.TIF
 6.3.2.4 Bekalan Air	
i. Pelan Bekalan Air	PBS1_IU_AIR_PELAN. TIF
ii. Jadual dan Program Implimentasi Bekalan Air	PBS1_IU_AIR_JAD_ PROGRAM.TIF
 6.3.2.5 Bekalan Elektrik	
i. Pelan Bekalan Elektrik	PBS1_IU_ELEKTRIK_ PELAN.TIF
ii. Jadual dan Program Implimentasi Bekalan Elektrik	PBS1_IU_ELEKTRIK_ JAD_PROGRAM.TIF

6.3.2.6 Telekomunikasi

ii. Jadual dan Program Implimentasi Telekomunikasi PBS1_IU_TELEKOM_JAD_PROGRAM.TIF

6.3.2.7 Pembuangan Sisa Pepejal

i. Pelan Sisa Pepejal PBS1_IU_PEPEJAL_PELAN.TIF

ii. Jadual dan Program Implementasi dan Skop Kerja Sisa Pepejal PBS1_IU_PEPEJAL_JAD_PROGRAM.TIF

6.3.2.8 Pengairan (Kaedah-kaedah Pengairan – Paip, Trak, Rainwater Harvesting Tank dsb)

i. Pelan Pengairan PBS1_IU_PENGAIRAN_PELAN.TIF

ii. Keratan Bujur Pengairan PBS1_IU_PENGAIRAN_KERATAN.TIF

iii. Jadual dan Program Implimentasi dan Skop Kerja PBS1_IU_PENGAIRAN_JAD_PROGRAM.TIF

6.4 Kerja Tanah

6.4.1 Laporan Kerja Tanah PBS1_KERJA_TANAH.DOC

- a. Kontur Sedia Ada
- b. Cadangan Pemetongan dan Penambakan
- c. Aras Muktamad
- d. Cerun Muktamad
- e. Kontur Cadangan
- f. Punca Tanah Penambakan
- g. Isipadu Pemetongan dan Penambakan
- h. Lokasi Stokpile
- i. Saliran Sementara
- j. Silt Trap
- k. Keratan Tapak dan Aras

I. Jadual & Program Implementasi dan Skop Kerja

6.4.2 Pelan dan Ilustrasi Kerja Tanah

i. Pe'an Kerja Tanah

PBS1_KT_PELAN.TIF

ii. Keratan Rentas Kerja Tanah

PBS1_KT_KERATAN.
TIF

iii. Jadual dan Program Implementasi dan Skop Kerja

PBS1_KT_JAD_
PROGRAM.TIF

6.5 Pelan Induk Landskap

6.5.1 Laporan Pelan Induk Landskap dan Program
Penyenggaraan

PBS1_LANDSKAP.
DOC

6.5.2 Pelan Induk Landskap

i. Pelan Inventori Pokok Sediada

PBS1_LSKP_INV_
POKOK.TIF

ii. Pelan Senireka Tanaman

PBS1_LSKP_
TANAMAN.TIF

iii. Pelan Landskap Pejal

a. Pelan Perabut Kelengkapan Landskap

PBS1_LSKP_
PERABUT.TIF

b. Pelan Sistem Papan Tanda & Pengiklanan

PBS1_LSKP_PTANDA.
TIF

c. Pelan Pagar

PBS1_LSKP_PAGAR.T
IF

d. Pelan Kemudahan Rekreasi

PBS1_LSKP_
REKREASI.TIF

e. Pelan Landskap Berciri Air

PBS1_LSKP_AIR.TIF

f. Pelan Sirkulasi Pejalan Kaki/ Basikal

PBS1_LSKP_
SIRKULASI.TIF

g. Pelan Landskap Pencahayaan

PBS1_LSKP_
PENCAHAYAAN.TIF

h. Pelan Pengairan

PBS1_LSKP_
PENGAIRAN.TIF

iv Jadual Pelan Induk Landskap

a. Jadual Inventori Pokok

PBS1_LSKP_JAD_INV
_POKOK.TIF

b. Jadual Senireka Tanaman

PBS1_LSKP_JAD_
TANAMAN.TIF

c. Jadual Perabut Kelengkapan Landskap

PBS1_LSKP_JAD_
PERABUT.TIF

d. Jadual Papan Tanda & Pengiklanan

PBS1_LSKP_JAD_
PTANDA.TIF

e. Jadual Pagar

PBS1_LSKP_JAD_
PAGAR.TIF

f. Jadual Kemudahan Rekreasi

PBS1_LSKP_JAD_
REKREASI.TIF

g. Jadual Landskap Berciri Air

PBS1_LSKP_JAD_AIR.
TIF

h. Jadual Sistem Sirkulasi Pejalan Kaki/ Basikal

PBS1_LSKP_JAD_
SIRKULASI.TIF

i. Jadual Landskap Pencahayaan

PBS1_LSKP_JAD_
PENCAHAYAAN.TIF

j. Jadual Pengairan

PBS1_LSKP_JAD_
PENGAIRAN.TIF

v. Jadual Penyenggaraan Landskap (tempoh 24 bulan) dan Skop Kerja

PBS1_LSKP_JAD_
SENGGARA.TIF

vi. Foto, Imej dan Lakaran setiap Komponen/ Elemen Landskap

a. Inventori Pokok Sediada

PBS1_LSKP_IMEJ_
INV_POKOK.TIF

b. Senireka Tanaman

PBS1_LSKP_IMEJ_
TANAMAN.TIF

c. Perabut Kelengkapan Landskap

PBS1_LSKP_IMEJ_
PERABUT.TIF

d. Papan Tanda dan Pengiklanan

PBS1_LSKP_IMEJ_
PTANDA.TIF

e. Pagar	PBS1_LSKP_IMEJ_PAGAR.TIF
f. Kemudahan Rekreasi	PBS1_LSKP_IMEJ_REKREASI.TIF
g. Landskap Berciri Air	PBS1_LSKP_IMEJ_AIR.TIF
h. Jadual Sistem Sirkulasi Pejalan Kaki/ Basikal	PBS1_LSKP_IMEJ_SIRKULASI.TIF
i. Landskap Pencahayaan	PBS1_LSKP_IMEJ_PENCAHAYAAN.TIF
j. Pengairan	PBS1_LSKP_IMEJ_PENGAIRAN.TIF
vii. Dua (2) Keratan Rentas Keseluruhan Tapak Pembangunan	PBS1_LSKP_KERATAN.TIF
viii. Pelan Tampak Sisi/ Tampak Hadapan Setiap Komponen/ Elemen Landskap	
a. Perabut Kelengkapan Landskap	PBS1_LSKP_TAMPAK_PERABUT.TIF
b. Papan Tanda dan Pengiklanan	PBS1_LSKP_TAMPAK_PTANDA.TIF
c. Pagar	PBS1_LSKP_TAMPAK_PAGAR.TIF
d. Kemudahan Rekreasi	PBS1_LSKP_TAMPAK_REKREASI.TIF
e. Landskap Berciri Air	PBS1_LSKP_TAMPAK_AIR.TIF
f. Landskap Pencahayaan	PBS1_LSKP_TAMPAK_PENCAHAYAAN.TIF
h. Pengairan	PBS1_LSKP_TAMPAK_PENGAIRAN.TIF

6.6 Alam Sekitar

6.6.1 Mengemukakan Laporan Pengurusan Alam Sekitar (EMR)

PBS1_AS_EMR.DOC

6.6.2 Lampiran yang mengandungi pelan-pelan seperti berikut:-

- | | |
|---|---------------------------|
| i. Pelan topografi bersama-sama dengan analisa kecerunan | PBS1_AS_TOPO.TIF |
| ii. Pelan lokasi sungai dan lain-lain badan air | PBS1_AS_BADAN_AIR.TIF |
| iii. Pelan jalan logistik dan kawasan penyimpanan "stockpile" | PBS1_AS_LOGISTIK.TIF |
| iv. Pelan pengezonan dan pengfasaan kerja tanah | PBS1_AS_KT_ZON_FASA.TIF |
| v. Pelan pemotongan dan penambakan kerja tanah | PBS1_KT_POTONG_TAMBAK.TIF |
| vi. Pelan Lokasi | |
| a. 'Silt Trap' | PBS1_AS_SILT_TRAP.TIF |
| b. 'Silt Fence' | PBS1_AS_SILT_FENCE.TIF |
| c. 'Kolam Takungan' | PBS1_AS_KOLAM.TIF |
| d. Sistem perparitan sementara dan kekal | PBS1_AS_PARIT.TIF |
| e. Kawasan yang akan ditanam dengan rumput. "hydroseed" | PBS1_AS_HYDROSEED.TIF |
| f. Perangkap minyak dan gris | PBS1_AS_MINYAK_GRIS.TIF |
| vii. Pelan analisis sedimen dan kawasan hakisan | PBS1_SEDIMENT.TIF |
| viii. Pelan kawasan servis dan tempat penyimpanan minyak diesel | PBS1_DIESEL.TIF |
| ix. Pelan lokasi stesen pengawasan air, udara dan bunyi bising. | PBS1_STESEN_AWASAN.TIF |

6.6.3 Surat-surat kelulusan dari agensi-agensi yang berkaitan seperti:-

- | | |
|-------------------------------------|--------------------------|
| i. Jabatan Alam Sekitar | |
| a. Kelulusan janakuasa tunggu sedia | PBS1_AS_SURAT_JKUASA.TIF |

b. Kelulusan ketinggian cerobong

PBS1_AS_SURAT_
CEROBONG.TIF

c. Kelulusan untuk pembinaan bagi pelepasan effluent/kumbahan baru

PBS1_AS_SURAT_
EFFLUEN.TIF

d. Kelulusan mendirikan 'batching plant'

PBS1_AS_SURAT_
BPLANT.TIF

e. Kelulusan EIA tambahan

PBS1_AS_SURAT_EIA_
_TAMBAH.TIF

ii. Lain-lain kelulusan berkaitan

PBS1_AS_SURAT_
LAIN.TIF

7. Mengemukakan satu (1) salinan Pelan Tapak dan satu (1) salinan lukisan perspektif bangunan (bird's eye view) yang ditampal di atas 'mounting board' berukuran A1 untuk dibawa di Mesyuarat JKPP.

Nota:



- Amendment

Lampiran B(i) (Pindaan 1)

Senarai Semakan Permohonan Untuk Permohonan Kebenaran Merancang Bagi Pendirian Bangunan (Seksyen 21(3) Mengenai Pendirian Bangunan, Akta Perancangan Bandar dan Desa, 1976)

- Laporan Sokongan LCP Termasuk Pelan/Gambarajah/Model



**Permohonan Kebenaran Merancang Bagi Pelan Susun Atur
(Seksyen 21, Akta Perancangan Bandar dan Desa, 1976)**

Projek :

Precinct:

Tarikh Perimaan :

SENARAI SEMAKAN TEKNIKAL

3.1 Laporan Sokongan LCP Termasuk Pelan/Gambarajah/Model (Geoteknikal, Kerjatanah, Saliran dan Pengairan)

	Perkara	UDG/Pelan Induk/Lain-lain				Catitan	Ulasan Teknikal
		Y	Ti	Ta	Tb		
1	Geoteknikal						
	1.1 Laporan						
	1.1.1 Geologi Tanah						
	1.1.2 Kerja-kerja Penyiasatan Tanah						
	1.1.3 Keadaan Sub-permukaan dan penerangan Lubang Gerek						
	1.1.4 Analisa Kestabilan Cerun						
	1.2 Pelan Geoteknikal yang Mengandungi:						
	1.2.1 Nod Lubang Gerek						
	1.2.2 Profil Tanah (Perkawasan)						
	1.3 Keratan Rentas Profil Tanah dan Lubang Gerek						
2	Kerja Tanah						
	2.1 Laporan						
	2.1.1 Kecerunan Asal						
	• Kurang 10°						
	• 10° - 15°						
	• 15° - 20°						
	• Lebih 20°						
	2.1.2 Isipadu Penambakan dan Pemetongan						
	2.1.3 Sumber Penambakan						
	2.1.4 Lokasi Stockpile						
	2.2 Pelan kerja Tanah yang merangkumi perkara berikut:						
	2.2.1 Petunjuk						
	2.2.2 Garis Kontor sedia ada						
	2.2.3 Kawasan pemetongan						
	2.2.4 Kawasan penambakan						

3.1 Laporan Sokongan LCP Termasuk Pelan/Gambarajah/Model - Hidrologi

Nota:- Semakan dibuat berbanding dengan UDG/ Master Plan/ atau mana-mana piawaian yang ditetapkan

Y - Mematuhi atau selaras dengan UDG/Master Plan/EIA/EMG/EMP

Ti - Tidak Lengkap/Tidak Selaras dengan UDG/Master Plan

Ta - Tidak ada (disertakan)

Tb - Tidak berkaitan

	Perkara	UDG/Pelan Induk/ Lain-lain				Catitan	Ulasan Teknikal
		Y	Ti	Ta	Tb		
	2.2.5 Lokasi stockpile						
	2.2.6 Aras Platform						
	2.2.7 Garis Kontor Cadangan						
	2.2.8 Kecerunan						
	• Kurang 10°						
	• 10° - 15°						
	• 15° - 20°						
	• Lebih 20°						
	2.2.9 Sumber Penambakan						
	2.2.10 Isipadu Penambakan dan						
	2.2.11 Silt Trap						
	2.2.12 Earth Drain						
	2.3 Keratan Rentas Kerja Tanah dan Gambarajah/ Ilustrasi lain (sekurang-3 keratan)						
	3 Saliran						
	3.1 Laporan						
	3.1.1 Saliran Utama						
	3.1.2 Saliran Sederhana/ Kecil						
	3.1.3 Lengkung IDF bagi Putrajaya 'basis' perkiraan rekabentuk saliran						
	3.1.4 Perkiraan Rekabentuk saliran (saiz bentuk saliran dan sebagainya)						
	3.2 Pelan Saliran yang merangkumi:-						
	3.2.1 Petunjuk						
	3.2.2 Sempadan Tadahan Saliran						
	3.2.3 Kelebaran Rezab Saliran						
	3.2.4 Lokasi nod Saliran (Sump)						
	3.2.5 Lokasi Perangkap Pencemaran Kasar						
	3.2.6 Alur Keluar Tadahan Saliran						
	3.2.7 Pembentung Paip Konkrit Bertetulang						
	3.2.8 Pembentung Kekotak Konkrit Bertetulang						
	3.2.9 Bahagian Saluran Terbuka						
	3.2.10 Perparitan Utama						
	3.2.11 Perparitan Sekunder						
	3.2.12 Aras Laras						
	3.2.13 Arah Saliran						
	3.2.14 Upper Catchment (Design)						
	3.2.15 Perangkap Minyak & Geris						
	3.3 Keratan Rentas Saliran						
	4 Pengairan						
	4.1 Laporan Pengairan						
	* Konsep Pengairan						
	* Kualiti Air dna Implikasi Kos						
	* Kriteria Rekabentuk						
	* Inner/ Outer Reticulation System						
	* Water Source/ Requirement						
	* Irrigation System (Manual)						
	* Tap/ Tap Point/ Quick Coupling/						
	* Mobile Tanker						
	* Rainwater Harvesting Tank						
	* Semi Automated/ Automated Irrigation						

Perkara	UDG/ Plan Induk/ Lain-lain				Catitan	Ulasan Teknikal
	Y	Ti	Ta	Tb		
* Movable Pulsator/ Rotary Sprinkler						
* Sprinkler System (Pop-up Spray, Bubble Spray)						
* Drip Irrigation (Drip Emitter, Dripper)						
* Programmable Logic Controller (PLC)/ Control Panel						
* Rain Sensor/ Lightning Arrestor						
* Cabling Work (M&E)						
* Tapping from Irrigation Main						
* Pump House						
4.2 Pelan Pengairan						
* Petunjuk						
* Irrigation System (Manual)						
* Tap/ Tap Point/ Quick Coupling/ Mobile Tanker						
* Rainwater Harvesting Tank						
* Semi Automated/ Automated Irrigation System (AIS)						
* Movable Pulsator/ Rotary Sprinkler						
* Sprinkler System (Pop-up Spray, Bubble Spray)						
* Drip Irrigation (Drip Emitter, Dripper)						
* Programmable Logic Controller Control Panel						
* Rain Sensor/ Lightning Arrestor						
* Cabling Work (M&E)						
* Tapping from Irrigation Main						
* Pump House						
4.3 Keratan Rentas Sistem Pengairan						

3.1 Laporan Sokongan LCP Termasuk Pelan/Gambarajah/Model - Hidrologi

Nota:- Semakan dibuat berbanding dengan UDG/ Master plan/ atau mana-mana piawaian yang ditetapkan

Y - Mematuhi atau selaras dengan UDG/Master Plan/EIA/EMG/EMP

Ti - Tidak Lengkap/Tidak Selaras dengan UDG/Master Plan

Ta - Tidak ada (disertakan)

Tb - Tidak berkaitan

 - Amendment

Lampiran B(i) (Pindaan 1)

Senarai Semakan Permohonan Untuk Permohonan Kebenaran Merancang Bagi Pendirian Bangunan (Seksyen 21(3) Mengenai Pendirian Bangunan, Akta Perancangan Bandar dan Desa, 1976)

- Laporan Ringkasan Cadangan Pemajuan dan Pelan – pelan Sokongan Lain



**Permohonan Kebenaran Merancang Bagi Pelan Susun Atur
(Seksyen 21(3), Mengenai Pendirian Bangunan,
Akta Perancangan Bandar dan Desa, 1976)**

Projek :

Precinct:

Tarikh Perimaan :

SENARAI SEMAKAN TEKNIKAL

4.0 Laporan Ringkasan Cadangan Pemajuan dan Pelan-pelan Sokongan Lain

	Perkara	UDG/Pelan Induk/ Lain-lain				Catitan	Ulasan Teknikal
		Y	Ti	Ta	Tb		
1	Kerja Tanah						
	1.1 Laporan						
	1.1.1 Sumber Penambakan						
	1.1.2 Isipadu Penambakan dan						
	1.1.3 Lokasi Stockpile						
	1.2 Pelan Kerja Tanah yang Merangkumi :-						
	1.2.1 Petunjuk						
	1.2.2 Isipadu Penambakan dan						
	1.2.3 Kawasan Pemotongan						
	1.2.4 Kawasan Penambakan						
	1.2.5 Sumber Penambakan						
	1.2.6 Lokasi Stockpile						
	1.2.7 Garis Kontur sedia ada						
	1.2.8 Aras Platform						
	1.2.9 Garis Kontur Cadangan						
	1.2.10 Kecerunan Muktamad						
	1.2.11 Silt Trap						
	1.2.12 Earth Drain						
	1.3 Pelan Keratan Rentas (Sekurang-keratan)						
2	Sistem Saliran						
	2.1 Laporan Saliran						
	2.2 Pelan Saliran yang merangkumi:-						
	2.2.1 Petunjuk						
	2.2.2 Sempadan Tadahan Saliran						
	2.2.3 Kaw. Perangkap Pencemaran						
	2.2.4 Kelebaran Rezab Saliran						
	2.2.5 Lokasi nod Saliran						
	2.2.6 Alur Keluar Tadahan Saliran						
	2.2.7 Pembentung paip konkrit						
	2.2.8 Pembentung kekotak konkrit						
	2.2.9 Bahagian Saluran Terbuka						
	2.2.10 Saliran Utama						
	2.2.11 Saliran Sekunder						
	2.2.12 Saliran Tertiary						
	2.2.13 Saliran Bawah Permukaan						
	2.2.14 Aras Laras						
	2.2.15 Arah Saliran						

4.0 Laporan Ringkasan CP dan Pelan Sokongan

- Nota:- Semakan dibuat berbanding dengan UDG/ Master plan/ atau mana-mana piawaian yang ditetapkan
- Y - Mematuhi atau selaras dengan UDG/Master Plan/EIA/EMG/EMP
 - Ti - Tidak Lengkap/Tidak Selaras dengan UDG/Master Plan
 - Ta - Tidak ada (disertakan)
 - Tb - Tidak berkaitan


Perkara	UDG/ Pelan Induk/ Lain-lain				Catitan	Ulasan Teknikal
	Y	Ti	Ta	Tb		
2.2.16 Tadahan Atas (Penyelarasan)						
2.2.17 Perangkap Minyak. & Gas						
2.3 Keratan Rentas Saliran						
3 Pengairan						
3.1 Laporan Pengairan						
* Konsep Pengairan						
* Kualiti Air dan Implikasi Kos						
* Kriteria Rekabentuk						
* Inner/ Outer Reticulation System						
* Water Source/ Requirement						
* Irrigation System (Manual)						
* Tap/ Tap Point/ Quick Coupling/						
* Mobile Tanker						
* Rainwater Harvesting Tank						
* Semi Automated/ Automated Irrigation (AIS)						
* Movable Pulsator/ Rotary Sprinkler						
* Sprinkler System (Pop-up Spray, Bubble Spray)						
* Drip Irrigation (Drip Emitter, Dripper)						
* Programmable Logic Controller (PLC)/ Panel						
* Rain Sensor/ Lightning Arrestor						
* Cabling Work (M&E)						
* Tapping from Irrigation Main						
* Pump House						
4.1 Pelan Pengairan						
* Petunjuk						
* Irrigation System (Manual)						
* Tap/ Tap Point/ Quick Coupling/						
* Mobile Tanker						
* Rainwater Harvesting Tank						
* Semi Automated/ Automated Irrigation (AIS)						
* Movable Pulsator/ Rotary Sprinkler						
* Sprinkler System (Pop-up Spray, Bubble Spray)						
* Drip Irrigation (Drip Emitter, Dripper)						
* Programmable Logic Controller Panel						
* Rain Sensor/ Lightning Arrestor						
* Cabling Work (M&E)						
* Tapping point from Irrigation Main						
* Pump House						
4.3 Keratan Rentas Sistem Pengairan						

* Merujuk kepada Laporan dan Pelan

4.0 Laporan Ringkasan CP dan Pelan Sokongan

Nota:- Semakan dibuat berbanding dengan UDG/ Master plan/ atau mana-mana piawaian yang ditetapkan

- Y - Mematuhi atau selaras dengan UDG/Master Plan/EIA/EMG/EMP
- Ti - Tidak Lengkap/Tidak Selaras dengan UDG/Master Plan
- Ta - Tidak ada (disertakan)
- Tb - Tidak berkaitan

 - Amendment

APPENDIX J

EVALUATION OF ALTERNATIVE IRRIGATION SYSTEMS

TABLES

Table J1	Irrigation Option Cost Estimates For Group I (Precinct 1)
Table J2	Irrigation Option Cost Estimates For Group II (Precinct 13)
Table J3	Irrigation Option Cost Estimates For Group III (Precinct 2, 3, 4 & 18)
Table J4	Irrigation Option Cost Estimates For Group IV (Precinct 5, 6 & 20)
Table J5	Irrigation Option Cost Estimates For Group V (Precinct 7, 8, 9, 10 & 11)
Table J6	Irrigation Option Cost Estimates For Group VI (Precinct 12, 14, 15, & DE)
Table J7	Irrigation Option Cost Estimates For Group VII (Precinct 16 & 17)
Table J8	Irrigation Option Cost Estimates For Group VIII (Precinct 19)

MAPS

MAP J1	Alternative Irrigation System For Precinct 1
MAP J2	Alternative Irrigation System For Precinct 13
MAP J3	Alternative Irrigation System For Precinct 5, 6 & 20
MAP J4	Alternative Irrigation System For Precinct 7, 8, 9, 10 & 11

EVALUATION OF ALTERNATIVE IRRIGATION SYSTEMS

1. Evaluation of Alternative Irrigation Options

The evaluations of alternative irrigation options have been carried out as below. For ease of comparisons, the irrigation areas are grouped into eight groups (I to VIII). Each group is served by one or a combination of water sources.

The schematic layout of the alternative system is shown in Map J1-J7 of this report and costing of each option is shown in Table J1-J8.

1.1 Group I – Precinct 1

This precinct already installed with irrigation facilities. Remaining areas without irrigation facilities are road reserves and public utility and some government reserve area whereby systems the total daily demand is not huge (only 0.04 Mld).

Option 1 - Pipe reticulation from lake and proposed pump house at PH A1

Capital cost : RM 3.24 million (inclusive RM 2.50 million for pipe jacking)
O & M cost : RM 0.020 million

In line with the 'no dig policy', option not recommended as it incurs excessive digging pipe jacking at paved area.

Option 2 – Pipe reticulation from Sewage Treatment Plant

It is not considered as irrigation area is far from source (STP1).

Option 3 - By trucking (13 truck trips daily)

Capital cost : RM 0.1 million
O & M cost : RM 0.14 million

Option is not favored as it incurs high O & M cost.

Option 4 - JBA Water

Capital cost	:	RM 0.08 million (Not inclusive cost for upgrading JBA main)
O & M cost	:	RM 0.02 million

Option is not feasible as current JBA supply does not cater for irrigation needs. In line with the 'no dig policy' option is not recommended.

Proposed Option - Combination of pipe reticulation and JBA water

Capital cost	:	RM 1.81 million
O & M cost	:	RM 0.02 million

This option is more expensive than Option 3 in terms of capital cost but much cheaper in O&M cost. It is also more practical with the installed pipe reticulation system from irrigation and JBA main.

1.2 Group II – Precinct 13

Wetland does not require irrigation. Area left to be irrigated is the shrub in wetland park, nursery and the completed roads.

Option 1 - All by Pipe Reticulation from Wetland

Capital cost	:	RM 1.60 million (inclusive RM 0.31 million for pipe jacking)
O & M cost	:	RM 0.06 million

Most expensive after Option 3. In addition, option requires digging along completed road. Option is therefore discarded.

Option 2 – All by Pipe reticulation from Sewage Treatment Plant

Option is discarded as irrigation areas is very far from source (STP1)

Option 3 - All by Truck

Capital cost	:	RM 1.10 million
O & M cost	:	RM 3.72 million

Option is discarded as it is too expensive in term of capital and O & M cost.

Option 4 - All by JBA Water

Capital cost : RM 0.24 million (Not inclusive cost for upgrading JBA main)

O & M cost : RM 0.41 million

Total irrigation demand is 1.1 Mld. This figure is substantial in terms of JBA supply and JBA does not cater for irrigation need. Hence option is not recommended.

Proposed Option - Pipe Reticulation from Wetland (Pump House PH7) to Wetland park, Nursery and Primary Distributor Road

Capital cost : RM 1.58 million

O & M cost : RM 0.06 million

Option more economical than Option 3 in terms of capital and O & M cost. Two locations have been considered for PH7. One location is at the Upper West Wetland and the other near the existing pumphouse E1. Siting PH7 at the Upper West Wetland is recommended as it is nearest to the nursery. Water availability at this location is not a problem during dry season. Moreover, it can be augmented by operating the existing wetland recirculation pump if required. The abstraction is small, i.e. 124 m³/hr compared to the wetland pump capacity of 3 x 1800m³/hr.

1.3 Group III – Precincts 2, 3, 4 & 18

Precinct 2 is an ongoing development while 3, 4 and 18 is still under preliminary planning.

Option 1 - All by Pipe reticulation from lake with Intake Pump at PH 1(Precinct 18) and PH2 (Precinct 4)

Capital cost : RM 3.91 million

O & M cost : RM 0.15 million

Total pipe reticulation is not possible particularly in Precinct 2 in which some government buildings and CUT are already completed. Alternative source is needed for these completed areas. Hence option not recommended in view of the 'no dig policy'.

Option 2 – All by Pipe reticulation from Sewage Treatment Plant

Option is discarded as irrigation areas are very far from source (STP1).

Option 3 - All by Trucking

Capital cost : RM 1.90 million

O & M cost : RM 3.46 million

Option not viable owing to very high capital and O&M cost. Hence no further consideration should be given.

Option 4 - By JBA water (Total water demand = 1.00Mld)

Capital cost : RM 0.70 million (Not inclusive cost for upgrading JBA main)

O & M cost : RM 0.40 million

Option not viable owing to high water demand. JBA supply does not cater for irrigation need. Option is discarded also due to high O & M cost.

Proposed Option - All by pipe reticulation from lake except government parcel in precinct 2 by JBA water due to no dig policy

Capital cost : RM 2.73 million

O & M cost : RM 0.13 million

Comparatively this option is more feasible both technically and economically compared to Option 1.

1.4 Group IV – Precincts 5, 6 & 20

These 3 precincts are still under preliminary planning stage, hence the implementation of pipe reticulation system becomes easier with lesser constraints.

Option 1 - All by pipe reticulation with Intake Pump at PH 5 located in Precinct 6

Capital cost : RM 7.43 million (inclusive RM 0.15 million for pipe jacking)

O & M cost : RM 0.36 million

Total irrigation demand is 6.62 Mld. This figure is substantial and will have some impact on lake draw down during drought. Hence, this option is not recommended if there is an alternative source. Capital cost is high.

Option 2 – All by Pipe Reticulation as below:

- Precinct 5 and nursery to source water from Sewage Treatment Plant (STP 2)- Demand 5.4 Mld
- Promenade, Precinct 6 & cemetery & religious area from Lake – Demand 0.6 Mld

Capital cost : RM 7.53 million (inclusive RM 0.30 million for pipe jacking)
O & M cost : RM 0.34million

This option utilises sewerage effluent as main source will significantly reduce dependence on the lake. Compared to option 1, it is cheaper in terms of capital and O&M cost.

Option 3 – All by Pipe Reticulation

- Precinct 5, 6 and nursery from Sewage Treatment Plant (STP 2)- Demand 5.5 Mld
- Promenade from lake – Demand 0.04 Mld
- Cemetery & religious area from Mining Pond – Demand 0.28 Mld

Capital cost : RM 7.85 million(inclusive RM 0.15 million for pipe jacking)
O & M cost : RM 0.47 million

This option utilizes mining pond water, which is highly acidic in nature. Therefore O&M cost becomes higher than Option 2 as treatment with lime is required. Moreover the long term impact due to acidic water is uncertain.

Option 4 - All by Truck

Capital cost : RM 12.2 million
O & M cost : RM 23.0 million

Option 5 - All by JBA Water

Capital cost : RM 1.05 million (Not inclusive cost for upgrading of JBA main)
O & M cost : RM 2.46 million

The total water demand is 6.62 Mld. Option not feasible due to high dependence on JBA water. JBA supply does not cater for this need. In addition, O & M cost is very high hence option not recommended.

Proposed Option – Option 2

This option utilises sewerage effluent as main source is in line with the policy to avoid over dependence on Putrajaya Lake. Compared to option 1 & 3, it is cheaper. As suitability of mining pond in Option 3 is also uncertain, option 2 is therefore recommended.

1.5 Group V – Precincts 7, 8, 9, 10 and 11

These precincts are located adjacent to each other on the north eastern part of the development. Precinct 9 and 10 are already been developed while 7, 8 and 11 are at various stages of construction.

Option 1 - All by Pipe Reticulation from Lake with Intake Pump at PH 4

Capital cost : RM 13.6 million (inclusive RM 7.75 million for pipe jacking)
O & M cost : RM 0.18 million

This option will incur digging and pipe jacking at the existing paved areas. It is also most expensive in terms of capital cost. In addition in line with the no dig policy, no further consideration can be given.

Option 2 – All by Pipe reticulation from Sewage Treatment Plant

It is not considered as irrigation areas too far from source (STP1)

Option 3 - All by Truck

Capital cost : RM 1.35 million
O&M cost : RM 5.22 million

Option is not recommended in view of its relatively higher cost (see proposed option) and its dependence on lake water. In addition, the lake as a source is far from Precinct 14, 15 & DE.

Option 2 - *All by Pipe from Sewage Treatment Plant STP1 except the Promenade*

Option considered not feasible for reasons:

- o STP water not suitable for promenade and religious area in Precinct 12
- o STP water is too far from Precinct 12

Option 3 - *All by truck*

Capital cost : RM 0.95 million
O & M cost : RM 3.22 million

Most expensive option in terms of O&M costs. Too many trucking (313 truck trips daily) can cause traffic congestion. Option hence discarded.

Option 4 - *All by JBA Water*

Capital cost : RM 0.77 million (Not inclusive cost for upgrading JBA main)
O & M cost : RM 0.38 million

Option is too dependent on JBA water. JBA policy does not cater for irrigation needs. Hence option is not considered further as it is also more expensive than the proposed option in terms of higher O&M cost.

Proposed Option - *Combination of pipe reticulation from lake and Sewage Water*

Capital cost : RM 3.61 million
O & M cost : RM 0.11 million

The sewage treatment plant (STP1) supplies 0.7 Mld of irrigation water, constituting 80 % of total demand of the 4 precincts. This option is preferred in line the policy to reduce dependency on lake water. This option is also cost effective than Option 1 hence

Very expensive option compared to the others. Moreover, too many trucking (508 truck trips daily) can cause traffic congestion. Hence, no further consideration will be given.

Option 4 - All by JBA Water

Capital cost : RM 1.04 million (Not inclusive cost for upgrading of JBA main)
O&M cost : RM 0.61 million

Total irrigation demand is 1.53 Mld. Option is not feasible/ recommended for reasons:

- o the existing JBA supply does not cater for irrigation need especially during drought
- o incurs digging of the paved areas in all the 5 precincts
- o high O & M cost

Option 5 – Combination of Trucking and JBA Water

Capital cost : RM 1.22 million
O & M cost : RM 2.70 million

Option is not feasible for reasons:

- o high O & M costs due to trucking
- o trucks plying protocol road and high speed roads are not practical

Proposed Option - Combination of pipe reticulation from lake, trucking and JBA water.

Capital cost : RM 4.81 million
O & M cost : RM 0.77 million

Most feasible option as it utilises combination of sources thereby reduces dependence on JBA & lake water.

1.6 Group VI – Precincts 12, 14, 15 & DE

These 4 precincts are located next to each other and all are still under planning stage. Hence the implementation of irrigation facilities and pipe reticulation system become easier with lesser constraints.

Option 1 - All by Pipe Reticulation from Lake with Pump Intake at PH6 located in Precinct 12

Capital cost : RM 4.16 million
O & M cost : RM 0.13 million

1.7 Group VII – Precincts 16 & 17

Precinct 16 is mostly been developed and with paved roads while Precinct 17 is still under preliminary planning stage.

Option 1 - All by Pipe Reticulation with Pump Intake at PH3 (located in precinct 19)

Capital cost : RM 3.08 million
O & M cost : RM 0.07 million

As Precinct 16 is already paved, pipe reticulation will incur digging and jacking at paved areas. Hence option not recommended.

Option 2 - All by Pipe Reticulation from Treated Sewage Plant STP1 (in Precinct 14) except Promenade vide pump Intake PH3

Capital cost : RM 4.85 million (inclusive RM 1.4 million for pipe jacking)
O & M cost : RM 0.053 million

Sewage Plant STP 1 is far from irrigated areas. Moreover, pipe reticulation in Precinct 16 will incur digging / pipe jacking at existing paved areas hence option is not recommended.

Option 3 - All by Truck

Capital cost : RM 0.58 million
O & M cost : RM 1.59 million

Option is too expensive in terms of O&M cost. Hence no consideration will be given.

Option 4 - All by JBA Water

Capital cost : RM 0.28 million (Not inclusive cost for upgrading JBA main)
O & M cost : RM 0.18 million

Option will incur digging paved areas in Precinct 16. JBA water does not cater for irrigation need (the water demand of 0.46 Mld is substantial). In line with 'no dig policy' and avoid dependence on JBA water, option is not recommended.

Proposed Option - *Combination of Pipe Reticulation from Lake (Intake at PH3), trucking and JBA water for Precinct 16*

Capital cost	:	RM 1.86 million
O & M cost	:	RM 0.12 million

Option is recommended as it is technically most feasible and is line with the 'no dig policy' for Precinct 16.

1.8 Group VIII- Precincts 19

Precinct 19 is currently under planning stage. Hence pipe option is possible and preferred.

Option 1 - *All by Pipe Reticulation with Pump Intake at PH3 (located in precinct 19)*

Capital cost	:	RM 2.21 million
O & M cost	:	RM 0.098 million

Option dependent on lake water and incur high capital cost.

Option 2 - *All by Pipe Reticulation from Treated Sewage Plant STP2 (in Precinct 19) except Promenade vide pump Intake PH3*

Capital cost	:	RM 2.24 million
O & M cost	:	RM 0.088 million

Option uses sewage water hence reduces dependency on lake water.

Option 3 - *All by Truck*

Capital cost	:	RM 0.58 million
O & M cost	:	RM 2.93 million

Option is discarded as it is too expensive and incurred high O&M cost to irrigate Taman Lindungan.

Option 4 - *All by JBA Water*

Capital cost	:	RM 0.44 million (Not inclusive cost for upgrading JBA main)
O&M cost	:	RM 0.33 million

High O&M cost. Option not feasible as JBA does not supply water for irrigation especially during drought.

Proposed Option – *Option 2 above (All by pipe from STP2 except promenade)*

Option 1 and 2 is comparable in terms of pipe length (5.6 KM) and distance from source. Option 2 is recommended as it will reduce dependency on lake water and is also cheaper.

TABLE J1

**IRRIGATION OPTION COST ESTIMATES
PRECINCT 1 (GROUP I)**

	CAPITAL COST			OPERATION & MAINTENANCE COST PER YEAR						LAND AREA (m ²)	
	Demand (m ³ /d)	Capacity (kW)	Amount (RM)	Usage (kW/day)	Rate (RM)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)		Amount (RM)
Group I - PRECINCT 1											
Option 1 - All by Pipe Reticulation from Lake											
1a. Intake & Pump House - PHA1	40	2*1	100,000.00	56	0.23	3,349.00	2.00%	2,000.00	5,349.00	16*12	
	Nominal Diameter (mm)	Length (m)	Rate (RM)	Amount (RM)				Amount (RM)	% of Capital C	Amount (RM)	AREA (m wide)
1b. Pipe reticulation	110	5,100	100.00	510,000.00	1.2698		0.00	2.00%	10,200.00	10,200.00	2.00
Extra over for pipe jacking	m	400	2,500.00	2,125,000.00							
ditto for working pit	no.	8	30,000.00	390,000.00							
ditto for reinstating	m ²	3,600	6.50	23,400.00							
	Park & Nursery Area (Ha)	Rate (RM/Ha)	Civic & Road Area (Ha)	Rate (RM/Ha)	Amount (RM)	% of Capital Cost	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)
1c. Watering system	-	-	1.59	52,500.00	83,280.75	3.00%	2,498.00	2.00%	1,666.00	4,164.00	
Total				3,235,905.75					5,847.00	13,866.00	19,713.00

Option 2 - All by Pipe Reticulation from Treated Sewerage Water (STP1)
- Not considered as far from source.

Option 3 - All by Truck										
	Number	Rate (RM)	Amount (RM)	Demand (m ³ /day)	Rate (RM/m ³)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)
3b. Lorry	13 Trips	2		40	13.00	135,200.00			135,200.00	-
3c. Depot	Lump	Sum	100,000.00		3.00%	3,000.00	2.00%	2,000.00	5,000.00	30*30
3d. Intake	0	300,000.00	0.00		3.00%	0.00	2.00%	0.00	0*(15*25)	
Total			100,000.00			138,200.00		2,000.00	140,200.00	900

Option 4 - All by JBA Water											
	Park & Nursery		Civic & Road		Amount (RM)	% of Capital Cost	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)
	Area (Ha)	Rate (RM/Ha)	Area (Ha)	Rate (RM/Ha)							
4a. Watering system	-	-	1.59	52,500.00	83,280.75	3.00%	2,498.00	2.00%	1,666.00	4,164.00	
4b. Water charges											
Total					83,280.75		17,058.00		1,666.00	18,724.00	0

Option 5 - Combination of Truck (92 m³/d) and JBA Water (22 m³/d)											
P3. By Truck for Road (Q = 92 m³/day)											
	Number	Rate (RM)	Amount (RM)	Demand (m ³ /day)	Rate (RM/m ³)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)	
P3b. Lorry	31 trips	5		92	13.00	310,960.00			310,960.00	-	
P3c. Depot	Lump	Sum	150,000.00		3.00%	4,500.00	2.00%	3,000.00	7,500.00	35*35	
P3d. Intake	0	300,000.00	0.00		3.00%	0.00	2.00%	0.00	0*(20*40)		
P4. By JBA Water for Government Reserve 1 and Public Utility (Q = 22 m³/day)											
	Park & Nursery		Civic & Road		Amount (RM)	% of Capital Cost	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)
	Area (Ha)	Rate (RM/Ha)	Area (Ha)	Rate (RM/Ha)							
P4a. Watering system	-	-	0.45	52,500.00	23,625.00	3.00%	709.00	2.00%	473.00	1,182.00	
P4b. Water charges											
Total					173,625.00		324,177.00		3,473.00	327,650.00	1,225

Proposed Option - Combination of Pipe Reticulation (92 m³/d) and JBA Water (22 m³/d)											
P1. By Pipe Reticulation for Road (Q = 92 m³/day)											
	Nominal Diameter (mm)	Length (m)	Rate (RM)	Amount (RM)			Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m wide)
1b. Pipe reticulation	110 - 140	4,000	104.00	416,000.00	1.2698		0.00	2.00%	8,320.00	8,320.00	2.00
Extra over for pipe jacking	m	400	2,500.00	1,000,000.00							
ditto for working pit	no.	8	30,000.00	240,000.00							
ditto for reinstating	m ²	3,600	6.50	23,400.00							
	Park & Nursery Area (Ha)	Rate (RM/Ha)	Civic & Road Area (Ha)	Rate (RM/Ha)	Amount (RM)	% of Capital Cost	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)
1c. Watering system	-	-	2.00	52,500.00	105,000.00	3.00%	3,150.00	2.00%	2,100.00	5,250.00	
P4. By JBA Water for Government Reserve 1 and Public Utility (Q = 22 m³/day)											
	Park & Nursery		Civic & Road		Amount (RM)	% of Capital Cost	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)
	Area (Ha)	Rate (RM/Ha)	Area (Ha)	Rate (RM/Ha)							
P4a. Watering system	-	-	0.45	52,500.00	23,625.00	3.00%	709.00	2.00%	473.00	1,182.00	
P4b. Water charges											
Total					1,808,025.00		11,867.00		10,893.00	22,760.00	2.00

Rationale for Proposed System

- Trucking is the only option for the completed road system unless 'no dig policy' can be waived at completed landscape buffer along the road.
- For VIP Hotel and Public Utilities, JBA water is proposed as surrounding areas have been developed ('no dig policy').
- JBA water is not proposed for the road system unless 'no dig policy' can be waived at completed landscape buffer along the road and the supply is limited.
- Upgrading of JBA pipe in Option 4 is excluded.

Note:

- | | | | | | | | | |
|---------------------------|-----|--------------|-----------------------------------|-----|-----------------|---|-----|--------------------|
| 1) Watering window = | 8 | hour | 5) Intake capacity for trucking = | 8 | trucks per time | 9) Proboard = | 0.6 | m |
| 2) Irrigation Frequency = | 250 | day per year | 6) Irrigation time for trucking = | 11 | hour | 10) Pond slope | 2.0 | (: :) |
| 3) Truck capacity = | 3 | cubic metre | 7) Filling time for trucking = | 0.5 | hour per batch | 11) Storage = | 1.0 | day demand |
| 4) Truck trip = | 4 | no. per day | 8) Water depth = | 2.4 | m | 12) All intake pump quantities are based on | | 1 duty & 1 standby |

TABLE J4
(Sheet 2/2)

IRRIGATION OPTION COST ESTIMATES
PRECINCT 5,6 & 20 (GROUP IV)

		CAPITAL COST			OPERATION & MAINTENANCE COST PER YEAR						LAND AREA (m2)	
		Number	Rate (RM)	Amount (RM)	Operation Cost		Maintenance Cost		Total			
Option 4 - All by Truck					Demand (m3/day)	Rate (RM/m3)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)		
4b Lorry	2,207 trips	368			6,621	13.00	22,378,980.00			22,378,980.00	-	
4c Depot		Lump	Sum	2,000,000.00		3.00%	60,000.00	2.00%	40,000.00	100,000.00	700*200	
4d Intake		34	300,000.00	10,200,000.00		3.00%	306,000.00	2.00%	204,000.00	510,000.00	34*(20*40)	
Total				12,200,000.00			22,744,980.00		244,000.00	22,988,980.00	67,200	
Option 5 - All by JBA Water												
		Park & Nursery		Civic & Road								
		Area (Ha)	Rate (RM/Ha)	Area (Ha)	Rate (RM/Ha)	Amount (RM)	% of Capital Cost	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m2)
5a. Watering system		3.75	52,500.00	16.33	52,500.00	1,054,236.75	3.00%	31,627.00	2.00%	21,085.00	52,712.00	
5b. Water charges							Demand (m3/day)	Rate (RM)	Amount (RM)		Amount (RM)	
							6,621	1.40	2,410,044.00		2,410,044.00	
Total						1,054,236.75		2,441,671.00		21,085.00	2,462,756.00	0
Proposed Option = Option 2												
i.e. Precinct 5 & nursery by Pipe Reticulation from Treated Sewerage Water (STP2 - 5404 m3/d)												
and Precinct 6, Precinct 5 promenade & cemetery from Lake (611 m3/d) i.e. Zone V & X												
Total						7,528,890.75		273,943.00		65,611.00	339,554.00	4,198

Rationale for Proposed System

1. Pipe reticulation from Lake is proposed for promenade and from mining pond for cemetery for sensitivity.
2. Pipe reticulation from treated sewerage water (STP2) for other areas is proposed to minimize the lake drawdown.
3. JBA water is not proposed as the supply is limited.
4. Irrigation for promenade at Precinct 19 (47m3/d) is proposed to be tapped from PHS nearby.
5. Upgrading of JBA pipe in Option 4 is excluded.

Note

- | | | | | | | | | |
|---------------------------|-----|--------------|-----------------------------------|-----|-----------------|---|-----|------------|
| 1) Watering window = | 1 | hour | 5) Intake capacity for trucking = | 4 | trucks per line | 9) Paddock = | 0.6 | m |
| 2) Irrigation frequency = | 360 | day per year | 6) Irrigation time for trucking = | 1 | hour | 10) Pond slope | 2 | (1:10) |
| 3) Truck capacity = | 3 | cubic meter | 7) Filling time for trucking = | 0.5 | hour per batch | 11) Storage = | 1 | day demand |
| 4) Truck trip = | 6 | no. per day | 8) Water depth = | 2.4 | m | 12) All intake pump quantities are based on | | |
| | | | | | | 1 duty at 1 standby | | |

TABLE J5
(Sheet 1/2)

IRRIGATION OPTION COST ESTIMATES
PRECINCTS 7,8,9,10 &11 (GROUP V)

		CAPITAL COST			OPERATION & MAINTENANCE COST PER YEAR						LAND	
		Demand (m ³ /d)	Capacity (k ³ W)	Amount (RM)	Operation Cost		Maintenance Cost		Total			
Group V - PRECINCTS 7, 8, 9, 10 & 11												
Option 1 - All by Pipe Reticulation from Lake												
		Demand (m ³ /d)	Capacity (k ³ W)	Amount (RM)	Usage (k ³ W/day)	Rate (RM)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)	
1a. Intake & Pump House - PHH		1,525	2*25	820,000.00	456	0.23	27,269.00	2.00%	16,400.00	43,669.00	16*12	
P5a. Intake & Pump House (Sq. Gajah)		59	2*1	120,000.00	56	0.23	3,349.00	2.00%	2,400.00	5,749.00	13*11	
		Nominal Diameter (mm)	Length (m)	Rate (RM)	Amount (RM)		Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m wide)	
1b. Pipe reticulation fr. PHH		110 - 200	24,310	154.00	3,743,740.00		0.00	2.00%	74,875.00	74,875.00	2.00	
Extra cover for pipe jacking		m	2,500	2,500.00	6,250,000.00							
dimo for working pit		no.	50	30,000.00	1,500,000.00							
dimo for reinstating		m2	21,810	6.50	141,765.00							
P5b. Pipe reticulation		110	100	100.00	10,000.00			2.00%	200.00	200.00	2.00	
		Park & Nursery		Civic & Road								
		Area (Ha)	Rate (RM/Ha)	Area (Ha)	Rate (RM/Ha)	Amount (RM)	% of Capital Cost	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)
1c. Watering system		1.84	52,500.00	18.04	52,500.00	1,043,742.00	3.00%	31,312.00	2.00%	20,875.00	52,187.00	
Total						13,629,247.00		61,930.00		114,750.00	176,680.00	339
Option 2 - All by Pipe Reticulation from Treated Sewerage Water (STP1)												
* Not considered as far from source.												
Option 3 - All by Truck												
		Number	Rate (RM)	Amount (RM)	Demand (m ³ /day)	Rate (RM/m ³)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)	
3b. Lorry		508 trips	85		1,525	13.00	5,154,500.00			5,154,500.00	-	
3c. Depot		Lump	Sum	450,000.00		3.00%	13,500.00	2.00%	9,000.00	22,500.00	95*95	
3d. Intake		3	300,000.00	900,000.00		3.00%	27,000.00	2.00%	18,000.00	45,000.00	3*(20*40)	
Total				1,350,000.00			5,195,000.00		27,000.00	5,222,000.00	11,425	
Option 4 - All by JBA Water												
		Park & Nursery		Civic & Road								
		Area (Ha)	Rate (RM/Ha)	Area (Ha)	Rate (RM/Ha)	Amount (RM)	% of Capital Cost	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)
4a. Watering system		1.84	52,500.00	18.04	52,500.00	1,043,742.00	3.00%	31,312.00	2.00%	20,875.00	52,187.00	
							Demand (m ³ /day)	Rate (RM)	Amount (RM)	Amount (RM)	AREA (m ²)	
4b. Water charges							1,525	1.40	555,100.00		555,100.00	0
Total						1,043,742.00			586,412.00	20,875.00	607,287.00	0

TABLE J5
(Sheet 2/2)

IRRIGATION OPTION COST ESTIMATES
PRECINCTS 7,8,9,10 & 11 (GROUP V)

	CAPITAL COST			OPERATION & MAINTENANCE COST PER YEAR						LAND		
	Demand (m ³ /d)	Capacity (kW)	Amount (RM)	Usage (kW/day)	Rate (RM)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)		AREA (m ²)	
Option V - PRECINCTS 7, 8, 9, 10 & 11 (Cont'd)												
Combination of Trucking (690 m³/d) and JBA Water (746m³/d) i.e. Zone IV												
P1. By Pipe Reticulation (Q = 90 m³/day)												
P1a. Intake & Pump House - PH4	90	2*4	150,000.00	104	0.23	6,219.00	2.00%	3,000.00	9,219.00	16*12		
P1b. Pipe reticulation fr PH4	Nominal Diameter (mm)	Length (m)	Rate (RM)	Amount (RM)		Amount (RM)		Amount (RM)	Amount (RM)	AREA (m wide)		
	110 - 140	0	104.00	0.00					0.00	2.00		
	Park & Nursery Area (Ha)	Rate (RM/Ha)	Area (Ha)	Rate (RM/Ha)	Amount (RM)	% of Capital Cost	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)	
P1&5c. Watering sys.	0.00	52,500	0.00	52,500.00	0.00	3.00%	0.00	2.00%	0.00	0.00		
	Volume (m ³)	Rate (RM)	Amount (RM)	Demand (m ³ /day)	Rate (RM/m ³)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)		
P3. Trucking (Q = 690 m³/day)	Number	Rate (RM)	Amount (RM)	Demand (m ³ /day)	Rate (RM/m ³)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)		
3b Lorry	230 trips	38		690	13.00	2,330,848.00			2,330,848.00	-		
3c. Depot		Lump	Sum		3.00%	6,000.00	2.00%	4,000.00	10,000.00	50*50		
3d. Intake		1	300,000.00		3.00%	9,000.00	2.00%	6,000.00	15,000.00	1*(20*40)		
P4 - JBA Water (Q = 746 m³/day)	Park & Nursery Area (Ha)	Rate (RM/Ha)	Area (Ha)	Rate (RM/Ha)	Amount (RM)	% of Capital Cost	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)	
4a. Watering system	1.58	52,500.00	9.22	52,500.00	566,863.50	3.00%	17,006.00	2.00%	11,337.00	28,343.00		
4b. Water charges				Demand (m ³ /day)	Rate (RM)	Amount (RM)			Amount (RM)	Amount (RM)	AREA (m ²)	
				746	1.40	271,544.00			271,544.00			
Total						1,216,863.50			2,640,617.00	24,337.00	2,664,954.00	3,494

Option 6 - Proposed Option												
Combination of Pipe Reticulation (355 m³/d), JBA water (1091 m³/d) and Trucking (79 m³/d)												
	Demand (m ³ /d)	Capacity (kW)	Amount (RM)	Usage (kW/day)	Rate (RM)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)		
P1a. Intake & Pump House - PH4	355	2*6.5	360,000.00	168	0.23	10,046.00	2.00%	7,200.00	17,246.00	18*14		
P1b. Pipe reticulation fr PH4	Nominal Diameter (mm)	Length (m)	Rate (RM)	Amount (RM)		Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m wide)		
	110 - 160	16,000	124.00	1,984,000.00		0.00	2.00%	39,680.00	39,680.00	2.00		
	Extra cover for pipe jacking	m	300	2,500.00	750,000.00							
	ditto for working pit	no.	20	30,000.00	600,000.00							
	ditto for reinstating	m ²	15,700	6.50	102,050.00							
	Volume (m ³)	Rate (RM)	Amount (RM)	Demand (m ³ /day)	Rate (RM/m ³)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)		
P3. Trucking (Q = 79 m³/day)	Number	Rate (RM)	Amount (RM)	Demand (m ³ /day)	Rate (RM/m ³)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)		
3b Lorry	26 trips	4		79	13.00	266,682.00			266,682.00	-		
3c. Depot		Lump	Sum		3.00%	4,500.00	2.00%	3,000.00	7,500.00	35*35		
3d. Intake		1	300,000.00		3.00%	9,000.00	2.00%	6,000.00	15,000.00	1*(20*40)		
P4 - JBA Water (Q = 1091 m³/day)	Park & Nursery Area (Ha)	Rate (RM/Ha)	Area (Ha)	Rate (RM/Ha)	Amount (RM)	% of Capital Cost	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)	
3g. Watering system	1.58	52,500.00	9.22	52,500.00	566,863.50	3.00%	17,006.00	2.00%	11,337.00	28,343.00		
4b. Water charges				Demand (m ³ /day)	Rate (RM)	Amount (RM)			Amount (RM)	Amount (RM)	AREA (m ²)	
				1,091	1.40	397,160.00			397,160.00	10*15		
Total						4,812,913.50			704,394.00	67,217.00	771,611.00	2,429

Rationale for Proposed System

1. Trucking is the only option for the road system (completed or ongoing) unless 'no dig policy' can be waived.
2. Upgrading of JBA pipe in Option 4 is excluded.

Note:

- | | | |
|--|---|--|
| 1) Watering window = 8 hour | 5) Intake capacity for trucking = 8 trucks per time | 9) Fretboard = 0.6 m |
| 2) Irrigation Frequency = 260 day per year | 6) Irrigation time for trucking = 12 hour | 10) Pond slope = 2 (1 : H) |
| 3) Truck capacity = 3 cubic meter | 7) Filling time for trucking = 0.5 hour per batch | 11) Storage = 1 day demand |
| 4) Truck trip = 6 no. per day | 8) Water depth = 2.4 m | 12) All Intake pump quantities are based on 1 duty & 1 standby |

TABLE J6

**IRRIGATION OPTION COST ESTIMATES
PRECINCTS 12,14,15 & DE (GROUP VI)**

	CAPITAL COST			OPERATION & MAINTENANCE COST PER YEAR						LAND AREA (m ²)	
	Demand (m ³ /d)	Capacity (kW)	Amount (RM)	Usage (kW/day)	Rate (RM)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)		Amount (RM)
Group VI - PRECINCTS 12, 14, 15 & DE											
Option 1 - All by Pipe Reticulation from Lake											
1a. Intake & Pump House - PH6	938	2*25	800,000.00	440	0.23	26,312.00	2.00%	16,900.00	42,312.00	16*12	
1b. Pipe reticulation	Nominal Diameter (mm)	Length (m)	Rate (RM)	Amount (RM)		Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m wide)	
	110 - 280	16,840	154.00	2,593,360.00			0.00	51,867.00	51,867.00	2.00	
	Park & Nursery Area (Ha)	Rate (RM/Ha)	Civic & Road Area (Ha)	Rate (RM/Ha)	Amount (RM)	% of Capital Cost	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)
	2.24	52,500.00	12.42	52,500.00	769,329.75	3.00%	23,080.00	2.00%	15,387.00	38,467.00	
1c. Watering system	2.24	52,500.00	12.42	52,500.00	769,329.75				15,387.00	38,467.00	
Total			4,162,689.75			49,392.00		83,254.00	132,646.00	194	

Option 2 - All by Pipe Reticulation from Treated Sewerage Water
- not considered as far from source.

Option 3 - All by Truck

	Number	Rate (RM)	Amount (RM)	Demand (m ³ /day)	Rate (RM/m ³)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)
2b. Lorry	313 trips	52	16,276.00	938	13.00	12,194.00	3.00%	7,050.00	31,720.00	-
2c. Depot	Lump	Sum	350,000.00		3.00%	10,500.00	2.60%	17,500.00	80*80	
2d. Intake	2	300,000.00	600,000.00		3.00%	18,000.00	2.60%	30,000.00	2*20*40	
Total			950,000.00			3,198,940.00		19,000.00	3,217,940.00	8,000

Option 4 - All by JBA Water

	Park & Nursery		Civic & Road		Amount (RM)	% of Capital Cost	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)
	Area (Ha)	Rate (RM/Ha)	Area (Ha)	Rate (RM/Ha)							
3a. Watering system	2.24	52,500.00	12.42	52,500.00	769,329.75	3.00%	23,080.00	2.00%	15,387.00	38,467.00	
3b. Water charges							938	1.40	341,432.00	341,432.00	
Total					769,329.75				364,512.00	379,899.00	0

Proposed Option - Combination of Pipe Reticulation from Lake (237 m³/d) & Treated Sewerage Water (695m³/d) i.e. Zone VI & IX

P1. By Pipe Reticulation (Q = 932 m³/day)											
	Demand (m ³ /d)	Capacity (kW)	Amount (RM)	Usage (kW/day)	Rate (RM)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)	
P1a. Intake & Pump House - PH6	237	2*7.5	250,000.00	160	0.23	9,568.00	2.00%	5,000.00	14,568.00	16*12	
P2a. Intake & Pump House - SP1	695	2*20	820,000.00	360	0.23	21,528.00	2.00%	16,400.00	37,928.00	16*12	
P1b. Pipe reticulation fr PH6	Nominal Diameter (mm)	Length (m)	Rate (RM)	Amount (RM)		Amount (RM)		Amount (RM)	Amount (RM)	AREA (m wide)	
	110 - 140	5,789	104.00	601,120.00						0.00	
P2b. Pipe reticulation fr SP1	110 - 225	8,360	134.00	1,120,240.00						0.00	
										0.00	
	Park & Nursery Area (Ha)	Rate (RM/Ha)	Civic & Road Area (Ha)	Rate (RM/Ha)	Amount (RM)	% of Capital Cost	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)
	2.24	52,500.00	12.42	52,500.00	769,329.75	3.00%	23,080.00	2.00%	15,387.00	38,467.00	
P1.2. Water. sys.											
EXCAVATION for Storage Pond											
P2d. SP1 at STP1 (PJP 14)	1,029	12.00	12,348.00				2.00%	247.00	247.00	30*30	
DISINFECTION using sodium hypochlorite											
P2e. STP1 for SP1	695		40,500.00	695	0.015	21,210.00	2.00%	810.00	22,020.00	10*15	
Total			3,613,537.75			75,386.00		37,844.00	113,230.00	1,440	

Rationale for Proposed System

1. Pipe reticulation from lake for Precinct 12 is proposed as nearby the source.
2. Pipe reticulation from treated sewerage water (STP1) is proposed due to proximity and to minimise lake drawdowns for Precincts 14, 15 & DE.
3. JBA water is not proposed as the supply is limited.
4. Upgrading of JBA pipe in Option 4 is excluded.

Note:

- | | | |
|--|---|--|
| 1) Watering window = 8 hour | 5) Intake capacity for trucking = 8 trucks per line | 9) Freshwater = 0.6 m |
| 2) Irrigation Frequency = 250 day per year | 6) Irrigation time for trucking = 12 hour | 10) Pond slope = 2 (1:50) |
| 3) Truck capacity = 3 cubic meter | 7) Filling time for trucking = 0.5 hour per batch | 11) Storage = 1 day demand |
| 4) Truck trip = 6 no. per day | 8) Water depth = 2.4 m | 12) All intake pump quantities are based on 1 duty & 1 standby |

TABLE J7
(Sheet 1/2)

IRRIGATION OPTION COST ESTIMATES
PRECINCTS 16 & 17 (GROUP VII)

		CAPITAL COST			OPERATION & MAINTENANCE COST PER YEAR						LAND
		Demand (m3/d)	Capacity (kW)	Amount (RM)	Usage (kW/day)	Rate (RM)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m2)
Group VII - PRECINCTS 16 & 17											
Option 1 - All by Pipe Reticulation from Lake											
1a. Intake & Pump House - PHA2		462	2*22	330,000.00	392	0.23	23,442.00	2.00%	6,600.00	30,042.00	16*12
		Nominal Diameter (mm)	Length (m)	Rate (RM)	Amount (RM)		Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m wide)
1b. Pipe reticulation		110 - 160	9,242	124.00	1,146,008.00		0.00	2.00%	22,920.00	22,920.00	2.00
Extra over for pipe jacking		m	400	2,500.00	1,000,000.00						
ditto for working pit		no.	10	30,000.00	300,000.00						
ditto for reinstating		m2	3,100	6.50	20,150.00						
		Park & Nursery	Civic & Road	Amount (RM)	% of Capital Cost	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	Amount (RM)	AREA (m2)
		Area (Ha)	Rate (RM/Ha)	Area (Ha)	Rate (RM/Ha)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	Amount (RM)	AREA (m2)
1c. Watering system		0.38	52,500	4.94	52,500.00	279,074.25	3.00%	8,372.00	2.00%	5,581.00	13,953.00
Total						3,075,232.25		31,814.00		35,101.00	66,915.00
Option 2 - All by Pipe Reticulation from Treated Sewerage Water (STP1 - 420 m3/d) except promenade from Lake (42 m3/d)											
2a. Intake & Pump House - PHA3		420	2*20	330,000.00	360	0.23	21,528.00	2.00%	6,600.00	28,128.00	16*12
2b. Intake & Pump House - PH3a		42	2*2	110,000.00	72	0.23	4,306.00	2.00%	2,200.00	6,506.00	13*11
		Nominal Diameter (mm)	Length (m)	Rate (RM)	Amount (RM)		Amount (RM)		Amount (RM)	Amount (RM)	AREA (m wide)
2c. Pipe reticulation fr PHA3		110 - 160	15,950	124.00	1,977,800.00		0.00			0.00	2.00
2d. Pipe reticulation fr PH3a		110	8,000	100.00	800,000.00		0.00			0.00	2.00
Extra over for pipe jacking		m	400	2,500.00	1,000,000.00						
ditto for working pit		no.	10	30,000.00	300,000.00						
ditto for reinstating		m2	3,100	6.50	20,150.00						
		Park & Nursery	Civic & Road	Amount (RM)	% of Capital Cost	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	Amount (RM)	AREA (m2)
		Area (Ha)	Rate (RM/Ha)	Area (Ha)	Rate (RM/Ha)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	Amount (RM)	AREA (m2)
2e. Watering system		0.38	52,500.00	4.94	52,500.00	279,074.25	3.00%	8,372.00	2.00%	5,581.00	13,953.00
		Volume (m3)	Rate (RM)	Amount (RM)		Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	Amount (RM)	AREA (m2)
EXCAVATION for Storage Pond 2f. PHA3 at STP1 (P&P 12)		658	12.00	7,896.00			2.00%	158.00		158.00	25*25
		Capacity (m3/day)	Amount	Demand (m3/day)	Rate (RM)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	Amount (RM)	
DISINFECTION using sodium hypochlorite											
2g. STP1 for PHA3		420		25,000.00	420	0.005	4,019.00	2.00%	500.00	4,519.00	10*15
Total				4,849,920.25			38,225.00		15,039.00	53,264.00	1,114
Option 3 - All by Truck											
		Number	Rate (RM)	Amount (RM)	Demand (m3/day)	Rate (RM/m3)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m2)
3b. Lorry		154 trips	26		462	13.00	1,561,560.00			1,561,560.00	-
3c. Depot		Lump	Sum	275,000.00		3.00%	8,250.00	2.00%	5,500.00	13,750.00	60*60
3d. Intake		1	300,000.00	300,000.00		3.00%	9,000.00	2.00%	6,000.00	15,000.00	1*(20*40)
Total				575,000.00			1,578,810.00		11,500.00	1,590,310.00	4,400
Option 4 - All by JBA Water											
		Park & Nursery	Civic & Road	Amount (RM)	% of Capital Cost	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	Amount (RM)	AREA (m2)
		Area (Ha)	Rate (RM/Ha)	Area (Ha)	Rate (RM/Ha)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	Amount (RM)	AREA (m2)
4a. Watering system		0.38	52,500.00	4.94	52,500.00	279,074.25	3.00%	8,372.00	2.00%	5,581.00	13,953.00
		Demand (m3/day)	Rate (RM)	Amount (RM)		Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	Amount (RM)	AREA (m2)
4b. Water charges					462	1.40	168,168.00			168,168.00	
Total				279,074.25			176,540.00		5,581.00	182,121.00	0

TABLE J8

**IRRIGATION OPTION COST ESTIMATES
PRECINCT 19 (GROUP VIII)**

	CAPITAL COST				OPERATION & MAINTENANCE COST PER YEAR						LAND	
	Operation Cost		Maintenance Cost		Total		AREA (m ²)					
Group VIII - PRECINCT 19												
Option 1 - All by Pipe Reticulation from Lake												
	Demand (m ³ /d)	Capacity (kW)	Amount (RM)	Usage (kW/day)	Rate (RM)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	Amount (RM)	AREA (m ²)	
1a. Intake & Pump House - PH3	858	2*40	960,000.00	680	0.23	40,664.00	2.00%	19,200.00	59,864.00	16*12		
	Nominal Diameter (mm)	Length (m)	Rate (RM)	Amount (RM)		Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	Amount (RM)	AREA (m wide)	
1b. Pipe reticulation	110 - 250	5,600	144.00	806,400.00		0.00	2.00%	16,128.00	16,128.00	2.00		
	Park & Nursery Area (Ha)	Rate (RM/Ha)	Civic & Road Area (Ha)	Rate (RM/Ha)	Amount (RM)	% of Capital Cost	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)	
1c. Watering system	1.42	52,500.00	7.05	52,500.00	444,601.50	3.00%	13,338.00	2.00%	8,892.00	22,230.00		
Total					2,211,001.50				54,002.00	44,220.00	98,222.00	194
Option 2 - All by Pipe Reticulation from Treated Sewerage Water (STP2 - 830 m³/d) except promenade from Lake (28 m³/d)												
	Demand (m ³ /d)	Capacity (kW)	Amount (RM)	Usage (kW/day)	Rate (RM)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	Amount (RM)	AREA (m ²)	
2a. Intake & Pump House - PH3	28	2*1.5	110,000.00	64	0.23	3,827.00	2.00%	2,200.00	6,027.00	13*11		
2b. Intake & Pump House - SP2	830	2*40	980,000.00	680	0.23	40,664.00	2.00%	19,600.00	60,264.00	16*12		
	Nominal Diameter (mm)	Length (m)	Rate (RM)	Amount (RM)		Amount (RM)			Amount (RM)	Amount (RM)	AREA (m wide)	
2c. Pipe reticulation fr PH3	110	2,530	100.00	253,000.00		0.00			0.00	0.00	2.00	
2d. Pipe reticulation fr SP2	110 - 225	3,370	134.00	451,580.00		0.00			0.00	0.00	2.00	
	Park & Nursery Area (Ha)	Rate (RM/Ha)	Civic & Road Area (Ha)	Rate (RM/Ha)	Amount (RM)	% of Capital Cost	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)	
2e. Watering system	1.42	52,500.00	7.05	52,500.00	444,601.50	3.00%	13,338.00	2.00%	8,892.00	22,230.00		
Total					2,239,181.50				57,829.00	30,692.00	88,521.00	339
Option 3 - All by Truck												
	Number	Rate (RM)	Amount (RM)	Demand (m ³ /day)	Rate (RM/m ³)	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	Amount (RM)	AREA (m ²)	
3a. Labour												
3b. Lorry	286 trips	48		858	13.00	2,900,040.00				2,900,040.00	-	
3c. Depot		Lump	275,000.00		3.00%	8,250.00	2.00%	5,500.00	13,750.00	15,000.00	70*70	
3d. Intake	1	300,000.00	300,000.00		3.00%	9,000.00	2.00%	6,000.00	15,000.00	1*(20*40)		
Total			575,000.00			2,917,290.00		11,500.00	2,928,790.00	5,700		
Option 4 - All by JBA Water												
	Park & Nursery Area (Ha)	Rate (RM/Ha)	Civic & Road Area (Ha)	Rate (RM/Ha)	Amount (RM)	% of Capital Cost	Amount (RM)	% of Capital C	Amount (RM)	Amount (RM)	AREA (m ²)	
4a. Watering system	1.42	52,500.00	7.05	52,500.00	444,601.50	3.00%	13,338.00	2.00%	8,892.00	22,230.00		
						Demand (m ³ /day)	Rate (RM)	Amount (RM)		Amount (RM)		
4b. Water charges						858	1.40	312,312.00		312,312.00		
Total					444,601.50			325,650.00	8,892.00	334,542.00	0	
Proposed Option - Option 2												
Option 2 - All by Pipe Reticulation from Treated Sewerage Water (STP2 - 830 m³/d) except promenade from Lake (28 m³/d)												
Total					2,239,181.50			57,829.00	30,692.00	88,521.00	339	

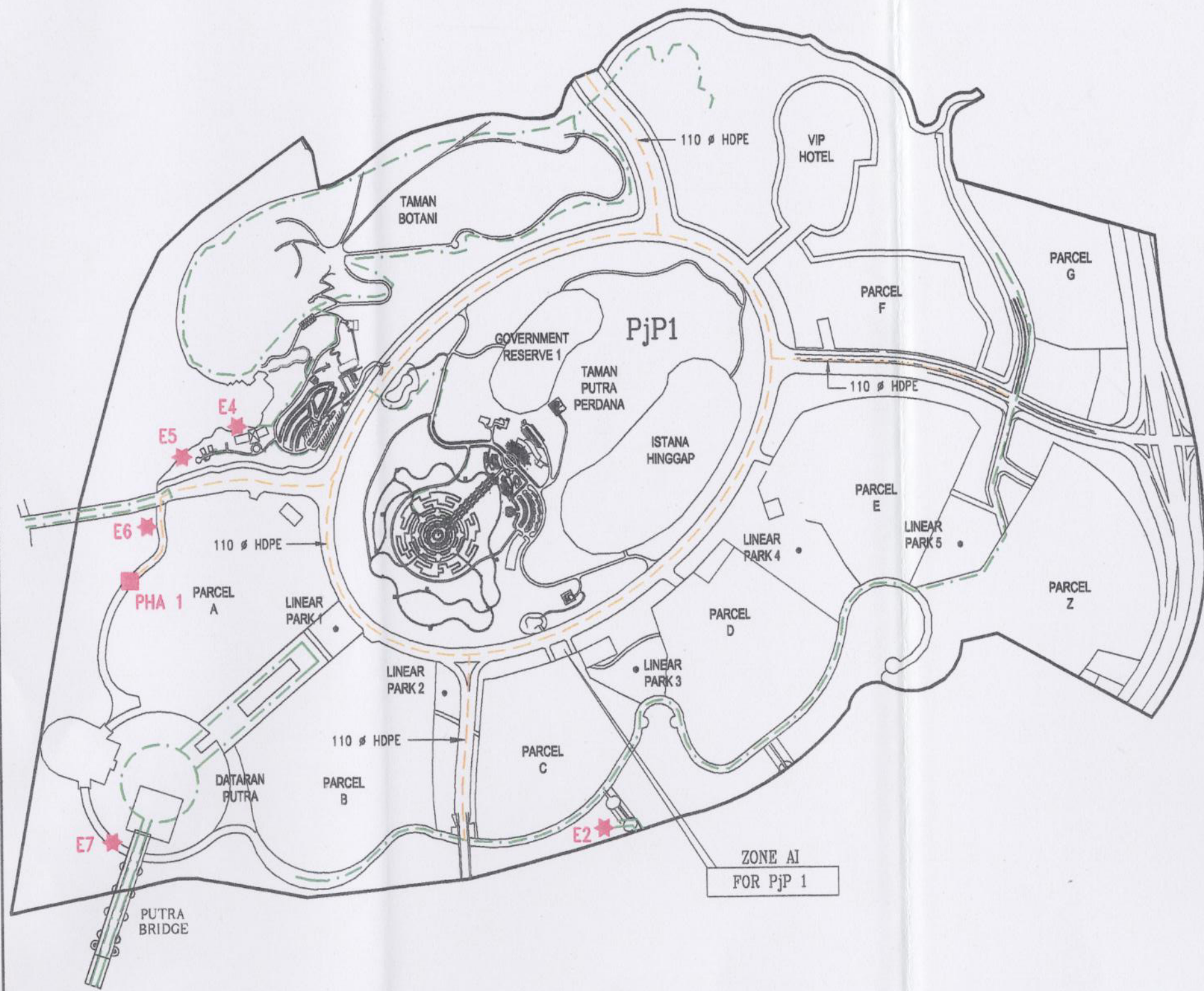
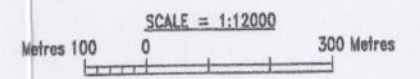
Rationale for Proposed System

- Pipe reticulation from Lake is proposed for promenade is proposed due to proximity.
- Upgrading of JBA pipe in Option 4 is excluded.

Note:

- | | | |
|--|---|--|
| 1) Watering window = 8 hour | 5) Intake capacity for trucking = 8 trucks per time | 9) Freeboard = 0.6 m |
| 2) Irrigation Frequency = 260 day per year | 6) Irrigation time for trucking = 12 hour | 10) Pond slope = 2 (1 : H) |
| 3) Truck capacity = 3 cubic meter | 7) Filling time for trucking = 0.5 hour per batch | 11) Storage = 1 day det. and |
| 4) Truck trip = 6 no. per day | 8) Water depth = 2.4 m | 12) All intake pump quantities are based on 1 duty & 1 standby |

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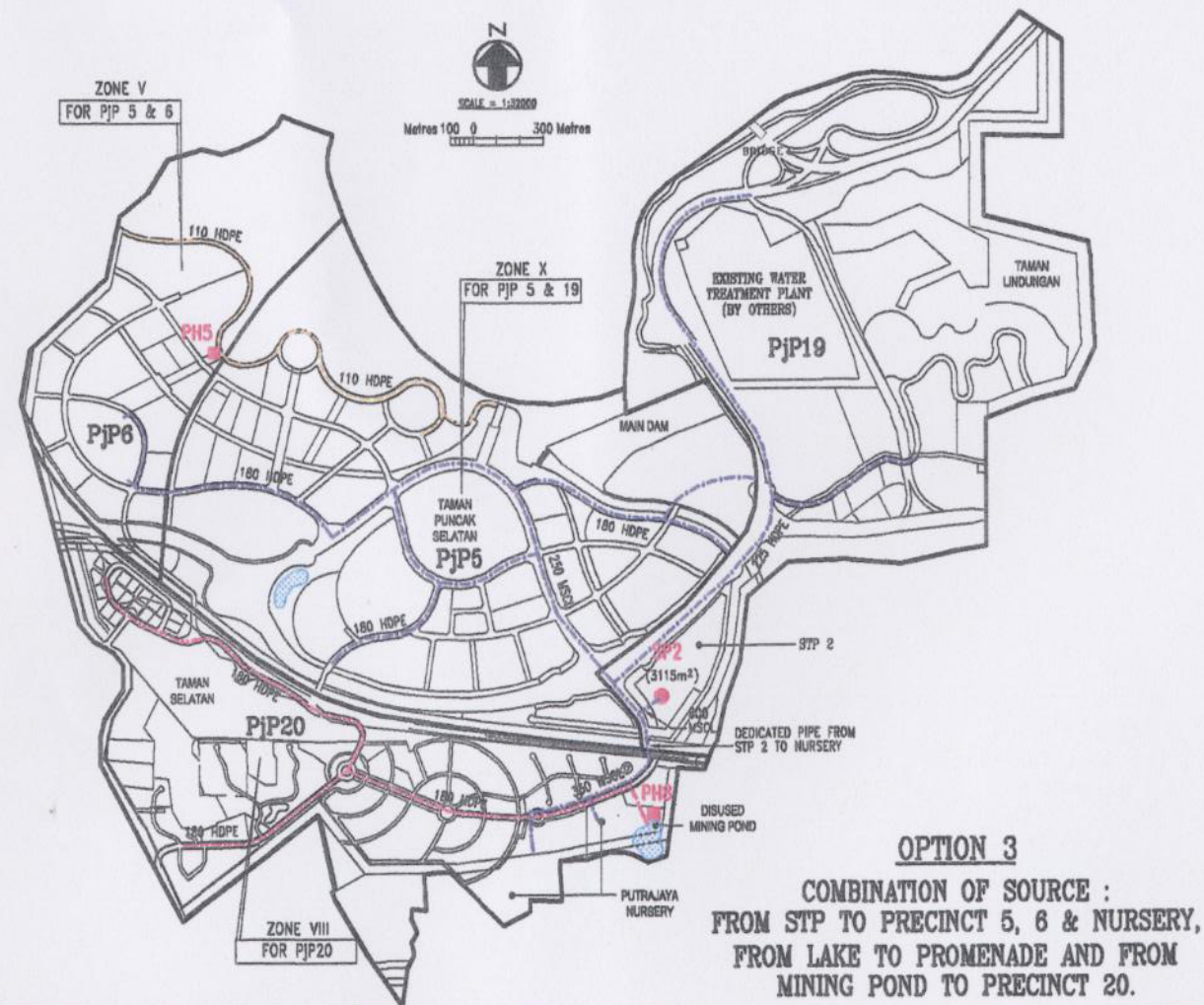
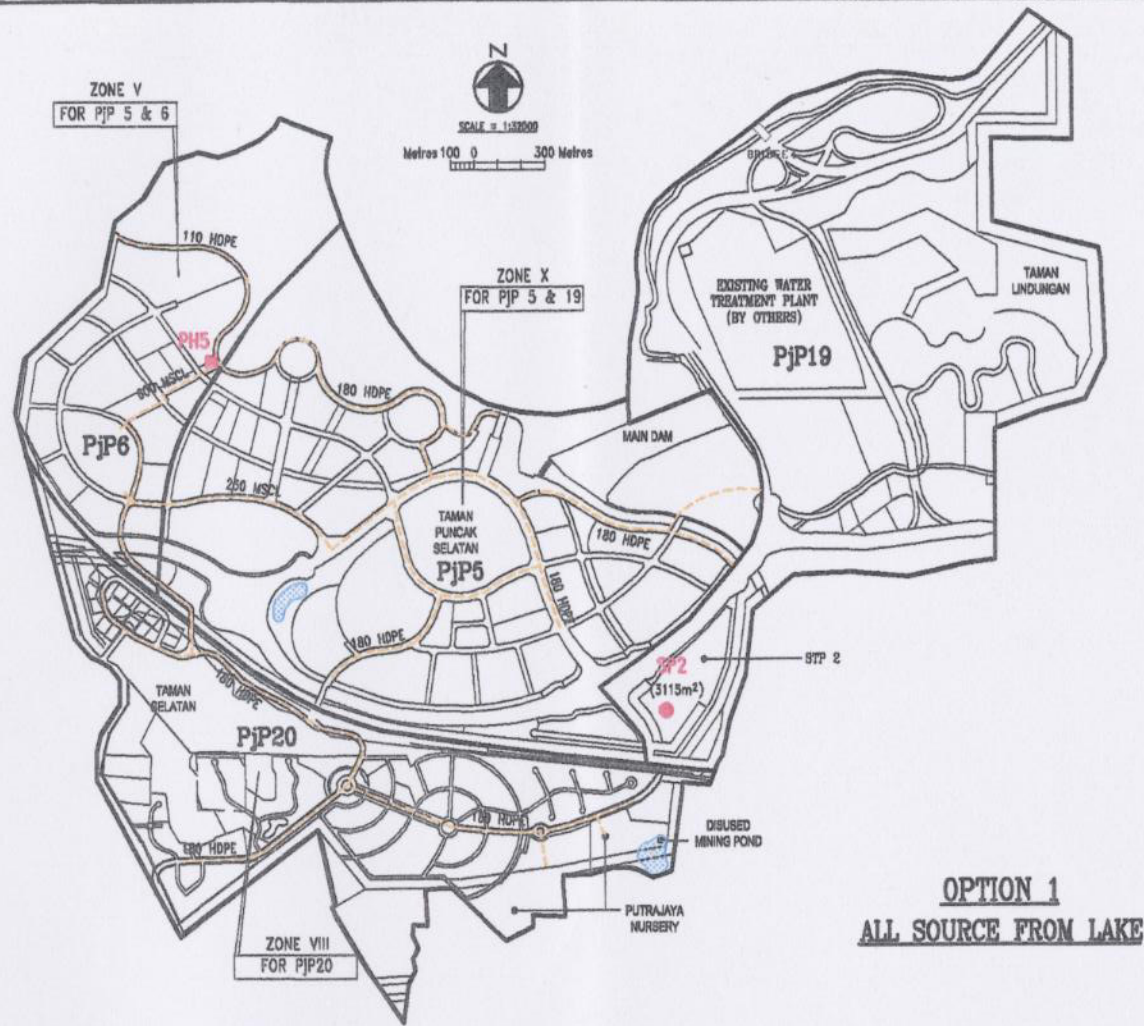


- LEGEND:**
- PRECINCT BOUNDARY
 - PIPE FROM LAKE
 - PIPE FROM STP
 - EXISTING PIPE
 - EXISTING DRAINAGE RETENTION PONDS
 - PROPOSED INTAKE FROM LAKE (PH1-PH8 & PHA1-PHA6)
 - PROPOSED INTAKE FROM SEWAGE TREATMENT PLANT (SP1 & SP2)
 - EXISTING INTAKE
 - E1** WETLAND MAIN PUMPING STATION } FOR WATER CIRCULATION TO WETLANDS
 - E2** UPPER BISA PUMPING STATION }
 - E3** PHASE 1A (ZONE 6) PUMPING STATION
 - E4** TAMAN BOTANI PUMPING STATION
 - E5** TAMAN PUTRA PERDANA PUMPING STATION
 - E6** BRIDGE 10 SUBMERSIBLE PUMP
 - E7** DATARAN PUTRA & PUTRA BRIDGE PUMPING STATION
 - E8** TAMAN WARISAN PERTANIAN PUMPING STATION (PUMP TO STI)
 - E9** PM RESIDENCE PUMPING STATION
 - E10** TAMAN WAWASAN PUMPING STATION
 - E11** PERSISIRAN WARISAN PUMPING STATION
 - STI** TAMAN WARISAN PERTANIAN STORAGE TANK (EXISTING)
 - STP** SEWERAGE TREATMENT PLANT
 - PjP1** PUTRAJAYA PRECINCT 1

OPTION 1
ALL SOURCE FROM LAKE



IRRIGATION MASTER PLAN FOR PUTRAJAYA
ALTERNATIVE IRRIGATION SYSTEM
FOR PRECINCT 1



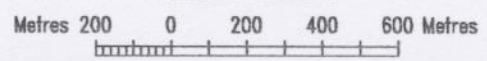
- LEGEND:**
- PRECINCT BOUNDARY
 - PIPE FROM LAKE
 - PIPE FROM STP
 - PIPE FROM MINING POND
 - EXISTING PIPE
 - EXISTING DRAINAGE RETENTION PONDS
 - PROPOSED INTAKE FROM LAKE (PH1-PH8)
 - PROPOSED INTAKE FROM SEWAGE TREATMENT PLANT (SP1 & SP2)
 - STP SEWERAGE TREATMENT PLANT
 - PjP1 PUTRAJAYA PRECINCT 1
 - (3115m²) POND AREA



IRRIGATION MASTER PLAN FOR PUTRAJAYA
ALTERNATIVE IRRIGATION SYSTEM FOR
PRECINCTS 5, 6 & 20



SCALE = 1:20000



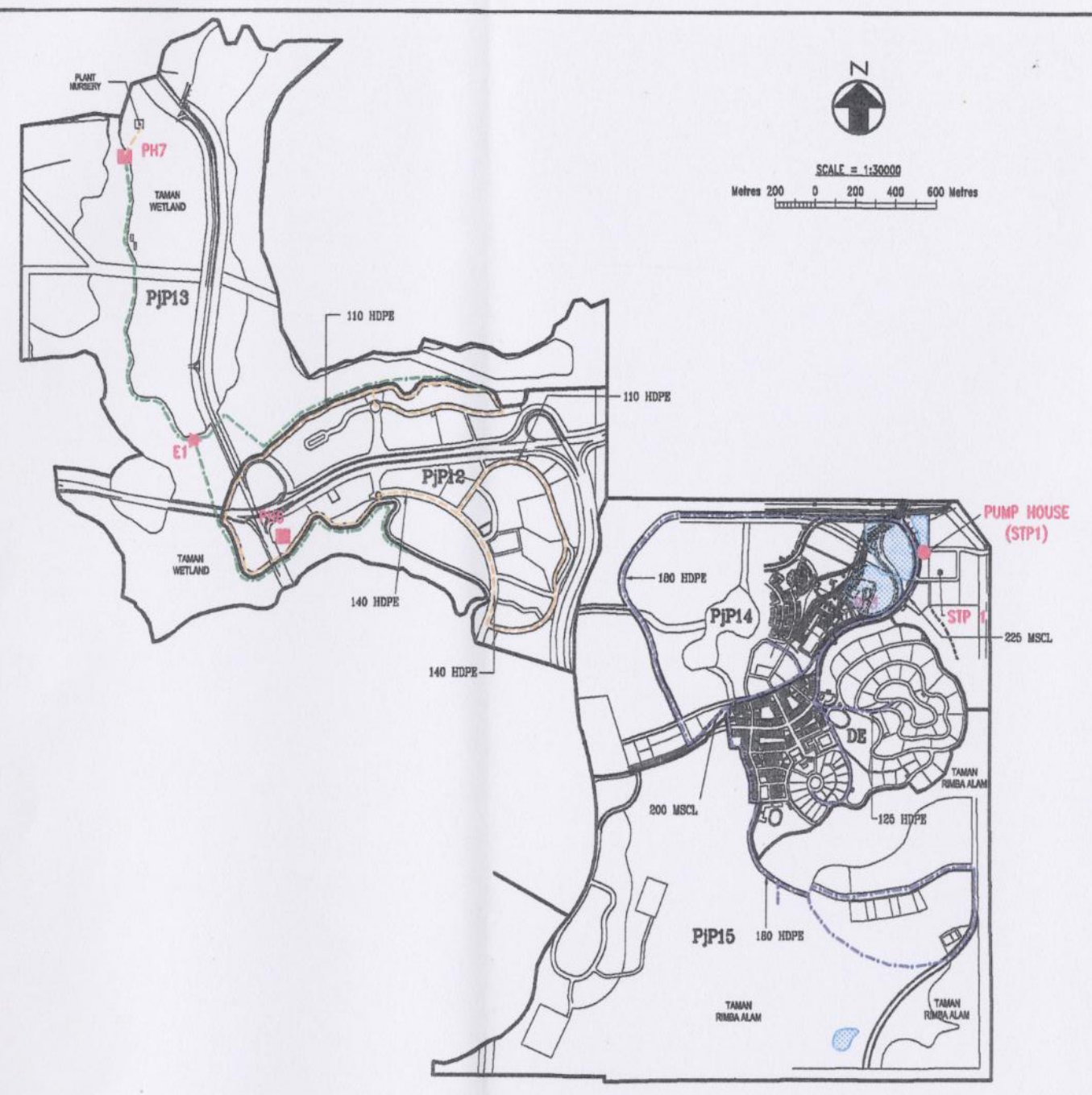
LEGEND:

- PRECINCT BOUNDARY
- PIPE FROM LAKE
- PIPE FROM STP
- PIPE FROM RETENTION POND
- EXISTING PIPE
- EXISTING DRAINAGE RETENTION PONDS
- PROPOSED INTAKE FROM LAKE (PH1-PH8 & PHA1-PHA6)
- PROPOSED INTAKE FROM SEWAGE TREATMENT PLANT (SP1 & SP2)
- EXISTING INTAKE
- E1 WETLAND MAIN PUMPING STATION
- E2 UPPER BISA PUMPING STATION
- E3 PHASE 1A (ZONE 6) PUMPING STATION
- E4 TAMAN BOTANI PUMPING STATION
- E5 TAMAN PUTRA PERDANA PUMPING STATION
- E6 BRIDGE 10 SUBMERSIBLE PUMP
- E7 DATARAN PUTRA & PUTRA BRIDGE PUMPING STATION
- E8 TAMAN WARISAN PERTANIAN PUMPING STATION (PUMP TO STI)
- E9 PM RESIDENCE PUMPING STATION
- E10 TAMAN WAWASAN PUMPING STATION
- E11 PERSISIRAN WARISAN PUMPING STATION
- STI TAMAN WARISAN PERTANIAN STORAGE TANK (EXISTING)
- STP SEWERAGE TREATMENT PLANT
- PjP1 PUTRAJAYA PRECINCT 1

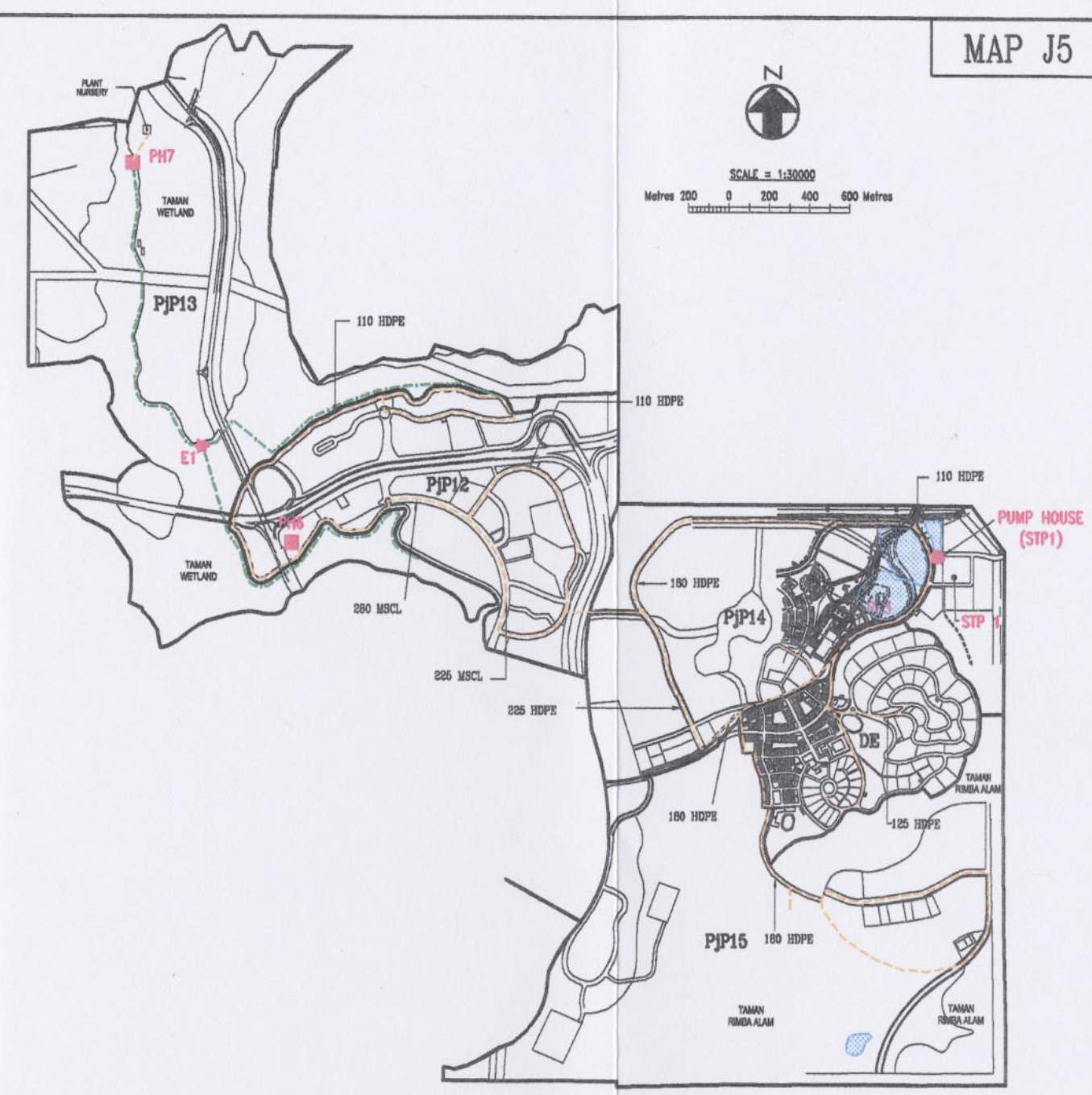
OPTION 1
ALL SOURCE FROM LAKE



IRRIGATION MASTER PLAN FOR PUTRAJAYA
ALTERNATIVE IRRIGATION SYSTEM
FOR PRECINCTS 7,8,9,10 & 11



PROPOSED OPTION
 COMBINATION OF SOURCE : FROM LAKE TO PRECINCT 12
 AND FROM STP1 TO PRECINCT 14, 15 AND DE



OPTION 1
 ALL SOURCE FROM LAKE

- LEGEND:**
- PRECINCT BOUNDARY
 - PIPE FROM LAKE
 - PIPE FROM STP
 - EXISTING WATER CIRCULATION PIPE FOR WETLAND
 - EXISTING DRAINAGE RETENTION PONDS
 - PROPOSED INTAKE FROM LAKE (PH1-PH6 & PHA1-PHA6)
 - PROPOSED INTAKE FROM SEWAGE TREATMENT PLANT (SP1, SP2, PHA7 & PHA8)

- EXISTING INTAKE**
- ★ E1 WETLAND MAIN PUMPING STATION } FOR WATER CIRCULATION TO WETLANDS
 - ★ E2 UPPER USA PUMPING STATION }
 - ★ E3 PHASE 1A (ZONE 6) PUMPING STATION
 - ★ E4 TAMAN BOTANI PUMPING STATION
 - ★ E5 TAMAN PUTRA PERDANA PUMPING STATION
 - ★ E6 BRIDGE 10 SUBMERSIBLE PUMP
 - ★ E7 DATARAN PUTRA & PUTRA BRIDGE PUMPING STATION
 - ★ E8 TAMAN WARISAN PERTANIAN PUMPING STATION (PUMP TO STI)
 - ★ E9 PM RESIDENCE PUMPING STATION
 - ★ E10 TAMAN WAWASAN PUMPING STATION
 - ★ E11 PERSISIRAN WARISAN PUMPING STATION

- ▲ STI TAMAN WARISAN PERTANIAN STORAGE TANK (EXISTING)
- STP SEWERAGE TREATMENT PLANT
- PjP1 PUTRAJAYA PRECINCT 1



IRRIGATION MASTER PLAN FOR PUTRAJAYA
 ALTERNATIVE IRRIGATION SYSTEM
 FOR PRECINCTS 12, 14, 15 & DE



SCALE = 1:10000

Metres 200 0 200 400 Metres



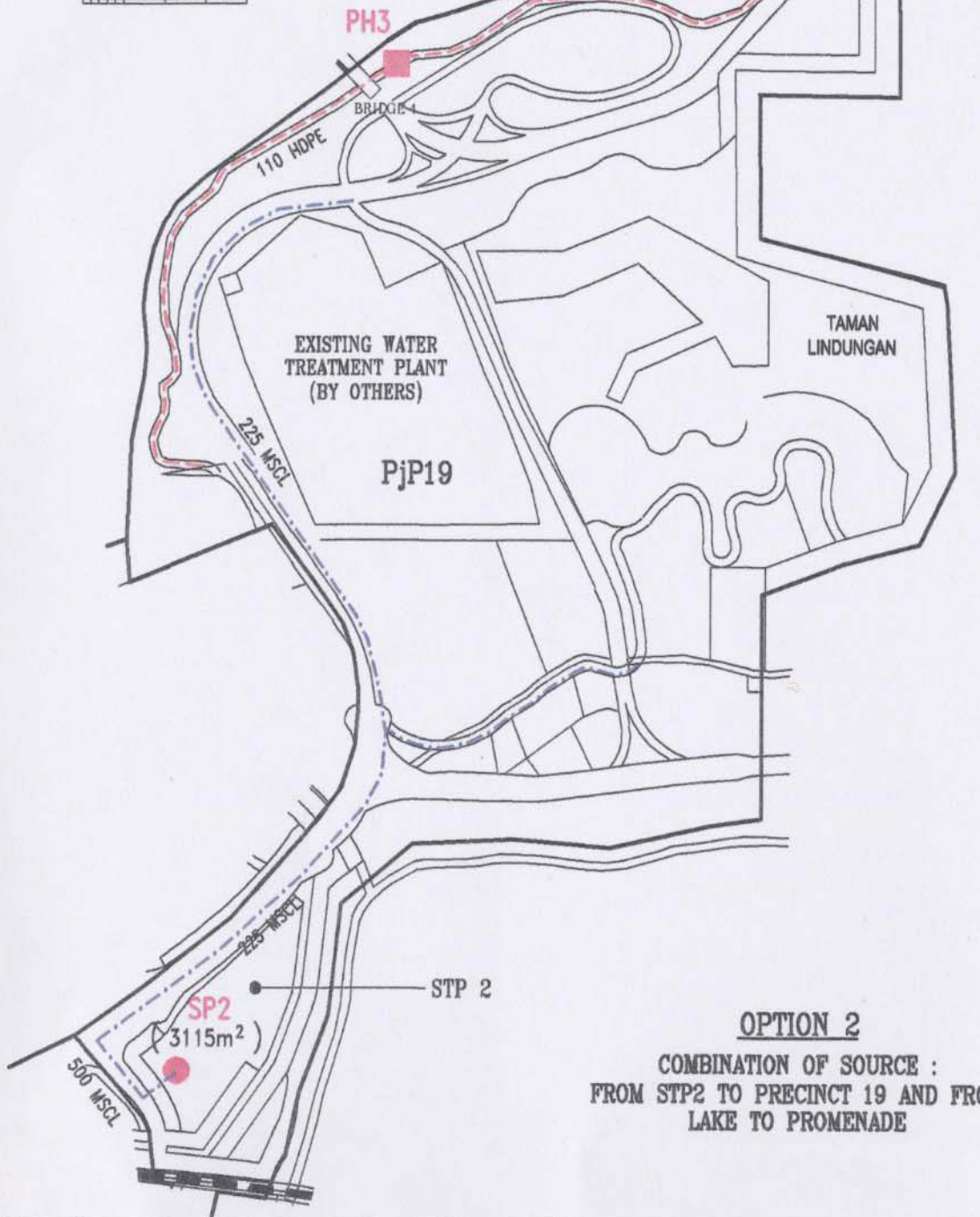
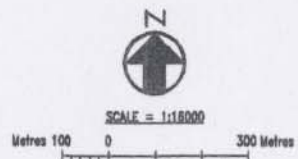
- LEGEND:**
- PRECINCT BOUNDARY
 - - - PIPE FROM LAKE (OPTION 1)
 - - - PIPE FROM STP (OPTION 2)
 - - - EXISTING PIPE
 - ▨ EXISTING DRAINAGE RETENTION PONDS
 - PROPOSED INTAKE FROM LAKE (PH1-PH8 & PHA1)
 - PROPOSED INTAKE FROM SEWAGE TREATMENT PLANT (SP1 & SP2)
 - ⊗ INTAKE POND (IP)
 - ★ EXISTING INTAKE
 - ★ E1 WETLAND MAIN PUMPING STATION
 - ★ E2 UPPER BISA PUMPING STATION
 - ★ E3 PHASE 1A (ZONE 6) PUMPING STATION
 - ★ E4 TAMAN BOTANI PUMPING STATION
 - ★ E5 TAMAN PUTRA PERDANA PUMPING STATION
 - ★ E6 BRIDGE 10 SUBMERSIBLE PUMP
 - ★ E7 DATARAN PUTRA & PUTRA BRIDGE PUMPING STATION
 - ★ E8 TAMAN WARISAN PERTANIAN PUMPING STATION (PUMP TO STI)
 - ★ E9 PM RESIDENCE PUMPING STATION
 - ★ E10 TAMAN WAWASAN PUMPING STATION
 - ★ E11 PERSISIRAN WARISAN PUMPING STATION
 - ▲ STI TAMAN WARISAN PERTANIAN STORAGE TANK (EXISTING)
 - STP SEWERAGE TREATMENT PLANT
 - PjP1 PUTRAJAYA PRECINCT 1
 - (807m²) POND AREA

MAP J6

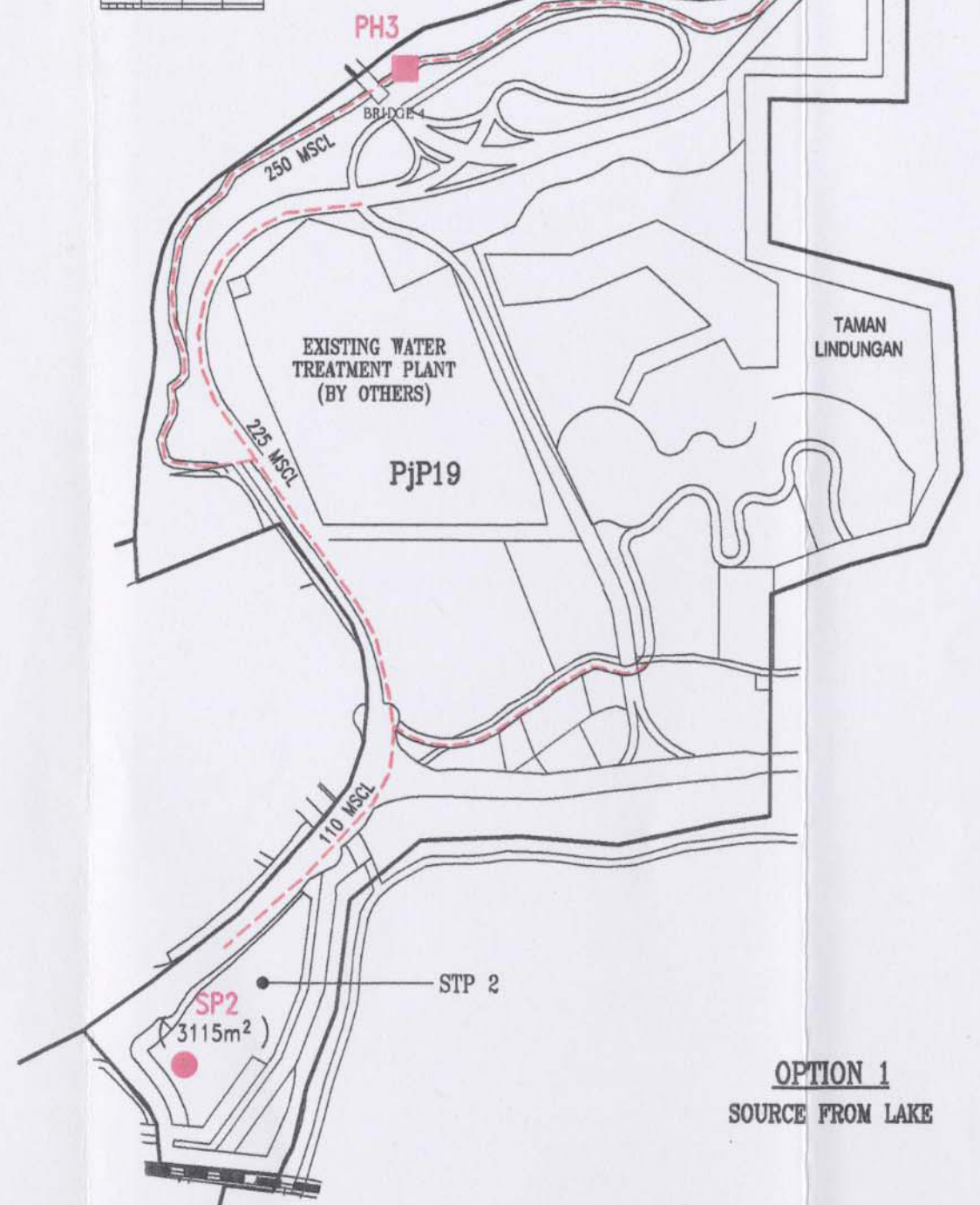


IRRIGATION MASTER PLAN FOR PUTRAJAYA
ALTERNATIVE IRRIGATION SYSTEM
FOR PRECINCTS 16 & 17

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OPTION 2
COMBINATION OF SOURCE :
FROM STP2 TO PRECINCT 19 AND FROM
LAKE TO PROMENADE



OPTION 1
SOURCE FROM LAKE

LEGEND:

- PRECINCT BOUNDARY
- - - PIPE FROM LAKE
- . - . PIPE FROM STP
- - - EXISTING PIPE
- ▨ EXISTING DRAINAGE RETENTION PONDS
- PROPOSED INTAKE FROM LAKE (PH1-PH8)
- PROPOSED INTAKE FROM SEWAGE TREATMENT PLANT (SP1 & SP2)
- ★ EXISTING INTAKE
- ★ E1 WETLAND MAIN PUMPING STATION } FOR WATER CIRCULATION TO WETLANDS
- ★ E2 UPPER BISA PUMPING STATION }
- ★ E3 PHASE 1A (ZONE 6) PUMPING STATION

- ★ E4 TAMAN BOTANI PUMPING STATION
- ★ E5 TAMAN PUTRA PERDANA PUMPING STATION
- ★ E6 BRIDGE 10 SUBMERSIBLE PUMP
- ★ E7 DATARAN PUTRA & PUTRA BRIDGE PUMPING STATION
- ★ E8 TAMAN WARISAN PERTANIAN PUMPING STATION (PUMP TO STI)
- ★ E9 PM RESIDENCE PUMPING STATION
- ★ E10 TAMAN WAWASAN PUMPING STATION
- ★ E11 PERSISIRAN WARISAN PUMPING STATION

- ▲ STI TAMAN WARISAN PERTANIAN STORAGE TANK (EXISTING)
- STP SEWERAGE TREATMENT PLANT
- PjP1 PUTRAJAYA PRECINCT 1
- (3115m²) POND AREA



IRRIGATION MASTER PLAN FOR PUTRAJAYA
ALTERNATIVE IRRIGATION SYSTEM FOR
PRECINCT 19