REVIEW OF THE NATIONAL WATER RESOURCES STUDY (2000-2050) AND FORMULATION OF NATIONAL WATER RESOURCES POLICY

FINAL REPORT

AUGUST 2011

VOLUME 1	-	EXECUTIVE SUMMARY
VOLUME 2	-	WATER RESOURCES GOVERNANCE
VOLUME 3	-	ENGINEERING STUDY
VOLUME 4	-	ENVIRONMENTAL STUDY
VOLUME 5	-	POTABLE WATER SUPPLY IMMEDIATE WORKS
VOLUME 6	-	WATER RESOURCES DECISION SUPPORT SYSTEM FRAMEWORK
VOLUME 7	-	PERLIS
VOLUME 8	-	KEDAH
VOLUME 9	-	PULAU PINANG
VOLUME 10	-	KELANTAN
VOLUME 11	-	TERENGGANU
VOLUME 12	-	PAHANG
VOLUME 13	-	PERAK
VOLUME 14	-	SELANGOR, FEDERAL TERRITORY OF KUALA LUMPUR AND PUTRAJAYA
VOLUME 15	-	NEGERI SEMBILAN
VOLUME 16	-	MELAKA
VOLUME 17	-	JOHOR
VOLUME 18	-	SABAH
VOLUME 19	-	FEDERAL TERRITORY OF LABUAN
VOLUME 20	-	SARAWAK

REVIEW OF THE NATIONAL WATER RESOURCES STUDY (2000-2050) AND FORMULATION OF NATIONAL WATER RESOURCES POLICY

FINAL REPORT

VOLUME 1 - EXECUTIVE SUMMARY

AUGUST 2011

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont/-)

TABLE OF CONTENTS (Cont/-)

Revision	Description	Originator	Reviewer	Approval	Date
4	Issued to Client	Key Team Members	LKM	CML	August 2011

REVIEW OF THE NATIONAL WATER RESOURCES STUDY (2000-2050) AND FORMULATION OF NATIONAL WATER RESOURCES POLICY

FINAL REPORT

VOLUME 1 - EXECUTIVE SUMMARY

AUGUST 2011

LIST OF TABLES

SECTION 2 WATER RESOURCES GOVERNANCE

SECTION 3 ENGINEERING STUDIES

LIST OF TABLES (Cont/-)

SECTION 4 ENVIRONMENTAL STUDIES

LIST OF TABLES (Cont/-)

REVIEW OF THE NATIONAL WATER RESOURCES STUDY (2000-2050) AND FORMULATION OF NATIONAL WATER RESOURCES POLICY

FINAL REPORT

VOLUME 1 – EXECUTIVE SUMMARY

AUGUST 2011

LIST OF FIGURES

LIST OF FIGURES (Cont/-)

SECTION 5 NATIONAL WATER RESOURCE MANAGEMENT DECISION SUPPORT SYSTEM FRAMEWORK

LIST OF ABBREVIATION

AAF	Annual Average Flow
AE	Actual Evaporation
AAGR	Average Annual Growth Rate
AKSB	Air Kelantan Sdn Bhd
AN	Ammoniacal Nitrogen
ARI	Average Recurrence Interval
BAKU	Bekalan Air Kelantan Utara
BCM	Billion Cubic Metres
BKSA	Badan Kawal Selia Air Pahang /State Water Regulatory Body
BLS	Barat Laut Selangor
BOD	Biochemical Oxygen Demand
BRH	Bernam River Headworks
COD	Chemical Oxygen Demand
CAPEX	Capital Expenditure
CORPRI	Corporatization/Privatization
CNII	Critical National Information Infrastructure
COAG	Council of Australian Government
CST	Centralised Septic Tanks
DAINET	Development Alternatives Information Network
DBKL	Dewan Bandaraya Kuala Lumpur
DID	Department of Irrigation and Drainage / Jabatan Pengairan dan Saliran
DO	Dissolved Oxygen
DOA	Department of Agriculture
DOE	Department of Environment / Jabatan Alam Sekitar
DSA	Drought Sequence Analyses
DSS	Decision Support System
DVS	Department of Veterinary Services Malaysia
ECER	Eastern Corridors Economic Region
ECM	Energy Commission of Malaysia
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EPU	Economic Planning Unit (Federal)
EQA	Environmental Quality Act
ESCP	Erosion and Sediment Control Plan
Eto	Evapo-transpiration

LIST OF ABBREVIATION

FAO	Food and Agriculture Organisation
FR	Forest Reserves
FT	Federal Territory / Wilayah Persekutuan
FTPP	Fair Trade Practices Policy
FTWCR	Federal Territories Water Resources Council
FTWRD	Federal Territories Water Resources Department
FWRD	Federal Water Resources Division
GDP	Gross Domestic Product
GEV	General Extreme Value
GIS	Geographical Information System
GNP	Gross National Product
GWh	Gigawatt-hour
GWh/a	Gigawatt-hours per annum
GWP	Global Water Partnership
ha	hectare
HEP	Hydro-electric Project
IADA	Integrated Agricultural Development Area
IADP	Integrated Agricultural Development Project
ICM	Integrated Catchment Management
ICZM	Integrated Coastal Zone Management
ICWE	International Conference on Water and the Environment
IFM	Integrated Flood Management
IFR	In-Flow-Requirement
ILBM	Integrated Lake Basin Management
INWQS	Interim National Water Quality Standard
IP	Intellectual Property
IPP	Independent Power Producer
IRBM	Integrated River Basin Management
IST	Individual Septic Tanks
ISRWT	Inter-State Raw Water Transfer
IUCN	International Union for the Conservation of Nature
IWK	Indah Water Konsortium Sdn Bhd
IWRM	Integrated Water Resources Management
IWRSNR	IWRS - Northern Region of Peninsular Malaysia
JAS	Jabatan Alam Sekitar / Department of Environment
JBA	Jabatan Bekalan Air / Water Supply Department

LIST OF ABBREVIATION

JICA	Japanese International Cooperation Agency
JKR	Jabatan Kerja Raya / Public Work Department
JMG	Jabatan Mineral dan Geosains / Department of Minerals and Geo-Science
JPS	Jabatan Pengairan dan Saliran / Department of Irrigation and Drainage
JPSPN	Jabatan Pengurusan Sisa Pepejal Negara
KeTTHA	Kementerian Tenaga, Teknologi Hijau Dan Air Malaysia / Ministry of Energy, Green Technology and Water Malaysia
KKM	Kementerian Kesihatan Malaysia / Ministry of Health
km	Kilometre
kW	kilowatt
KWB	Kuching Water Board
kWh	kilowatt-hour
LAP	Lembaga Air Perak
LPPP	Laporan Penyiasatan Pengeluaran Padi
l/c/d or lcd	litres/capita/day
l/w/d of lwd	litres/worker/day
LNG	Liquefied Natural Gas
LN2P	Log-normal 2- parameter
LN3P	Log-normal 3-parameter
LSAN	Lembaga Sumber Air Negeri Kedah
LUAS	Lembaga Urus Air Selangor / Selangor Water Management Authority
LUAN	Lembaga Urus Air Kedah / Kedah Water Resource Board
MADA	Muda Agricultural Development Authority
MAF	Mean Annual Flood
MAM	Mean Annual Minimum
MAR	Mean Annual Catchment Rainfall
MARDI	Malaysian Agricultural Development Institute
MC&I	Malaysian Criteria & Indicator
MCM	Million Cubic Metres
MD	Maximum Demand
ME	Multiple Effect
MHLG	Ministry of Housing and Local Government
Ml	Million Litres
Mld	Million Litres Per Day

LIST OF ABBREVIATION

MMD	Malaysian Meteorological Department / Jabatan Meteorologi Malaysia
MNC	Multinationals Company
MNMP	Malaysian National Medicine Policy
MOH	Ministry of Health
MoNRE/NRE	Ministry of Natural Resources and Environment Malaysia
MP	Malaysia Plan
MSF	Multi-stage Flash
MSMA	Manual Saliran Mesra Alam
MVA	Manufacturing Value-added
MW	Megawatt
m3/s	Cubic metres/second
NAHRIM	National Hydraulic Research Institute of Malaysia
NAM	Non-aligned Movement
NATIP	National Timber Industry Policy
NCER	Northern Corridors Economic Region
NDWQSP	National Drinking Water Quality Surveillance Programme
NERC	National Environment Research Council
NGO	Non Government Organisation
NIPP	National Intellectual Policy
NLC	National Land Council
NREO	Natural Resources and Environment Ordinance
NRW	Non Revenue Water
NWI	National Water Initiative
NWMS	National Water Market System
NWQMS	National Water Quality Management Strategy
NWRC	National Water Resources Council
NWRD	National Water Resources Department
NWRL	National Water Resources Law
NWRP	National Water Resources Policy
NWRS	National Water Resources Study
NWSC	National Water Services Commission
OIC	Organization of Islamic Conference
OPP3	Third Outline Perspective Plan
PAAB	Pengurusan Aset Air Berhad
PCC/pcc	Per capita consumption
PDMP	Power Development Master Plan

LIST OF ABBREVIATION

PE	Population Equivalent
PFR	Permanent Reserved Forests
PGMS	Pacific Garbage Management Systems
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PPA	Power Purchase Agreement
PSMP	Power Systems Development Master Plan
PTG	Pejabat Tanah dan Galian / Land and Mines Department
PWD	Public Works Department / Jabatan Kerja Raya
RBC	Rotating Biological Contractor
RC	Reinforced Concrete
RDC	Regional Development Corridor
RDZ	Regional Demand Zone
RO	Reverse Osmosis
SAINS	Syarikat Air Negeri Sembilan Sdn Bhd
SAIP	Sabah Agro-Industrial Precinct
SALCRA	Sarawak Land Consolidation and Rehabilitation Authority
SAMB	Syarikat Air Melaka Berhad
SAP	Sabah Agricultural Policy
SBCP	Sapangar Bay Container Port
SCORE	Sarawak Corridors of Renewable Energy
SDC	Sabah Development Corridor
SESB	Sabah Electricity Sdn Bhd
SESCO	Sarawak Electricity Supply Company
SEB	Sarawak Energy Berhad
SFMLA	Sustainable Forest Management License Agreement
SFZ	Sapangar Free Zone
SITExT	Sandakan Integrated Trade Exchange Terminal
SMI	Small And Medium Industry
SPAN	Suruhanjaya Perkhidmatan Air Negara / National Water Services Commission
SSMP	Sabah Shoreline Management Plan
STIDC	Sarawak Timber Industry Development Corporation
STP	Sewage Treatment Plant
SWB	Sibu Water Board
SWR	State Water Resources
SWRA	State Water Resources Agency
SWRC	State Water Resources Council
SWRD	State Water Resources Department

LIST OF ABBREVIATION

SWRTC	State Water Resources Technical Committee
SYABAS	Syarikat Bekalan Air Selangor Sdn Bhd
TCM	Total Catchment Management
TEM	Transient electromagnetic
TNB	Tenaga Nasional Berhad
Tonnes/ha	Metric tons per hectare
TOR	Terms of Reference
TSS	Total Suspended Solids
UNDP	United Nations Development Programme
UPEN	Unit Perancang Ekonomi Negeri / State Economic Planning Unit
URS	Conduct a User Requirements Study
VC	Vapour Compression
WAMCO	Water Asset Management Company
WDM	Water Demand Management
WF	Water for the Future
WHO	World Health Organization
WP	Wilayah Persekutuan / Federal Territory
WQI	Water Quality Index
WQIP	Water Quality Improvement Plan
WRP	Water Resources Plans
WRDMC	Water Resources Development and Management Corporation
WSIA	Water Services Industry Act 2006
WTP	Water Treatment Plant
WWC	World Water Council

SECTION 1

INTRODUCTION

Section 1 INTRODUCTION

1.0 INTRODUCTION

1.1 BACKGROUND AND OBJECTIVES OF THE STUDY

(1) The two preceding nation-wide studies on water resources commissioned by the Federal Government of Malaysia were the *National Water Resources Study Malaysia* (1982) carried out by the Japan International Cooperation Agency (JICA), and the *National Water Resources Study (2000-2050) for Peninsular Malaysia,* by a consortium of consultants. The primary objectives of these studies were to meet the escalating water demands and the need for conserving water for man and nature, with the rationale for water sector reforms to allow for more efficient and equitable distribution of the increasingly scarce water resources. It is recognized that water is a finite and vulnerable resource, and protecting this resource is a cornerstone of Malaysia's economic development policies.

(2) In the last decade since the *National Water Resources Study (2000-2050) for Peninsular Malaysia*, there is a process of perceptible change in the water sector, mainly to enhance water services following from the recommendations of the above reports. However, the water resources sector remains uncharted, as it was not advocated strongly in the previous report. Thus, today the most pressing challenge is having an effective water resources governance structure that is both unifying and yet not devolving any jurisdictions and functions of the States with regards to water, since water as a resource is almost purely under the jurisdiction of the State.

(3) The water resources sector has strong advocacy locally and internationally through the concepts of Integrated Water Resources Management (IWRM) and its sub-sets of Integrated River Basin Management (IRBM) and Integrated Flood Management (IFM) etc. The Department of Irrigation and Drainage (DID) Malaysia is one of the water-related agencies that is building up its capacity to face the new challenge to guide the development and management of water resources in the country, which is the basis of this review study.

(4) Against this backdrop, the previous *National Water Resources Study (2000-2050) for Peninsular Malaysia* is reviewed insofar as it helps to fast forward our present Study with regards to water sector reforms for water security and sustainability for all beneficial uses. This is necessary due to increasing population and escalating water demands, where the amount of available clean water is fast diminishing because of water pollution. The vagaries of rainfall and climatic change also play an important role in limiting the amount of water resources where measures are needed immediately to conserve water source areas, and to explore and develop alternative sources of water in the country.

(5) The creation of the Ministry of Natural Resources and Environment Malaysia (MoNRE) has committed the Federal Government to review the *National Water Resources Study (2000-2050) for Peninsular Malaysia,* especially in terms of water resources governance, including setting priorities at the Federal and State levels on water resources management and development. The bold objective was to formulate a unified and comprehensive National Water Resources Policy (NWR Policy) and a National Water Resources Law (NWR Law) to ensure security and sustainability of water resources for all (including nature and the environment), in an era of rapid economic development and a growing population. These factors have important implications on how Malaysia will manage its water resources and development in the years ahead.

(6) The DID Malaysia under the MoNRE is entrusted with the responsibility to carry out the Study entitled "*Review of the National Water Resources Study (2000-2050) and Formulation of National Water Resources Policy*". Thus in order to achieve the study Ranhill Consulting Sdn Bhd was appointed as the Consultant to undertake the task. The Study commenced on 9 October 2009 and was completed over a period of 16 months.

1.2 SCOPE OF WORKS

(1) Following from the above-mentioned objectives for the Study, the scope of work has been structured by the Terms of Reference to produce the required principal outputs as follows:-

(i) Water Resources Governance

(a) Draft National Water Resources Policy (NWR Policy);
(b) Draft National Water Resources Law (NWR Law);
(c) Proposal for institutional arrangements.

(ii) Engineering Studies and Environmental Assessment

(a) Review of water resources availability and demand for all water users;
(b) Proposal for water resources projects for:

- All water users up to 2050;
- Potable water supply immediate works to meet demand up to 2020.

(iii) Development of a framework for a Decision Support System (DSS).

(2) The Study adopted a stakeholder-focussed participatory approach through a series of strategic consultations. Discussions were held with the Technical and Steering Committees set up by DID Malaysia and with various stakeholders and Officers from a wide reach of Government Departments and Agencies.

(i) **National Stakeholder Workshops** – No. 1 on 19th January 2010; No. 2 on

31st May – 1st June 2010; and No. 3 on 30th September to 1st October 2010.

(ii) **Regional State Meetings** – All States in Peninsular Malaysia, Sabah and Sawarak from 23th August 2010 to 14th September 2010.

(iii) **Dedicated Team Meetings on Water Resources Governance** – Members were from the Bahagian Sumber Asli, Saliran dan Hidrologi of MoNRE, Jabatan Peguam Negara and selected Senior Officers from JPS for five Meetings between 14th April 2010 and 20th August 2010.

(iv) **Special Meetings with Secretariat of the NWRS / DID, Legal Advisors from MoNRE, and Kementerian Tenaga, Teknologi Hijau Dan Air Malaysia (KeTTHA)** – Meetings for draft NWR Policy on 16th June 2010; draft NWR Law on 23th – 24th December 2010; and draft NWR Policy and proposed Institutional Arrangements on 29th December 2010.

(v) **Peer Review Meetings on Draft NWR Policy** – The Peer Review members comprised four local experts in water resources. Meetings were held on 10th and 24th January 2011.

1.3 REPORT STRUCTURE

(1) The ensuing findings and recommendations from the Consultant for this *Review of the National Water Resources Study (2000-2050) and Formulation of National Water Resources Policy,* are presented in a 20-volume report, and are summarised in this Volume 1 - Executive Summary.

(2) Volumes 2 to 6 will provide the main sectors of the Study, while Volumes 7 to 20 are designated for the 13 States together with the three Federal Territories.

1.4 CHRONOLOGY OF STUDY EVENTS

A chronology of the main events from the commencement of the Study is listed below.

DATE	MAJOR EVENTS
09/10/09	Study Commencement
22/11/09	Technical Committee Meeting on Inception Report
21/01/10	Steering Committee Meeting on Inception Report
19/01/10	1st Stakeholder Workshop, Kuala Lumpur
02/03/10	Technical Committee Meeting on Interim Report– Potable Water Supply Immediate Works
11/03/10	Meeting with KeTTHA on Interim Report – Potable Water Supply Immediate Works
14/04/10-20/08/10	Dedicated Team Meetings on Water Resources Governance – draft NWR Policy, draft NWR Law and Institutional Arrangement
31/05-1/06/10	2nd Stakeholder Workshop, Kuala Lumpur
30/06/10	Technical Committee Meeting on Draft Final Report – Potable Water Supply Immediate Works
27/01/10	Meeting with KeTTHA on Draft Final Report – Potable Water Supply Immediate Works
23/08/10-12/09/10	Regional State Meetings in Peninsular Malaysia, Sabah and Sarawak
01/09/10	Technical Committee Meeting on Interim Report
20/09/10	Meeting with KeTTHA on Final Report – Potable Water Supply Immediate Works
30/09-1/10/10	3rd Stakeholder Workshop, Putrajaya
23-29/12/10	Special Meetings with the Secretariat of National Water Resources / DID Malaysia and legal advisors from MoNRE and KeTTHA on Water Resources Governance: draft NWR Policy, draft NWR Law and Institutional Arrangement
26/10/10	Presentation to KSU, MoNRE on Water Resources Governance – draft NWR Policy and draft NWR Law
26/11/10	Presentation to YB Minister of MoNRE on draft NWR Policy and draft NWR Law
10 & 24/01/11	Peer Review on draft NWR Policy
14/01/11	Presentation and Discussion with the Secretariat of National Water Resources / DID Malaysia on Institutional Arrangement
14/03/11	Meeting with DID Malaysia on Draft Final Report – Water Resources Governance
08/02/11	Technical Committee Meeting on Draft Final Report
24/03/11	Steering Committee Meeting on Final Report
13/04/11	Presentation on Water Resources Governance to Ministry of Federal Territory and Urban Well-being
20/05/11	Presentation on draft NWR Policy to Ministry of the Federal Territories and Urban Wellbeing
30/06/11	Meeting on AG's Comments on draft NWR Law
02/08/11	Steering Committee Meeting on Final Report / Conclusion of Study

1.5 ACKNOWLEDGEMENTS

(1) During the course of the Study, the Consultant's team members have met and discussed various facets of the Study with many stakeholders and officers from a wide reach of Government Departments and Agencies. Their co-operation and assistance are highly appreciated and gratefully acknowledged, and the feedback and constructive comments received during the Stakeholder Workshops and in the various Consultative Meetings during the Study process, have been accordingly incorporated in documenting the reports.

(2) The Consultant reserves special thanks for the assistance and guidance rendered by the Directors and Officers from the DID (Jabatan Pengairan dan Saliran), MoNRE and the Dedicated Team and the Peer Review Group, who have untirelessly contributed to the periodic review of the Study, and have contributed so much to the successful completion of the Study.

(3) This Report in effect reflects the combined endeavors from all the personnel in one way or another, including the Consultant's specialists and team members, who have collectively contributed to the Project, without which much less could have been achieved within the time-span for the Study.

(4) The Consultant hopes that the recommendations arising from this Study will mark an important milestone in ensuring the security and sustainability of water resources that have been increasingly under stress and imminently becoming scarce in the country.

(5) The Consultant is looking forward with a great deal of interest on the water resources sector reforms initiated through this Study, and on the progressive transformation of water resources governance from the initial draft NWR Policy, draft NWR Law and the proposed institutional arrangements to their full implementation in the country.

SECTION 2

WATER RESOURCES GOVERNANCE

Section 2

WATER RESOURCES GOVERNANCE

2.0 WATER RESOURCES GOVERNANCE

2.1 INTRODUCTION

(1) This NWRS on water resources governance considers four categories of water resources as follows:

(i) Surface water;
(ii) Groundwater;
(iii) Coastal water (up to three nautical miles from the Malaysian coastline); and
(iv) Water in the atmosphere.

(2) Despite the apparent abundance of water resources in the country, there are areas of water stress and areas that are flood-prone due to the vagaries of rainfall, which is unevenly distributed. This compels a need for water resources to be prudently managed so that there is sufficient water of the desired quality to meet the escalating demand of a burgeoning population that is growing in tandem with an expanding economy in the country.

(3) At the Second World Water Forum in the Hague in 2000, the Global Water Partnership (GWP) Framework for Action made it known that, a "*water crisis is often a crisis of governance*"; and to remedy this, "*making governance effective*" is recommended as the highest priority. Later at Bonn in 2001, the Ministers at the Freshwater Conference recommended that, "*each country should have in place applicable arrangements for the governance of water affairs at all levels and, where appropriate, accelerate water sector reforms*". A target was set at the Johannesburg World Summit on Sustainable Development in 2002, for countries to prepare Integrated Water Resources Management and Water Efficiency Plans by 2005, a date that has since been amended, to allow each country to set their own timeframe. Malaysia has committed itself to all these international strategies on water resources conservation and sustainability, which now form the basis of this water resource governance study.

(4) Water resources governance in Malaysia has been sectorally managed by many departments, often resulting in overlapping functions with grey areas of responsibilities. To implement the management of water resources in an integrated and prudent manner, the Integrated Water Resources Management (IWRM) concept was adopted. IWRM is defined by GWP as:

> *"a process which promotes the coordinated development and management of water, land, and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (GWP TAC No 4)."*

(5) The adoption of the IWRM approach has seen several concrete measures achieved, such as:

(i) The formulation of a National Water Vision to focus attention on the importance of and need for water security and sustainability in the country;

(ii) The setting up of a dedicated Ministry for Natural Resources and Environment to look after natural resources, which include water resources;

(iii) The establishment of the National Water Resources Council (NWRC) as an apex advisory body for all matters relating to water and water resources in the country;

(iv) The integration of IWRM into the National Five-Year Development Plans and all other official planning documents; and

(v) The initiation of capacity-building programs for water reforms through implementation of formal and informal training on all aspects of water resources, and through the usage of various platforms such as seminars, forums and dedicated projects, to disseminate the rationale and approach in the management of water resources.

(6) Most importantly, the basis on the way forward is the recognition of the need to promote the adoption of uniformity in water resources governance throughout the country. This is anticipated to be achieved by having a national water resources policy and dedicated legislation on water resources to create an enabling environment for establishing an appropriate institutional arrangement for managing and developing the water resources sector.

2.2 NATIONAL WATER RESOURCES POLICY

(1) The formulation of the draft National Water Resources Policy (draft NWR Policy) took cognizance of the need to ensure that the proposed draft adhered to the provisions of the Federal Constitution of Malaysia. Considerations were made as to the extent of the Federal legislative and executive power to formulate such a policy that will encompass and address concerns related to water resources, which, in general, lie within the legislative jurisdiction of the State. The executive powers of the Federal Government too, as provided in the Constitution, remain within that which is provided for under the legislative provisions, save several exceptions whereby the executive reach can be extended over matters related to inquiries; surveys and statistics; research; provision and maintenance of experimental and demonstration stations; advice and technical assistance; education; and publicity. The premise of the Federal-State relationship as established in the Federal Constitution, in as far as water resources are concerned, suggests a partnership, whereby the mandated custodian can lean on the Federal Government to set directions and provide support for it to better exercise custody of water resources to benefit the country as a whole.

(2) It is clear that water resources have and will continue to be the catalyst for social well-being and economic development in Malaysia. As encapsulated in the Tenth Malaysia Plan (2011-2015), the sustainability of water resources is an important issue, and the imperative now is to set an over-arching policy direction that will outline measures to ensure efficient and effective management, which will see the streamlining of existing policies and legislations, so as to allow for more efficient and equitable distribution. The 10th Malaysia Plan recommends the policy to establish a process to ensure the security of water supply, expanding implementation of adopted integrative approaches, address risks and boost preparedness, raise awareness as well as intensify research and development in areas of water resources management and conservation. Central to the Plan is the need to develop a sustainable water sector for the national economy. These recommendations have served as the basis for structuring the draft NWR Policy, which seeks to provide directions for the establishment of processes, mechanisms and measures that will consolidate and reconcile the multiple policy and legislative regimes related to water resources management. Through the policy is it proposed that the security and sustainability of water through sustainable use and conservation of water resources shall be made a national priority to ensure adequate and safe water for all, including for nature and the environment.

(3) The justification for a draft NWR Policy also lies on the fact that, after reviewing more than 51 national policies and several key State Government policies, the following are observed:

(i) There is no comprehensive policy on water resources, but only policy statements relating to various aspects of water resources;

(ii) There is no clear policy direction on what needs to be done for effective water resources governance (covering both administrative and management aspects), or direction to consolidate different measures and approaches;

(iii) There is a need to consolidate existing policies related to water resources and to provide directions to complement existing policy statements; and

(iv) There is a need to strengthen the executive reach of the Ministry of Natural Resources and Environment Malaysia (MoNRE), mandated with water resources management, by detailing the focus areas, aspects and targets for which policy directions will be made.

In addition, the term "water resources" alone indicates the multiple areas and components that constitute it, recognizing the need to put the term into context. This ensures that the policy directions through the different key core areas, thrusts, strategy and strategic action plans are grounded within matters related to water resources, to avoid overlaps and to strengthen existing policy directions related to water resources hosted by various Government Ministries (both Federal and State) and agencies (both Federal and State).

(4) A draft NWR Policy has been prepared and included in Volume 2 - Water Resources Governance of this Final Report. The contents, among others, include the Policy Statement, Rationale, Objectives, Principles and four Key Core Areas.

(5) The policy statement, consistent with the Tenth Malaysia Plan, is "The security and sustainability of water resources shall be made a national priority to ensure adequate and safe water for all, through sustainable use, conservation and effective management of water resources enabled by a mechanism of shared partnership involving all stakeholders".

(6) The rationale for the draft NWR Policy is to set the strategic direction and framework for action to ensure that water resources are secured for sustainable use and development to benefit the nation, both people and environment as a whole. The draft NWR Policy sets out strategies that will help guide the many water resources stakeholders to structure actions that will effect better conservation and management of water resources in an integrated, concerted and coordinated manner, bearing in mind that water resources may transcend traditional jurisdictional boundaries. A review of the literature on current local and international trends, as well as feedback from strategic consultations and Stakeholder Workshops have indicated that there are four key areas that require strategic policy directions and recommendations, which are, core areas pertaining to the security of water resources; sustainability of water resources; establishment of partnerships; and building capacity and expertise. Also noted was the need to ensure that the draft NWR Policy would be time-bound, open for review and include measurable outcomes.

(7) In order to frame the four core areas of water resources security; namely water resources sustainability; partnerships establishment; and capacity and expertise building, through the same process described above, three key objectives were identified:

(i) To set the direction to facilitate uniform actions towards ensuring water resources security and sustainability.

(ii) To establish mechanisms and identify processes to facilitate concerted actions for water resources security and sustainability.

(iii) To establish mechanisms for partnership between multiple stakeholders and means for stakeholder engagement.

(8) Underlying these objectives are the principles of water resources security and water resources sustainability. Of the four key core areas, nine thrust components were also identified and tabled for feedbacks from various stakeholders. From these nine thrust components, 18 target areas were identified, complemented by 28 strategies and 69 strategic action plans.

(9) Key to the structure and content of the draft NWR Policy is that it is an instrument that sets out directions to effect the means and measures, with a collective objective to ensure that water resources in Malaysia are secured and sustained for the long term. This also takes into account that water resources must be made a national priority concern, as these resources transcend boundaries, and the use and impacts have implications that also extend beyond traditional administrative jurisdiction. The integrative approaches adopted since the 1990's will have to be revisited and expanded, to ensure that water resources are seen as a continuum of a whole rather than a segment of parts. Central to the policy recommendation is the enhancement of water intelligence and development of integrative water resources use and conservation plans, to ensure that programs and actions taken are consolidated and measured. Crucial to the draft NWR Policy is the setting up of a collaborative partnership, where water concerns, issues and options are addressed in a collective and uniform manner. The intent of the draft NWR Policy is to bring to the table, a set of directions that will have a two-pronged effect through an over-arching goal for water resources, namely, it will strengthen the role of multiple stakeholders to ensure the security and sustainability of water resources, and provide the means for a better as well as effective partnership in water resources governance.

2.3 LEGISLATIVE FRAMEWORK FOR IWRM

(1) The Federation of Malaysia is governed by a written constitution. The relationship, powers and responsibilities of the Federal and State Governments are stipulated in the Constitution. It may generally be stated that "water" is largely a State matter. This jurisdiction would include rivers, lakes, streams, and water on and beneath the surface of the land. However, water is not a matter exclusively within the sole jurisdiction of the States. The Federal Government has powers over specific matters including federal works, trans-boundary rivers, canals and various aspects of water resource utilization such as hydropower generation, navigation, marine fisheries and mining. The Federal Government may also make laws related to items listed in the Concurrent List, and these include water supplies, town and country planning, drainage, wildlife and rehabilitation of land with soil erosion. Parliament may make laws with respect to any matter in the State List for the purpose of **promoting uniformity of laws** of two or more States and to implement international conventions and agreements.

(2) A review of current legislations related to integrated management of water resources is contained in this Final Report. The main conclusions arising from this review may be summarized as follows.

(i) In general, existing Federal legislations do cover various aspects of the management of water resources including use of water for certain purposes, protection from pollution and to a certain extent, development planning. However, these legislation are sectoral in nature and do not enable the adoption of measures to implement IWRM.

(ii) The Waters Act 1920 has been adopted by many States. The Act, however, is generally outdated and does not contain provisions for the implementation of IWRM and Integrated River Basin Management (IRBM).

(iii) Increasingly, many States including Kedah, Melaka, Negeri Sembilan, Pahang, Sabah, Sarawak and Selangor have enacted State legislations that deal with aspects related to the management of water resources. The legislations in these States differ in jurisdiction, purpose, scope and powers.

(iv) The legislations reviewed recognize both Federal and State control of water resources within their respective jurisdictions. In many of the new State legislations, the approach adopted towards the management of "water resources" is not comprehensive and therefore the laws do not permit the integrated management of water resources within the respective States.

(v) The functions related to water resources are distributed amongst many Federal Government agencies. There is currently no federal agency vested with policy or legislation to enable focussed national direction for the integrated management and sustainable development of water resources or to undertake coordination amongst all the relevant authorities.

(vi) Due to the nature of the existing fragmented and segregated structure of the regulatory bodies and authorities involved, directly or indirectly, with water resources, there do not exist any standard, consistent, clear and comprehensive guidelines or policies on water resources for the country.

(3) The State authorities, constitutionally, are placed in a better position to control and regulate matters on the ground pertaining to the integrated management of water resources in their respective States. However, IWRM, handled individually and disparately by 13 States and three Federal Territories, has already created many issues as mentioned in this Final Report. At the very least, there must be Federal support, capacity building and financing to ensure that the finite and limited water resources of the nation are managed for the benefit of the nation. That the support and active participation of the Federal Government is vital, is shown by international experiences in countries like Brazil and Australia. States which have pioneered better governance of their water resources in Malaysia could have achieved better success if there was focused and sustained Federal support for their programs.

(4) The current lack of an appropriate Federal law on IWRM, if not addressed, will continue to pose difficulties in the adoption of IWRM concepts, methodology and policies on a coordinated national basis. This Final Report recommends the repeal of the Waters Act 1920 to be replaced with a national law, which may be adopted by all States in order to establish greater consistency of approach and application in the implementation of IWRM on a national basis. Such a law should also enable the Federal authorities to undertake and implement their obligations and responsibilities as provided for under the Constitution and consistent with the national commitments made under global conventions. A draft NWR Act has been formulated and included

in Volume 2 - Water Resources Governance, adopting an integrated national approach, which is consistent with global standards and approaches to IWRM.

(5) One of the key challenges, in order to frame and implement a national legislative approach for the governance of water resources in Malaysia, is to secure the cooperation of all the States. The current jurisdiction of States over water resources shall not be usurped. However, there must be willingness by all stakeholders, in line with national initiatives, to subscribe to and adopt uniformity of standards, methods and procedures. The successful implementation of IWRM by all States also crucially depends on the availability of sufficient expertise, manpower and funds. The State authorities will require Federal support to implement IWRM in this respect. The draft NWR Law seeks to empower both the State and Federal Governments with appropriate jurisdiction as stipulated in the Constitution.

2.4 INSTITUTIONAL ARRANGEMENTS

(1) Arising from the directions in the draft NWR Policy and the draft NWR Law, a series of Federal and State institutional arrangements (with recommended organisation, function and responsibility) has been proposed. The arrangements are intended to address the future implementation of the core thrust areas of water security, sustainability, partnership and capacity building, and conceivably to promote uniformity of legislations among States with regards to water resources in the country.

(2) The recommendations on institutional arrangements both at the Federal, State and Federal Territory levels, were developed after a detailed review of previous institutional studies in the JICA Study (1982) and the NWRS (200-2050), as well as other water resources governance formats in ASEAN and selected foreign countries. Also reviewed were the water-related functions of 16 Ministries and their departments, in terms of scope and perceived duplication of responsibilities and functions, to determine the direction of rationalization of the proposed structure and function for water resources governance.

(3) The JICA Study (1982) and the NWRS (200-2050) recommended a centralised vertical organisational structure towards the management of water resources. The NWRS (2000) went on to recommend the formation of a NWRC as an apex body to provide the policy and implementation directions for water resources development in Peninsular Malaysia. Both studies recommended the formation of a Federal Water Resources Department to be headed by a Director–General to provide the technical support on the decisions made at the NWRC.

(4) The formats and structures of water resources governance in the ASEAN countries and five selected non-ASEAN countries (United Kingdom, Australia, France, Brazil and Japan) showed that different countries have different forms and formats of institutional arrangements, depending on their own requirements and what they perceived as important in terms of benefits to their country. There is no standard format for institutional arrangements although the objectives are basically similar,

which are, to conserve, secure and sustain the water resources for all beneficial uses.

(5) This Study has taken into consideration various imperatives and views of the stakeholders to develop acceptable options for institutional arrangements for the Federal and State Governments. Whichever option is selected and adopted by the Federal and State Governments, if it is a progressive option, it will pave the way for meaningful water resources management in the country based on the IWRM principles and its sub-sets of IRBM, Integrated Lake Basin Management (ILBM) and Integrated Flood Management (IFM). These approaches are already embedded within the administrative arrangements, as stated in Section 4 of Volume 2 - Water Resources Governance.

(6) The recommended institutional arrangements in this Final Report are guided by a set of guiding principles, the most important of which is to avoid devolution of the water-related functions and responsibilities of existing institutions and agencies. Secondly, it is also important that the States have to be comfortable and therefore willing to rationalize their institutional arrangements to benefit their States, since water is under State jurisdiction. The recommendations on the institutional arrangements are therefore flexible as they depend largely on the perceptions of the States in accordance with the Constitution, the draft NWR Policy and the draft NWR Law.

(7) **Legislative Positions of the States on Water Resources Governance**

Currently, different States have different legislative positions with different approaches towards water and water resources management. As shown in **Table 2.1**, some States have institutional structures empowered by the State Enactments for water resources management (Category 1 - Selangor, Kedah and Sabah), while most States have enactments mainly catering to the water services sector (see Category 2 - Sarawak, Melaka, Negeri Sembilan and Pahang). Category 3 involves States that are still using the Waters Act 1920, while the FT Labuan does not have any legislation pertaining to water resources management. In the FT Putrajaya, the position is based on the Specific Municipal By-Law for Control of Activities in FT Putrajaya that controls the activities of the Putrajaya Lake.

Table 2.1 - Current Water Legislative Positions of States in Malaysia

CATEGORY	LEGISLATION	STATE
1	State Water Resources Enactment	Selangor Kedah Sabah
2	State Enactments related to Water (i.e. mainly water services & supply)	Pahang Negeri Sembilan Melaka Sarawak
3	Waters Act 1920	Perlis Perak Pulau Pinang Kelantan Terengganu Johor FT Kuala Lumpur
4	NIL	FT Labuan
5	Specific Municipal By-Law for Control of Activities in FT Putrajaya	FT Putrajaya

(8) Institutional Arrangement Positions of the States

As of 2010, there were four main categories of institutional arrangements in practice related to water resources governance in the country (see **Table 2.2**). These institutional arrangements do not follow strictly the legislative positions shown in **Table 2.1.** The States in Categories 1 and 2 already have functional institutional structures and are mandated by State legislations for water resources management. The States in Category 3 have some aspects of water resources management structure but they are more geared to water services functions as bounded by the Water Services Industry Act (WSIA, 2006). In Category 4, water is managed by line agencies of the Federal and State Governments, except FT Putrajaya.

Table 2.2 - Categories of Current Institutional Arrangements in Malaysia

CATEGORY	INSTITUTIONAL ARRANGEMENTS	STATES	REMARKS
1	Fully developed and implemented	Selangor (LUAS), Sabah, Sarawak	Fully functional with institutional structures addressing or aiming address most aspects of water resources management
2	Developed and/or need refinement and/or to be implemented	Kedah (LUAN), *1Pahang (*Kelantan, Terengganu, Negeri Sembilan*)	All have been mandated by legislation but institutions are not fully functional yet. Kedah is more developed than the rest in this Category as it has a specific structure for water resources management. The States in italics are in both Categories 2 and 3 because their legislations have taken into consideration the water resources components, eventhough they are mainly service-oriented agencies.
3	Service-oriented and industry-based or distribution-based	*2Melaka *3Johor *4Negeri Sembilan Perak Kelantan Terengganu Pulau Pinang Sarawak	Development through corporatisation and/or privatisation approach (CORPRI). Negeri Sembilan has enacted legislation for water services (2009).
4	None of the above, or preparations are underway for an arrangement	Perlis FT Kuala Lumpur FT Putrajaya FT Labuan	No provisions yet except in FT Putrajaya. Syarikat Air Perlis has recently signed an agreement with PAAB regarding water assets (2010).

*1 BAKAP – Badan Kawal Selia Air Pahang
*2 BAKAM – Badan Kawal Selia Air Melaka
*3 BAKAJ – Badan Kawal Selia Air Johor
*4 BAKANS – Badan Kawal Selia Air Negeri Sembilan

(9) Specific Recommendations from Stakeholders

(i) From the outcomes of the Consultative Stakeholders Workshops and the dialogues with the States and stakeholders, there were clear compelling reasons for a strong institutional structure with greater uniformity in the management of water resources through the empowerment of the NWRC to play a greater role in the water resources sector, serving as an advisory apex body with equivalent State Water Resources Councils at the State level.

(ii) There was also consensus that there was no necessity to create a new National Water Resources Agency or Department, but to re-align an existing agency that is already generally performing most of the functions of a water

resource agency. This has the advantage of not subsuming any of the current water-related functions and responsibilities of any existing agencies, but rather to strengthen them through collaboration actions in managing water resources collectively and effectively in the country. Thus, the institutional structure that is proposed in this Study will reflect all these views and perspectives.

(10) **Recommendations on Institutional Arrangements for Federal and States**

(i) The National Water Resources (NWR) Model for institutional arrangements at the national level has generally been accepted by all stakeholders in the Consultative Stakeholders' Workshops and at the Federal, State and regional consultations (see **Figure 2.1**). The institutional arrangement at the Federal level is prescribed according to the Constitution and is in line with those proposed in the previous NWRS (2000-2050) but with amended responsibilities based on the draft NWR Policy and draft NWR Law.

(ii) **NWR Model**: The NWR Model recommends three levels of administration at the national level as follows:

(a) **The National Water Resources Council (NWRC)**: The NWRC shall be a national apex advisory body for water resources governance in the country consisting of all the Heads of State Governments and relevant Ministries. It shall be chaired by the Prime Minister and/or the Deputy Prime Minister. It shall act in an advisory capacity and when fully mandated under the National Water Resources (NWR) Act, it shall:

- Have vested powers to consider, adopt and make recommendations on national policies, plans and programs related to water resources;
- Be an apex body to oversee to the adoption of the NWR Policy and monitor its implementation and undertake periodic reviews of the Policy;
- Be a platform to co-ordinate national policies on IWRM/IRBM;
- Be an avenue for consultation and co-ordination among States and stakeholders on river basin development especially on inter-basin and inter-state water transfers;
- Provide directions to the MoNRE and the NWRD and other related bodies on matters pertaining to IWRM/IRBM;
- Consider issues related to inter-state and trans-boundary IWRM matters, and provide advice where mandated and to assist in

policy decisions on issues pertaining to the management of international trans-boundary catchments, water resources and aquifers;

- Provide advice to the State and Federal Governments on the transfer, sale of water between States and to other regional and international countries; and

- Adopt a national program for research and development on water resources and empower the NWRD to implement these programs.

(b) **National Water Resources Secretariat (NWR Secretariat)**: At the national level, there is already a NWR Secretariat, the functions of which are currently shared between KeTTHA and MoNRE. It is recommended that the NWR Secretariat be housed in one Ministry for more effective administration of water resources *per se*, since there is already a separation of the water sector into water services (under KeTTHA) and water resources (under the MoNRE).

(c) **National Water Resources Department (NWRD)**: To carry out the technical functions of water resources management and development, a National Water Resources Department with State line departments, is recommended, where the main responsibility areas are in atmospheric, surface, coastal and ground water from source to sea. The NWRD has to take on the key water resources functions of:

- Water resource assessment;
- Water resource sustainable management;
- Water hazard management;
- Water resource allocation priorities and guidelines to support the State focus on water resources allocations and implementation;
- Water resource technical and scientific support;
- International technical water resource services; and
- Inter-state and intra-state matters.

By benchmarking the above water resources core functions against the functions of all major water-related agencies in the country, the Study has come to the conclusion that there is already an agency in the country that is performing most of the water resources functions or significant parts of these functions as mentioned above. That agency is the DID Malaysia, which is recommended as an appropriate agency to become the NWRD, affirming the views and recommendations of the stakeholders in the Stakeholders' Workshops.

Through a detailed functional analysis of DID Malaysia, the Study recommended that only a slight re-alignment of its existing functions would be adequate for it to be a full-fledged NWRD in the country. The rationale for such a recommendation is predicated on the fact that DID Malaysia is already performing many of the water resources functions and therefore there will be less disruption in terms of manpower deployment (DID already has most of the critical expertise and manpower compared to other agencies); retention of talent, expertise and experience; cost savings; and in retention of all current physical assets and infrastructure within the Department.

(d) **Technical Inter-Agency Committee:** At the State and Federal Territories levels, the proposed institutional arrangements include a technical inter-agency committee to provide technical guidance to the respective departments.

(iii) **Federal Territories (FT):** The institutional arrangements for the Federal Territories of Kuala Lumpur, Labuan and Putrajaya differ slightly in context and administrative arrangements, and by having different legislative positions, their institutional structure for water resources management is also different as shown in **Figures 2.2 to 2.4**.

The FT Kuala Lumpur is located in the mid-section of the Sg Klang Basin, while FT Putrajaya is located at the southern end of the Sg Chaau Basin, a tributary of Sg Langat. In the case of FT Labuan, which consists of the main island and six smaller islands, it has 24 small river basins, but nevertheless these river basins are important water source areas, however small. In terms of water resources, the Federal Territory Water Resources Department (FTWRD) will assume the functions for water resources management. The Federal Territory Water Resources Council (FTWRC) may or may not be needed, as the NWRC can assume that function since these three Federal Territories are directly under the Federal Government, and therefore the Model shown in **Figures 2.2 to 2.4** can be implemented with or without that institutional level, but for information purposes, it is shown in the Model for completeness.

(iv) **State Water Resources Council (SWRC) or equivalent:** The NWR Model also provides for a State-level equivalent in terms of structure, in order that the two levels of Government can align themselves for enhanced integrated water resources management.

At the State level, the SWRC is the apex advisory body with the Menteri Besar/Chief Minister as the Chairman. The main function of the SWRC is to provide the policy direction on water resources management in the State.

The responsibilities of the SWRC, amongst others, shall include matters relating to:

- Approving policies pertaining to water allocation and conservation;
- Determining water use priorities;
- Gazettal of water catchments;
- Approving IRBM plans; and
- Approving pricing policies for raw water resources.

The SWRC is supported by a State Water Resources Agency (SWRA) or equivalent for the implementation of policies, plans and programs for water resources management in the State.

At the basin level in the State, the SWRA achieves this through having Basin Water Resources Units (BWRU) as the lowest level of water resources administration and management.

(11) At the State level, two options for the SWRA have been proposed (**Models 1** and **2**) for institutional arrangements (see **Figure 2.5** and **Figure 2.6**).

(12) **Model 1** is the preferred option for all States as it promotes uniformity in water resources governance. A key strength in Model 1 is that it consolidates existing limited resources such as expertise and funds into a single technical agency able to effectively manage scarce water resources in an integrated manner. However, because of the extent of differences in water resources availability vis-à-vis the demands, different levels of internal technical capacity and resources, scale of the river basins and associated water resource issues/concerns; most States will require an adjustment period to streamline their existing institutional structure to **Model 1**. In **Model 1,** it is proposed that the existing State DID shall be the SWRA. Under this Model, the State DID will also, as at present, continue to carry out the Federal functions.

(13) In **Model 2**, (e.g. in Selangor, Sabah and to a certain extent, Kedah), the SWRA is already in place, which is essentially a State structure. For all intent and purposes, these States should be left to develop and streamline their own institutional structures until such time that they may want to follow the uniformity concept in line with the provisions in NWR Act as shown in **Model 1**.

(14) The final decision and choice of the institutional Model at the State level, and the time frame to adopt the structure will invariably be left to the decisions of the State and Federal Governments after a series of thorough consultations has been carried out.

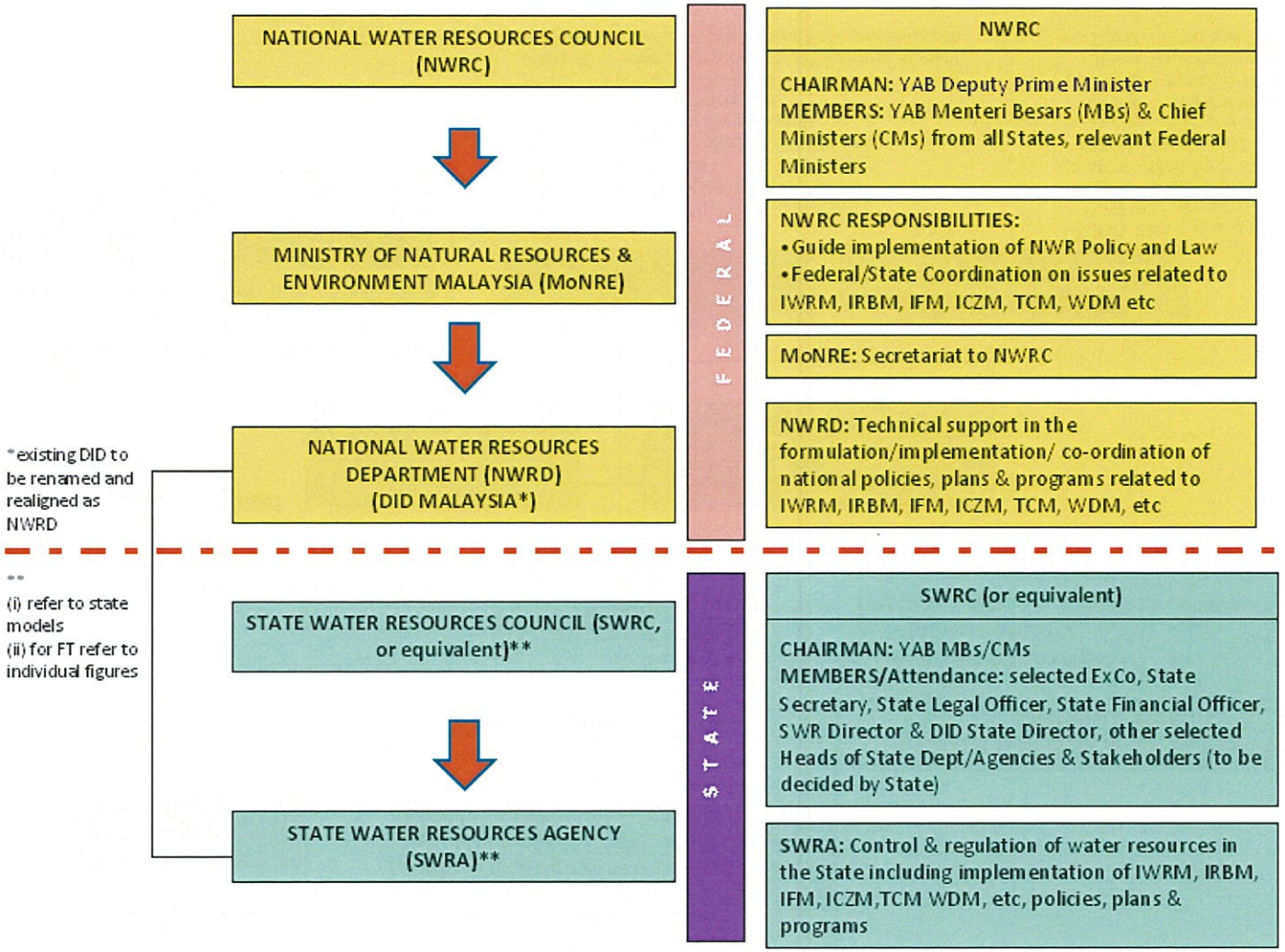


Figure 2.1 – Structure for an Institutional Arrangement at the National Level

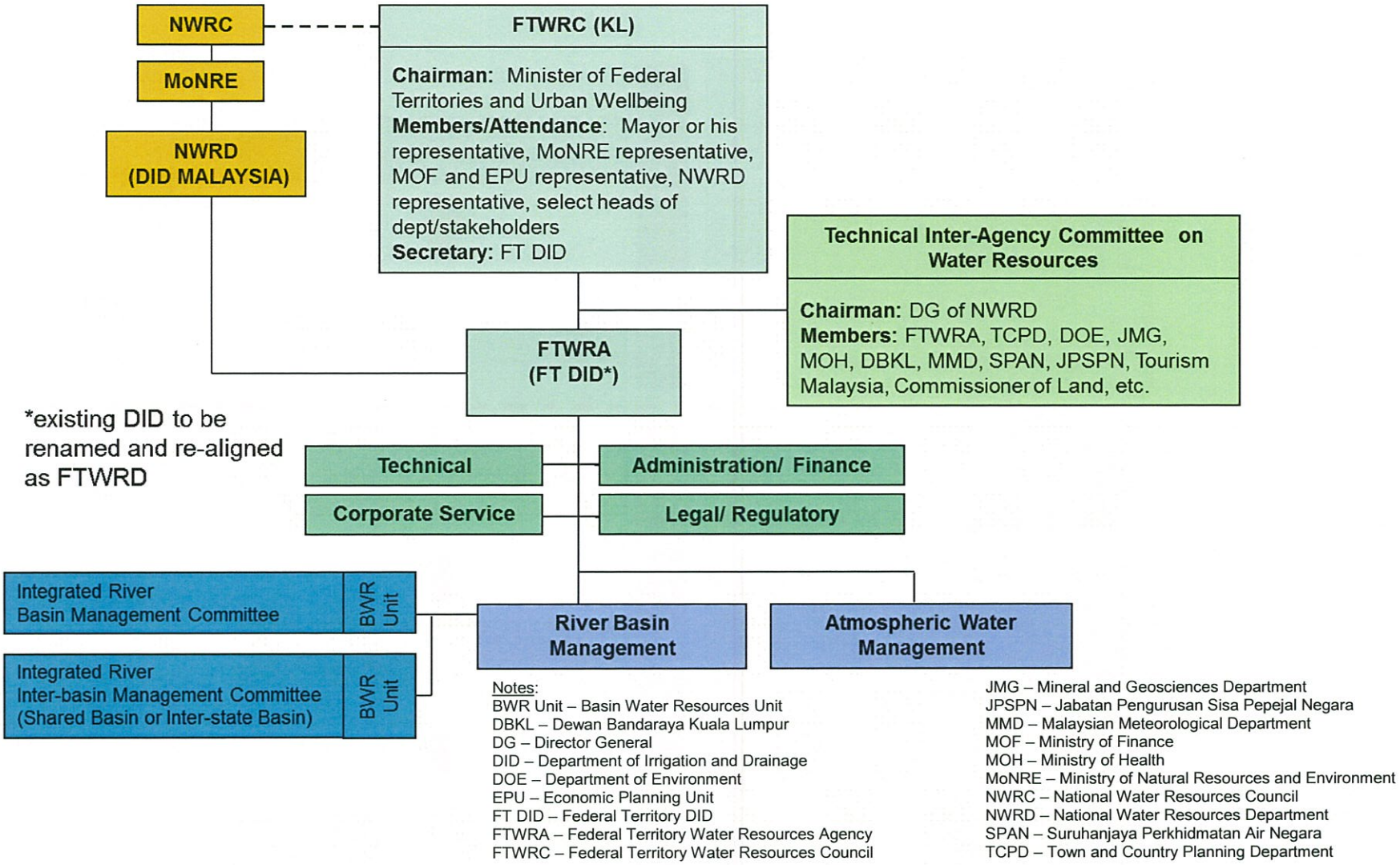


Figure 2.2 - Institutional Arrangements for the Federal Territory of Kuala Lumpur

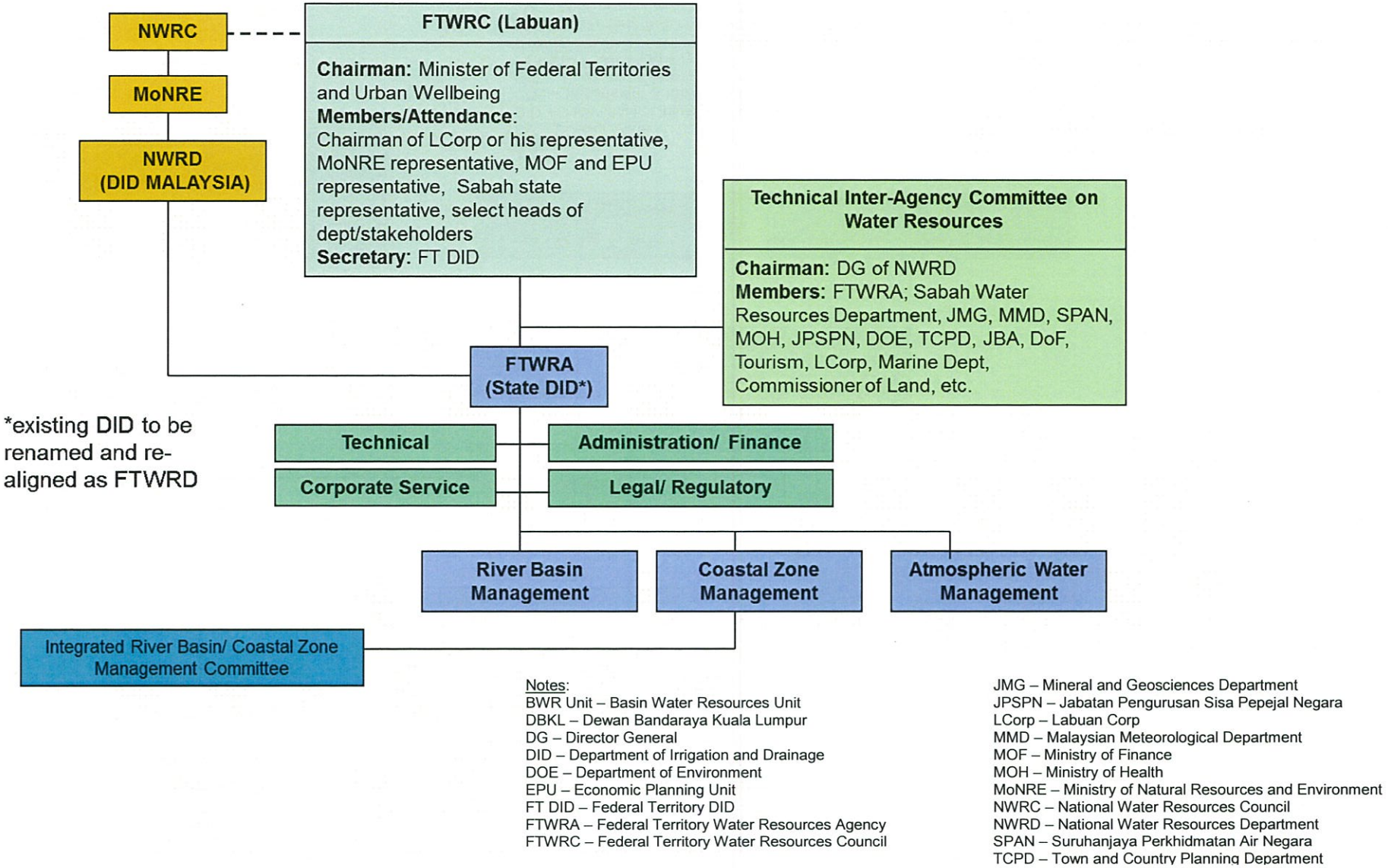
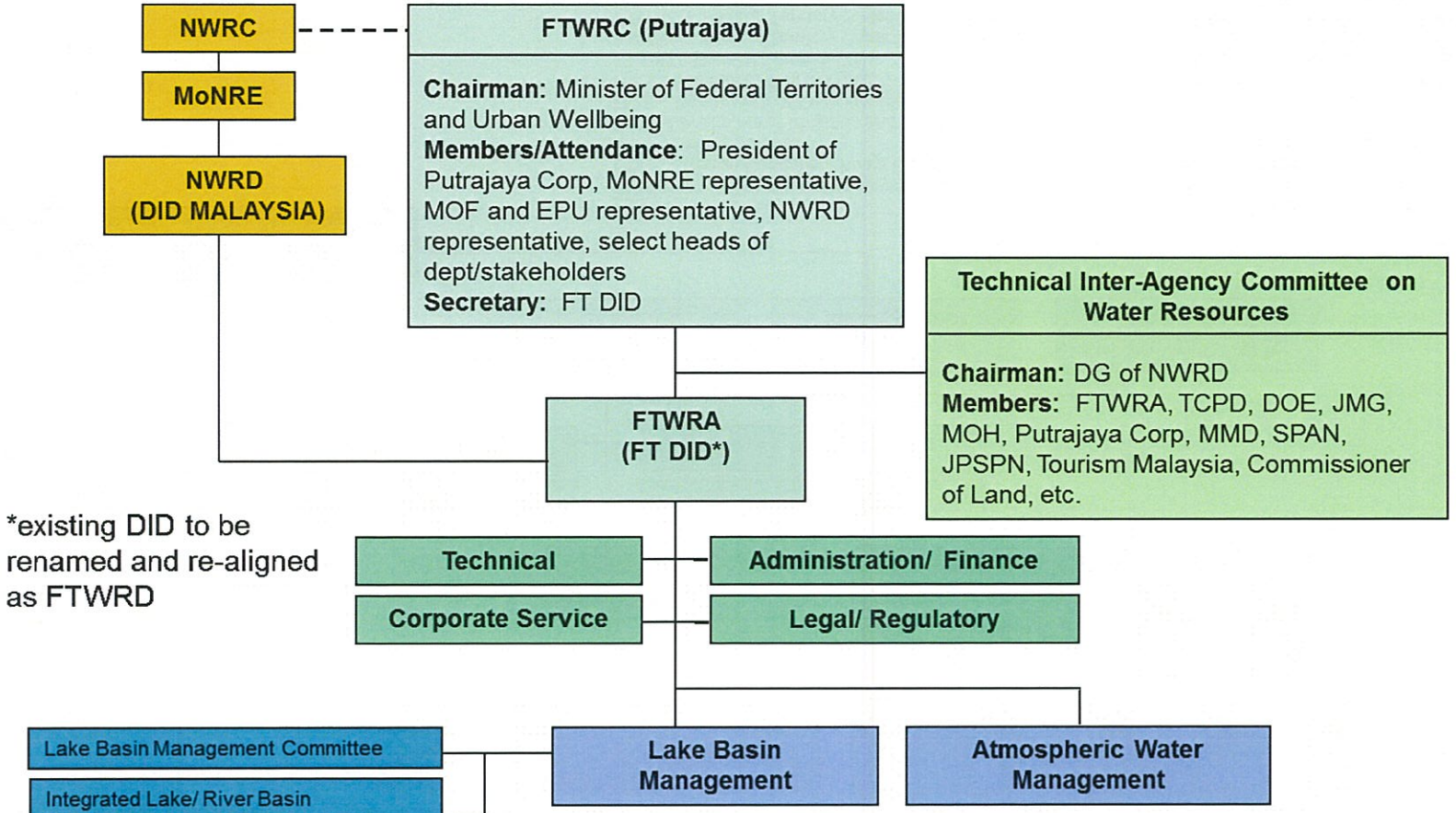


Figure 2.3 - Institutional Arrangement for the Federal Territory Labuan



Notes:
DG – Director General
DID – Department of Irrigation and Drainage
DOE – Department of Environment
EPU – Economic Planning Unit
FT DID – Federal Territory DID
FTWRC – Federal Territory of Water Resources Council
FTWRA – Federal Territory Water Resources Agency
JMG –Mineral and Geosciences Department
JPSPN – Jabatan Pengurusan Sisa Pepejal Negara
MMD – Malaysian Meteorological Department
MOF – Ministry of Finance
MOH - Ministry of Health
NWRC – National Water Resources Council
NWRD – National Water Resources Department
MoNRE – Ministry of Natural Resources and Environment
SPAN – Suruhanjaya Perkhidmatan Air Negara
TCPD – Town and Country Planning Department

Figure 2.4 - Institutional Arrangements for the Federal Territory of Putrajaya

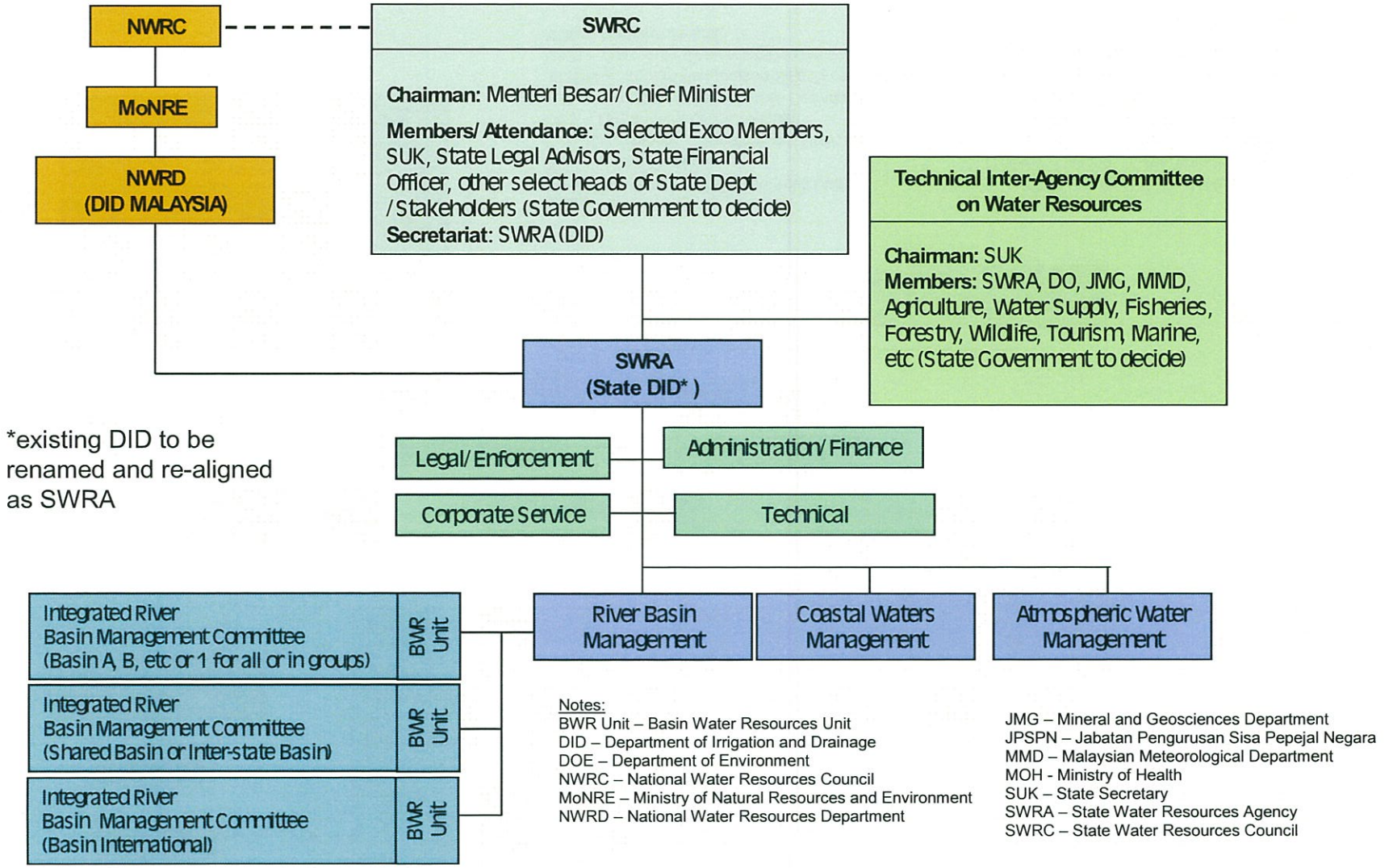


Figure 2.5 - Model 1 – Institutional Arrangements for States

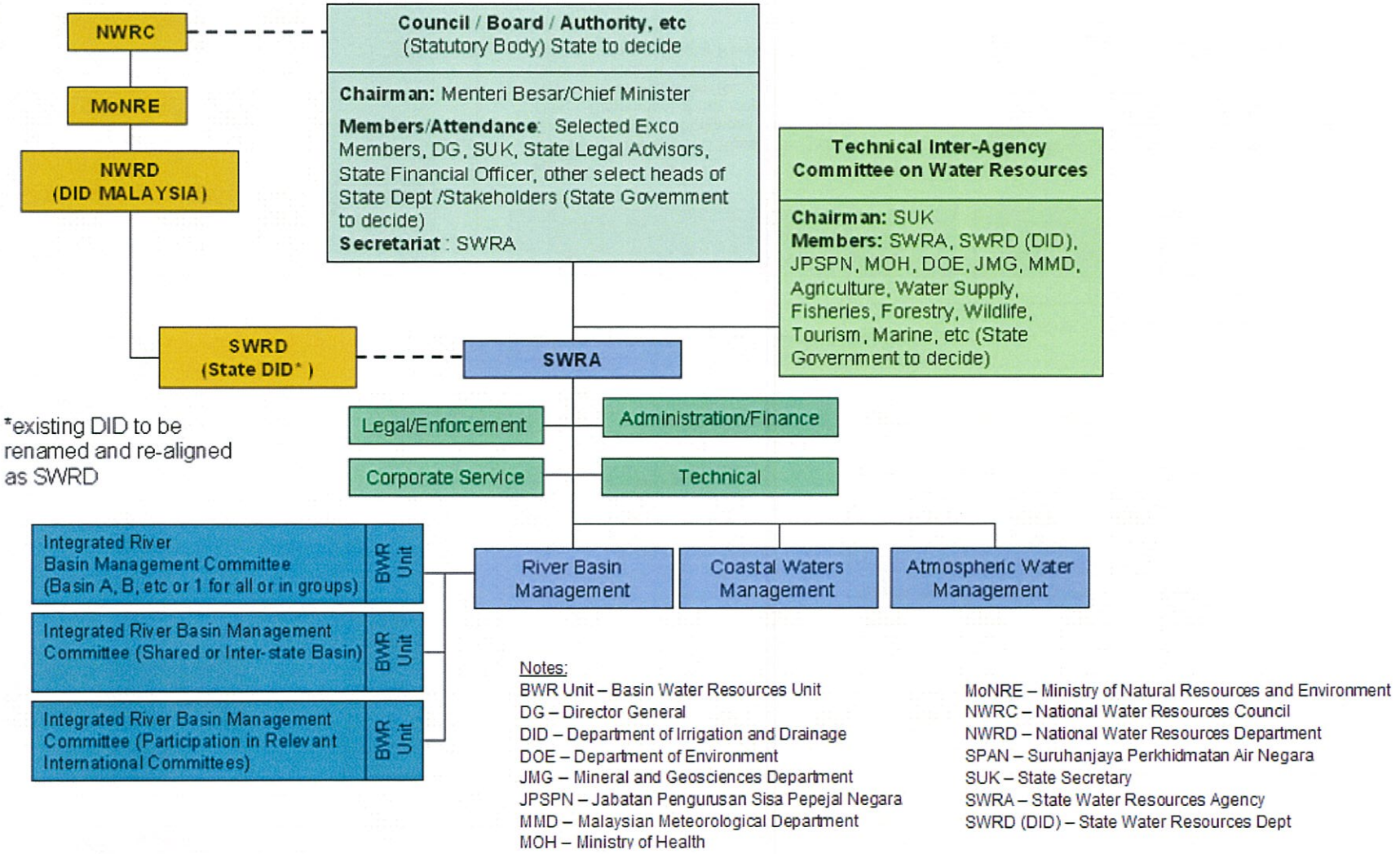


Figure 2.6 - Model 2 – Institutional Arrangements for States

SECTION 3

ENGINEERING STUDIES

Section 3

ENGINEERING STUDIES

3.0 SUMMARY OF ENGINEERING STUDIES

3.1 WATER AVAILABILITY – SURFACE WATER

(1) The water demand for the various sectors is measured in various units, million litres per day (MLD) for potable water supply, acre-feet for irrigation, or alternatively as million cubic meter per annum (MCM).

(2) It maybe convenient for water resources planning to simplify and rationalize all water demands into the common denominator of rainfall in the metric system. With this, it would be convenient to regard the water demand in a particular State as "how much rain that has fallen in the particular State, is required to satisfy the total demand, and by each of the water demand sectors". This then becomes a measure on the sufficiency of water resources in the State to meet its water requirements, and how dependent the State is on inter-state water transfer to meet any shortfall in requirements.

(3) **Table 3.1** shows the water resources availability in terms of total rainfall per year for the various States in Peninsular Malaysia, Sabah and Sarawak.

3.1.1 Water Availability – Climate Change and Surface Water Resources

(1) Climate change, in particular global warming, is well recognized to be real and has a direct impact on water resources availability and water demand. Increasing global temperature generally increases evaporation rates, atmospheric water vapour and rainfall. However, a streamflow characteristics and hence water availability may increase or decrease under the climate change scenario at different locations. Sea level rise would reduce the availability of fresh water due to salinity intrusion and inundation of coastal lands.

(2) Several studies have been conducted in Malaysia to assess the impact of climate change on rainfall and streamflow characteristics. The NAHRIM (2006) Study projected that rainfall in Peninsular Malaysia could increase by about 2.6% by 2041-2050 while river flood flow and low flow would become more extreme. For instance, monthly low flows in Sg Muda and Sg Selangor were projected to decrease by 79% and 93% respectively. The simulated river flows of the eight key streamflow stations in NAHRIM (2006) Study are summarised in **Table 3.2a.**

Table 3.1 - Available Rainfall in Malaysia

State	Area	Unit in mm per year				Unit in Billion Cu M per year			
	(sq km)	Rainfall	Actual Evaporation	Groundwater Recharge	Surface Runoff	Rainfall	Actual Evaporation	Groundwater Recharge	Surface Runoff
Perlis	821	1,880	1,290	120	470	1.54	1.06	0.10	0.38
Kedah	9,500	2,310	1,430	130	750	21.95	13.59	1.24	7.12
P Pinang	1,048	2,350	1,430	120	800	2.46	1.50	0.13	0.83
Perak	21,035	2,480	1,320	170	990	52.17	27.77	3.58	20.82
Selangor	8,396	2,190	1,280	150	760	18.39	10.75	1.26	6.38
Negeri Sembilan	6,686	1,830	1,210	130	490	12.24	8.09	0.87	3.28
Melaka	1,664	1,880	1,210	100	570	3.13	2.01	0.17	0.95
Johor	19,210	2,470	1,130	200	1,140	47.45	21.71	3.84	21.90
Pahang	36,137	2,470	1,250	120	1,100	89.26	45.17	4.34	39.75
Terengganu	13,035	3,310	1,470	150	1,690	43.15	19.16	1.96	22.03
Kelantan	15,099	2,600	1,290	140	1,170	39.26	19.48	2.11	17.67
Pen Malaysia	**132,631**	**2,495.5**	**1283.8**	**147.6**	**1064.0**	**330.98**	**170.28**	**19.56**	**141.11**
Sabah	73,631	2,560	1,190	190	1,180	188.50	87.62	13.99	86.89
Sarawak	124,450	3,640	1,250	240	2,150	453.00	155.56	29.87	267.57
FT Labuan	91	3,100	1,480	150	1,470	0.28	0.13	0.01	0.14
East Malaysia	**198,172**	**3,238.5**	**1,227.8**	**221.4**	**1,789.3**	**641.78**	**243.31**	**43.87**	**354.60**
Malaysia	**330,803**	**2,940.6**	**1,250.3**	**191.8**	**1,498.5**	**972.78**	**413.60**	**63.45**	**495.71**

Table 3.2a - Simulated Flows for Historical and Future Periods (NAHRIM 2006 Study)

Streamflow Station Name	Max. Monthly Flow (m^3/s)		Mean Monthly Flow (m^3/s)		Min. Monthly Flow (m^3/s)	
	[A]	[B]	[A]	[B]	[A]	[B]
Sg Klang @ Jambatan Sulaiman	31	46	14	13	2.6	3.5
Sg Selangor @ Rantau Panjang	108	109	41	38	7.1	0.5
Sg Dungun @ Jambatan Jerangau	398	570	93	98	13.1	10.8
Sg Kelantan @ Jambatan Kusial	1535	1951	536	602	158	126
Sg Pahang @ Temerloh	1697	2177	670	718	156	123
Sg Perak @ Jambatan Iskandar	524	578	286	300	184	139
Sg Muda @ Jambatan Syed Omar	307	340	106	104	25.3	5.3
Sg Johor @ Rantau Panjang	83	94	33	32	9.8	6.8

(Source NAHRIM: [A] 1984-1993
[B] 2025-2034 & 2041-2050

(3) The MMD (2009) Study simulated future temperature and rainfall up to year 2099 for the entire country. Compared with the base period 1990-1999, the simulated mean annual rainfall for 2020-2029 and 2050-2059 are significantly lower. However, for 2090-2099, the simulated rainfall is significantly higher than 1990-1999 especially for Sarawak and Peninsular Malaysia. The projected rainfall changes in the MMD (2009) Study are shown in **Table 3.2b**:

Table 3.2b - Annual Rainfall Changes (%) Relative to 1990 – 1999 (MMD 2009 Study)

Region	2020 – 2029	2050 – 2059	2090 - 2099
North – West PM	-11.3	6.4	11.9
North – East PM	-18.7	-6.0	4.1
Central PM	-10.2	2.3	14.1
Southern PM	-14.6	-0.2	15.2
East Sabah	-17.6	-12.8	-3.6
West Sabah	-8.9	-1.2	0.3
East Sarawak	-9.1	-1.3	6.2
West Sarawak	-8.8	3.8	14.6

Source: MMD, 2009

(4) In this NWRS six JPS rainfall stations representing six different regions in Malaysia have been selected for trend analysis. The results show that 1981-1990 and 1991-2000 were the drier periods, while 2001-2010 was the wettest. Nevertheless, similar to the MMD (2009) Study, the analysis did not show a consistent trend in the change of rainfall. The trend analysis was also carried out for Sg Kelantan and Sg Pahang using long-term streamflow records in this Study with the result indicated again that no obvious trend change was detected in the flow series.

(5) The impacts of climate change on water resources characteristics could not be avoided but its negative impacts could be mitigated with the following strategies and measures:

- Construction of more storage dams to capture the high flows for release during periods of low flows.
- Construction of inter-basin and interstate water transfer.
- Implementation of efficient water supply and demand management in the areas of:
  - Improvement of irrigation efficiency as irrigation is currently still the largest water user and the irrigation efficiency is relatively low.
  - Reduction of irrigation water use via better farm practices and introduction of paddy varieties with lesser water demand.
  - Reduction of non-revenue water and other wastage.
  - Implementation of potable water demand management by lowering domestic consumption and water recycling, and use of alternative water resources.
- Prudent landuse planning for new developments in anticipation of sea level rise and raising of coastal bunds with pumping systems to protect existing development areas.
- Provision of structural and non-structural flood mitigation measures in view of increasing rainfall and more extreme flood runoff.

3.1.2 Water Availability – Groundwater

(1) Unlike surface water, groundwater has not been exploited in any major way, except in the State of Kelantan. Groundwater as a valuable resource is beginning to receive a lot of attention, and the other States are beginning to focus on its use as a source of potable water similar to the State of Kelantan.

(2) Currently, the actual extent of groundwater in every river basin is still relatively unknown, as no single concerted groundwater exploration program has been carried out yet. Existing exploration has been on an *ad hoc* demand basis in specific localized areas. Hence, unlike surface water, groundwater resource is not fully exploited as yet.

(3) The existing number of wells sunk for groundwater usage is listed in **Table 3.3**, which indicates that, except for Kelantan and Perak, the yields are generally low.

Table 3.3 - Numbers of Tube-wells

State	No. of Wells	Yield (m^3/hr)	1 Aquifers	Ground water Potential Rating
Perlis	163	0 – 163	Hard-rock aquifers (fractures)	Good
Kedah	270	0 - 54	Alluvium - Hard-rock aquifers (fractures)	Poor - Good
Pulau Pinang	66	0 - 43	Hard-rock aquifers (fractures)	Poor - Medium
Kelantan	310	0 – 2,619	Alluvium - Hard-rock aquifers (fractures) incl. Limestone	Good
Perak	144	0 – 1,098	Alluvium - Hard-rock aquifers (fractures) incl. Limestone	Good
Selangor	744	0 – 623	Alluvium - Hard-rock aquifers (fractures)	Good
FT Kuala Lumpur	35	0 - 18	Hard-rock aquifers (fractures)	Poor - Medium
Negeri Sembilan	228	0 - 68	Hard-rock aquifers (fractures)	Poor - Medium
Terengganu	323	0 – 184	Alluvium - Hard-rock aquifers (fractures)	Medium - Good
Melaka	179	0 - 31	Hard-rock aquifers (fractures)	Poor - Medium
Johor	274	0 – 189	Alluvium - Hard-rock aquifers (fractures)	Medium - Good
Pahang	449	0 - 102	Alluvium - Hard-rock aquifers (fractures)	Medium - Good
Sabah	203	0 – 120	Alluvium - Hard-rock aquifers (fractures)	Poor - Good
Sarawak	466	0 - 50	Alluvium - Hard-rock aquifers (fractures)	Medium - Good
FT Labuan	15	0 - 104	Hard-rock aquifers (fractures)	Medium - Good

(Source: JMG)

3.1.3 Water Availability – Alternative Water

(1) The various alternative water sources reviewed in the Study include the following:

(i) Rainfall harvesting;
(ii) Recycling of treated sewerage;
(iii) Desalination;
(iv) Natural lakes/ponds/wetlands; and
(v) Inter-basin/State raw water transfers.

(2) The factors that need to be considered in exploiting such alternative water resources include, amongst others:

(i) Economy
(ii) Environment
(iii) Social factors

(3) The need to exploit alternative sources of water varies from State to State depending on the availability of surface water; and inevitably some States will give higher priority to alternative water sources than others.

(4) The outcome of the assessment is presented in **Table 3.4**, which presents the priority rating given to various alternative water sources in different States. It can be seen

that, as an example, Pulau Pinang, which is a water-stressed State, is giving a high priority to all alternative sources of water in comparison with Pahang, which is a water-rich State.

Table 3.4 - Priorities for Development for Alternative Water Resources

Alternative Water Source	Priority Rating													
	Perlis	Kedah	P Pinang	Kelantan	Terengganu	Pahang	Perak	Selangor	N Sembilan	Melaka	Johor	Sabah	Sarawak	Labuan
Rainfall Harvesting	H	N	H	L	L	L	L	H	N	N	N	N	N	H
Recycling of Treated Sewerage	N	NA	H	L	L	L	L	H	L	L	L	L	L	H
Desalination	N		H	L	L	L	L	N	L	L	L	L	L	H
Natural Lakes / Pond / Wetlands	H		H	L	L	L	L	N	L	N	L	L	L	H
Interbasin/State Transfer	H		H	NA	NA	NA	NA	H	NA	N	NA	NA	NA	H
Island Water Supplies														
Water Importation Via Pipelines and Barges	NA	H	H	NA	H	NA	NA	H	NA	NA	H	H	H	H
Groundwater		H	H		H			H			H	H	H	H
Groundwater Dams		H	H		L			H			H	H	H	H
Water Reuse For Non-portable Purposes		H	H		L			H			H	N	H	H
Surface water collection		H	H		N			H			H	N	H	H
Desalination		N	H		N			N			H	N	H	H

L = Low Priority N= Normal Priority H= High Priority NA = Not Applicable

3.2 WATER DEMAND – ECONOMIC FACTORS

(1) The economic projections in terms of Gross Domestic Product (GDP) of various sectors are derived for every State and summed up for the country as a whole. The sectors are agriculture, mining, construction, manufacturing, services and others,

(2) **Table 3.5** indicates the GDP by key economic sector while **Table 3.6** indicates the GDP by states between 2010 and 2050. The table assumes scenario 2 of 2.6.2 as the adopted future GDP between 2020 and 2050. The projected GDP assumes an average annual growth rate (AAGR) of 5.3% for the planning period (2010-2050) and 4.9% between 2020 and 2050. The reason to adopt this scenario is to ensure water resources planning will take into consideration the probability high water demand due to higher economic growth.

Table 3.5 - Malaysia Projected GDP by Key Economic Sectors, 2010 – 2050

Year	Value in RM million								AAGR (%) 2010-2050	AAGR (%) 2020-2050
	2010	2020	2025	2030	2035	2040	2045	2050		
Agriculture	40	53	70	93	118	120	146	176	3.8	4.1
Mining	42	47	41	54	69	75	91	110	2.4	2.9
Manufacturing	139	245	308	410	521	662	802	971	5	4.7
Construction	17	24	34	45	57	66	80	97	4.5	4.8
Services	317	682	948	1,263	1,604	2,085	2,525	3,058	5.9	5.1
GDP Total	**555**	**1,051**	**1,400**	**1,865**	**2,369**	**3,009**	**3,644**	**4,412**	**5.3**	**4.9**

*Based on 2008 prices

Table 3.6 - Projected GDP Growth in States (Value in RM million)

State	2010	2020	2030	2040	2050	AAGR(%) 2010-2050	AAGR(%) 2020-2050
Johor	53,033	102,117	180,262	296,852	424,743	5.3	4.8
Kedah	19,483	37,531	62,713	107,611	159,971	5.4	4.9
Kelantan	9,310	19,672	32,839	57,511	86,634	5.7	5.1
Melaka	15,094	29,337	48,652	83,788	124,440	5.4	4.9
N.Sembilan	20,335	38,198	63,485	107,991	159,590	5.3	4.9
Pahang	24,996	48,236	81,153	137,355	203,307	5.4	4.9
Pulau Pinang	47,916	91,245	151,169	269,634	384,848	5.3	4.9
Perak	29,433	60,701	103,791	187,210	260,459	5.6	5.0
Perlis	3,048	5,697	9,209	16,126	23,832	5.3	4.9
Selangor	117,824	232,312	444,157	672,357	1,000,134	5.5	5.0
Terengganu	15,361	30,554	51,098	88,499	132,235	5.5	5.0
FT KL	74,884	171,750	324,99	506,478	733,258	5.9	4.9
Sabah	30,577	56,835	95,493	154,088	236,040	5.2	4.9
Sarawak	53,000	88,776	150,493	241,775	381,843	5.1	5.0
FT Labuan	2,529	5,354	8,595	13,926	22,824	5.6	5.0
Supra State	33,664	33,013	56,900	67,800	77,902	2.1	2.9
Total Malaysia	**550,487**	**1,051,328**	**1,865,000**	**3,009,000**	**4,412,060**	**5.3**	**4.9**

*Based on 2008 prices

3.2.1 Water Demand – Population Factors

(1) Three population scenarios were provided in this NWRS to estimate water demand; namely:

(i) High variant scenario
(ii) Medium variant scenario, and
(iii) Low variant scenario

(2) The criteria for the three growth scenarios are based on a combination of population growth in the States and the component of foreign labour force within the total population.

(3) The main assumptions in the projections are:

(i) Low growth scenario assumes that the present Government policy capping the total foreign labour force at 1.5 million at national level is maintained throughout the project period up to 2050.

(ii) High variant of projection growth adopts the projection made by the Department of Statistics (DOS), which assumes that foreign workers will make up 16% of the total population by 2020 increasing to more than 25% by 2050.

(iii) Medium projection assumes that foreign workers will make up about 13-14% of the national population.

Table 3.7 tabulates the population projections for the three scenarios mentioned above.

(4) The previous NWRS (2000-2050) similarly adopted the three population growth scenarios of High, Medium and Low, and selected the medium projection as the Planning Population for the derivation of water demands. Population projection for the Low scenario was derived and the Medium and High scenarios were factored from it. However, only the base Low population scenario was tabulated in a complete form, while that for the Medium and High scenarios were tabulated in accordance to districts, with no summing up for individual State. The only tabulated summary of the total population in each State was that of the served population.

(5) **Table 3.8** shows the difference between the base Low population and the served population in individual State. It can be noticed that there are significant differences between the population served and the projected population to the extent of 46.1% (2010) and 81.2% (2050) in the case of the State of Melaka.

(6) **Table 3.9** depicts a comparison of the Medium population of our Study, this NWRS, against that of the previous NWRS (2000-2050) for the States in Peninsular Malaysia. The population projections for Sabah, Sarawak and FT Labuan are based on the latest studies, namely, the Sabah Structural Plan, Sarawak Integrated Water Resources Management Master Plan (2009 Draft Final Report) and a JKR Study for Labuan.

(7) **Table 3.10** is a comparison between the Medium population of our Study and the Planning Population served in the previous NWRS (2000-2050) and other studies. This Table is a better reflection of the differences in water demand between the two studies over a period of 10 years.

(8) **Figures 3.1, 3.2 and 3.3** show the total populations in this Study and the population under review for Peninsular Malaysia, East Malaysia and Malaysia.

(9) In general, the population projection adopted in this NWRS is significantly lower than that of the previous NWRS (2000-2050), and the studies in East Malaysia/Sabah, Sarawak, and FT Labuan. This explains the reasons that many projects that were scheduled for completion between 2000 and 2010 were not required to be implemented in Peninsular Malaysia because of the overly high water demand projections based on a very high population projection, which is never realized.

(10) This Study shall adopt the medium population for projecting water demands for the various sectors.

Table 3.7 - Population Projections for this NWRS

Scenario	High						Median						Low					
Year	2010	2015	2020	2030	2040	2050	2010	2015	2020	2030	2040	2050	2010	2015	2020	2030	2040	2050
Johor	3,458	3,842	4,224	5,004	5,548	6,084	3,458	3,802	4,117	4,533	4,879	5,140	3,230	3,475	3,719	4,124	4,426	4,653
Kedah	2,043	2,274	2,504	2,975	3,304	3,629	2,043	2,251	2,440	2,695	2,906	3,065	1,908	2,057	2,205	2,452	2,636	2,775
Kelantan	1,677	1,918	2,159	2,679	3,054	3,434	1,677	1,899	2,104	2,427	2,686	2,901	1,567	1,735	1,901	2,208	2,436	2,626
Melaka	785	867	949	1,112	1,226	1,337	785	859	925	1,008	1,078	1,129	733	785	836	917	978	1,022
Negeri Sembilan	1,032	1,127	1,221	1,406	1,533	1,656	1,032	1,116	1,190	1,274	1,348	1,399	964	1,020	1,075	1,159	1,223	1,266
Pahang	1,573	1,745	1,916	2,263	2,505	2,743	1,573	1,727	1,867	2,050	2,203	2,317	1,469	1,579	1,687	1,865	1,998	2,098
Perak	2,441	2,662	2,883	3,316	3,613	3,899	2,441	2,634	2,810	3,004	3,177	3,294	2,280	2,408	2,539	2,733	2,882	2,982
Perlis	246	272	299	352	390	427	246	269	291	319	343	361	230	246	263	291	311	326
Pulau Pinang	1,609	1,750	1,889	2,161	2,346	2,525	1,609	1,732	1,841	1,958	2,064	2,133	1,503	1,583	1,663	1,781	1,872	1,931
Selangor	5,288	5,800	6,312	7,330	8,030	8,712	5,288	5,740	6,152	6,640	7,062	7,359	4,939	5,246	5,558	6,041	6,406	6,662
Terengganu	1,149	1,316	1,483	1,846	2,108	2,375	1,149	1,302	1,445	1,672	1,854	2,006	1,073	1,190	1,306	1,521	1,682	1,816
W.P. Kuala Lumpur	1,682	1,764	1,846	1,990	2,086	2,174	1,682	1,746	1,799	1,803	1,834	1,836	1,571	1,595	1,625	1,641	1,664	1,662
P.Malaysia	**22,983**	**25,337**	**27,685**	**32,434**	**35,743**	**38,995**	**22,983**	**25,075**	**26,981**	**29,385**	**31,434**	**32,939**	**21,468**	**22,918**	**24,377**	**26,734**	**28,513**	**29,818**
Sabah	3,177	3,545	3,873	4,733	5,235	5,728	3,267	3,600	3,874	4,400	4,719	4,958	2,970	3,204	3,410	3,904	4,176	4,381
Sarawak	2,660	2,,934	3,208	3,869	4,366	4,874	2,660	2,905	3,127	3,505	3,839	4,117	2,484	2,656	2,825	3,189	3,483	3,727
W.P. Labuan	88	96	103	121	131	140	88	95	101	110	115	118	82	87	91	100	104	107
East Malaysia	**5,925**	**6,455**	**7,184**	**8,723**	**9,732**	**10,742**	**6,014**	**6,600**	**7,102**	**8,015**	**8,674**	**9,193**	**5,536**	**5,946**	**6,325**	**7,193**	**7,763**	**8,216**
Malaysia	**28,908**	**31,792**	**34,869**	**41,157**	**45,475**	**49,737**	**28,997**	**31,675**	**34,083**	**37,400**	**40,108**	**42,132**	**27,004**	**28,864**	**30,703**	**33,926**	**36,276**	**38,033**

Table 3.8 - Projected Population and Served Population from previous NWRS (2000-2050)

State	Previous NWRS 2000 (Population – Table 3.1 Volume 3) ('000)					Previous NWRS (2000-2050) (Population Served) ('000)					% Difference Population Served over Population		
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050	2010	2030	2050
Perlis	273	318	359	396	424	291	355	410	460	504	6.6%	14.2%	18.9%
Kedah	1,916	2,257	2,586	2,891	3,153	2,042	2,526	2,952	3,366	3,745	6.6%	14.2%	18.8%
Pulau Pinang	1,397	1,528	1,636	1,722	1,783	1,587	1,916	2,155	2,384	2,594	13.6%	31.7%	45.5%
Perak	2,409	2,713	3,002	3,251	3,442	3,071	3,627	4,161	4,656	5,089	27.5%	38.6%	47.9%
Selangor and FT Kuala Lumpur	6,083	7,347	8,414	9,276	9,904	7,728	9,485	10,100	10,397	10,774	27%	20%	9%
Negeri Sembilan	1,023	1,178	1,322	1,446	1,541	1,123	1,358	1,555	1,734	1,884	9.8%	17.6%	22.3%
Melaka	697	796	885	958	1,009	1,018	1,310	1,524	1,701	1,828	46.1%	72.2%	81.2%
Johor	3,495	4,236	4,968	5,686	6,336	3,616	4,502	5,246	6,063	6,759	3.5%	5.6%	6.7%
Pahang	1,732	2,150	2,601	3,077	3,553	1,939	2,470	3,144	3,818	4,492	12.0%	20.9%	26.4%
Terengganu	1,341	1,665	2,021	2,390	2,753	1,383	1,738	2,121	2,505	2,872	3.1%	4.9%	4.3%
Kelantan	1,980	2,466	3,001	3,552	4,092	1,980	2,466	3,001	3,552	4,092	0.0%	0.0%	0.0%
Peninsular Malaysia	22,346	26,654	30,795	34,645	37,990	25,778	31,753	36,369	40,636	44,633	15.4%	18.1%	17.5%

Table 3.9 - Medium Population Projections – A Comparison

State	This Study					NWRS 2000 (population) and Other Studies					% difference This Study over NWRS 2000		
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050	2010	2030	2050
Perlis	246	291	319	343	361	273	318	359	396	424	-10%	-11%	-15%
Kedah	2,043	2,440	2,695	2,906	3,065	1,916	2,257	2,586	2,891	3,153	7%	4%	-3%
Pulau Pinang	1,609	1,841	1,958	2,064	2,133	1,397	1,528	1,636	1,722	1,783	15%	20%	20%
Perak	2,441	2,810	3,004	3,177	3,294	2,409	2,713	3,002	3,251	3,442	1%	0%	-4%
Selangor and FT Kuala Lumpur	6,970	7,951	8,443	8,896	9,195	6,083	7,347	8,414	9,276	9,904	15%	0%	-7%
Negeri Sembilan	1,032	1,190	1,274	1,348	1,399	1,023	1,178	1,322	1,446	1,541	1%	-4%	-9%
Melaka	785	925	1,008	1,078	1,129	697	796	885	958	1,009	13%	14%	12%
Johor	3,458	4,117	4,533	4,879	5,140	3,495	4,236	4,968	5,686	6,336	-1%	-9%	-19%
Pahang	1,573	1,867	2,050	2,203	2,317	1,732	2,150	2,601	3,077	3,553	-9%	-21%	-35%
Terengganu	1,149	1,445	1,672	1,854	2,006	1,341	1,665	2,021	2,390	2,753	-14%	-17%	-27%
Kelantan	1,677	2,104	2,427	2,686	2,901	1,980	2,466	3,001	3,552	4,092	-15%	-19%	-29%
Peninsula Malaysia	**22,983**	**26,981**	**29,383**	**31,434**	**32,940**	**22,346**	**26,654**	**30,795**	**34,645**	**37,990**	**3%**	**-5%**	**-13%**
Sarawak	2,660	3,127	3,505	3,839	4,117	2,778	3,669	4,597	5,677	6,743	-4%	-24%	-39%
Sabah	3,267	3,874	4,400	4,719	4,958	2,682	3,505	4,652	6,246	8,414	22%	-5%	-41%
FT Labuan	88	101	110	115	118	82	97	115	135	154	7%	-4%	-23%
East Malaysia	**6,015**	**7,102**	**8,015**	**8,673**	**9,193**	**5,542**	**7,271**	**9,364**	**12,058**	**15,311**	**9%**	**-14%**	**-40%**
Malaysia	**28,998**	**34,083**	**37,398**	**40,107**	**42,133**	**27,888**	**33,925**	**40,159**	**46,703**	**53,301**	**4%**	**-7%**	**-21%**

Table 3.10 - Medium Population and Population Served – A Comparison

State	This Study					NWRS 2000 (population served) and Other Studies					% difference This Study over NWRS 2000		
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050	2010	2030	2050
Perlis	246	291	319	343	361	291	355	410	460	504	-15%	-22%	-28%
Kedah	2,043	2,440	2,695	2,906	3,065	2042	2526	2952	3366	3745	0%	-9%	-18%
Pulau Pinang	1,609	1,841	1,958	2,064	2,133	1587	1916	2155	2384	2594	1%	-9%	-18%
Perak	2,441	2,810	3,004	3,177	3,294	3071	3627	4161	4656	5089	-21%	-28%	-35%
Selangor & FT Kuala Lumpur	6,970	7,951	8,443	8,896	9,195	7728	9485	10100	10397	10774	-10%	-16%	-15%
Negeri Sembilan	1,032	1,190	1,274	1,348	1,399	1123	1358	1555	1734	1884	-8%	-18%	-26%
Melaka	785	925	1,008	1,078	1,129	696.5	796	885.1	957.8	1009	13%	14%	12%
Johor	3,458	4,117	4,533	4,879	5,140	3616	4502	5246	6063	6759	-4%	-14%	-24%
Pahang	1,573	1,867	2,050	2,203	2,317	1939	2470	3144	3818	4492	-19%	-35%	-48%
Terengganu	1,149	1,445	1,672	1,854	2,006	1340.9	1664.9	2021.1	2390	2753	-14%	-17%	-27%
Kelantan	1,677	2,104	2,427	2,686	2,901	1980.2	2466.3	3000.6	3551.9	4092.2	-15%	-19%	-29%
Peninsula Malaysia	**22,983**	**26,981**	**29,383**	**31,434**	**32,940**	**25,415**	**31,166**	**35,630**	**39,778**	**43,695**	**-10%**	**-18%**	**-25%**
Sarawak	2,660	3,127	3,505	3,839	4,117	2,778	3,669	4,597	5,677	6,743	-4%	-24%	-39%
Sabah	3,267	3,874	4,400	4,719	4,958	2,682	3,505	4,652	6,246	8,414	22%	-5%	-41%
FT Labuan	88	101	110	115	118	82	97	115	135	154	7%	-4%	-23%
East Malaysia	**6,015**	**7,102**	**8,015**	**8,673**	**9,193**	**5,542**	**7,271**	**9,364**	**12,058**	**15,311**	**9%**	**-14%**	**-40%**
Malaysia	**28,998**	**34,083**	**37,398**	**40,107**	**42,133**	**30,957**	**38,437**	**44,993**	**51,836**	**59,006**	**-6%**	**-17%**	**-29%**

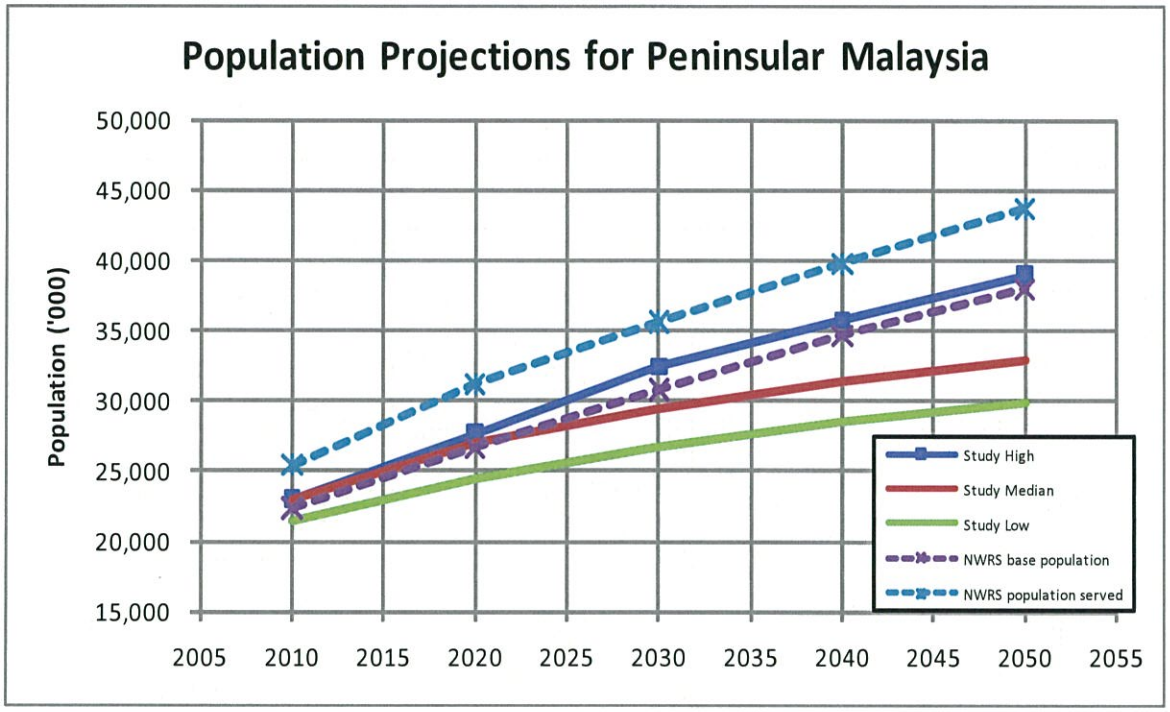


Figure 3.1 - Population Projections for Peninsular Malaysia

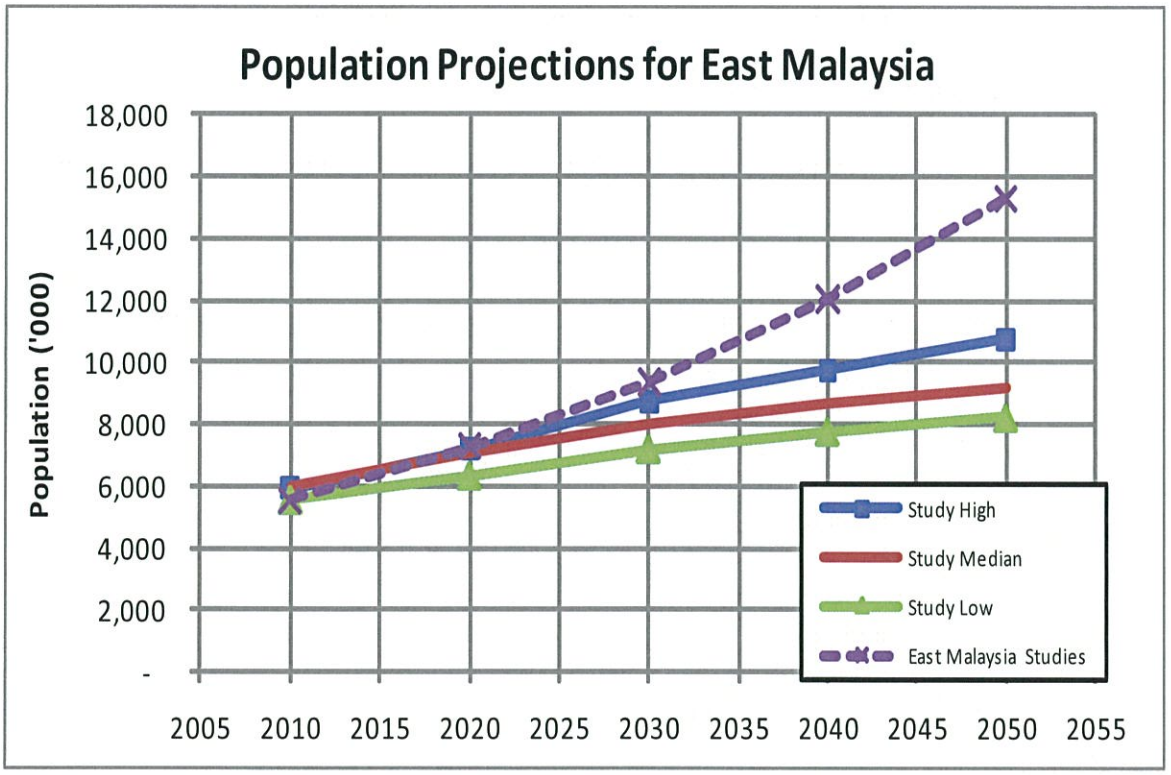


Figure 3.2 - Population Projections for East Malaysia

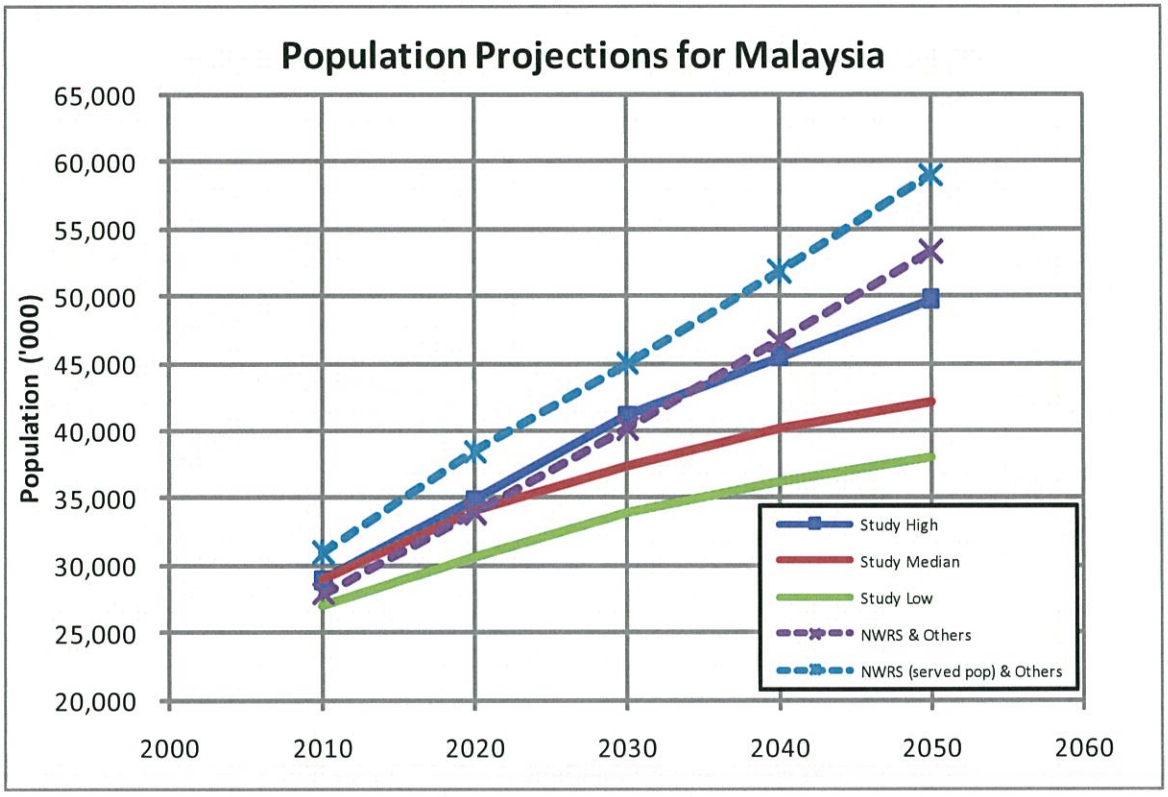


Figure 3.3 - Population Projections for Malaysia

3.2.2 Water Demand – Potable Water

(1) The factors that were taken into account in the water demand projections include:

(i) Population.

(ii) Per capita consumption (PCC), i.e. average water consumed by a person on a daily basis.

(iii) Water demand categorised into four main sectors:

- Domestic,
- Industrial,
- Commercial, and
- Institutional.

(iv) Non -revenue water (NRW).

(v) Service factor.

(2) The factors vary from State to State depending on the existing PCC, NRW, service factors and others.

(3) Special Factor 1 – Industrial Water Demand

A key difference between this NWRS and the previous NWRS (2000-2050) is that the present NWRS uses manufacturing worker population, derived in the demography studies, to derive the industrial water consumption. This approach is adopted on the premise that the manufacturing workers' population can be more accurately projected, and therefore the demand for water can be better estimated, compared to the previous NWRS (2000-2050) report that used manufacturing GDP indicator, which has not produced consistent results since there is no direct correlation between GDP and industrial water demand in all the States studied. Our approach is directly relating workers population with industrial water demand, and therefore is more accurate.

Data on industrial water use per manufacturing worker population is obtained from various States; the criteria are shown in **Table 3.11** for projecting industrial water supply.

Table 3.11 - Industrial Consumption Per Day Per Manufacturing Worker

Type of Industry	litre/worker/day
Significantly heavy industry	>2800
Heavy industry	1200 - 2800
Medium and light industry	400 - 1200
Cottage, backyard industries	100 - 400

(4) Special Factor 2 - WTP Designed Capacity

The capacity of WTPs individually and collectively would have to be above the projected demand in the State. This is to enable the water supply systems to continue functioning in the event that demand departs from the average annual water demand attributed to daily variation, outages of WTPs and other operational problems. In such cases, a loading capacity over and above the projected annual demand would become necessary to overcome the potential problem.

The level of loading depends on the operational needs of the water supply system, which in turn is dependent on:

(i) Daily variation across the 365 days in a year.

(ii) Actual demand growth rates higher than the projection.

(iii) The risk of water deficit in the daily operation of industries, which would have to be aborted with heavy financial losses.

(iv) Sudden increase in demand due to specific high water demanding industries attracted to a particular area and consequently put an immediate stress on the existing water supply situations.

(v) Shutdowns of WTPs.

(vi) Unevenness in water demand.

(vii) Delays in commissioning of new WTPs.

(viii) Inability to achieve the targeted NRW.

Should the total capacity of WTPs in a State be at the projected demand level, any of the above factors would trigger system failures that may occur several times in the year making water supply system in the State unreliable for consumers and investors.

It is understood that SPAN has already been working on a Key Performance Index (KPI) to determine a minimum buffer to ensure an acceptable level of service and as a safeguard against system failure.

The energy - power section is already using a loading of about 25% minimum, to ensure reliability of supply. This is an indication of the level of service from the production aspect, which should be used as a guide for the security of potable water supply.

The loadings for potable water supply systems are proposed and as shown in **Table 3.12.**

Table 3.12 - Components of Loading Factors

Item	Loading
Daily peaks	7%
Unaccounted Increase in growth rates	1.5%
Sudden increase in industrial demand due to high water demand industries	2%
Scheduled and unscheduled WTP shutdowns	4%
Unevenness in water demand	3%
Others	2.5%
Total Loading	**20%**

It is proposed that 20% be developed, starting with 10% for the immediate works for the Tenth Malaysian Plan. The Eleventh Malaysian Plan period shall be used as a transition period where the loading would be increased from 10% to the full 20% by 2020.

(5) Special Factor 3 – Non-Revenue Water (NRW)

NRW reduction will depend on the extent of CAPEX to be spent. Normally high NRW can be reduced at a higher rate than that for the lower NRW as it is easier and faster

to reduce commercial losses than physical losses in the pipe network.

It is also noted that pipe distribution systems are also subjected to increase in water losses due to aging of the pipe mains systems. This natural rate of loss is known as the Natural Rate of Rise (NRR) and has been known to be in the region of 1.8% per annum in Selangor State and FT Putrajaya. Hence, for lower NRW, further reduction becomes more and more difficult.

The following NRW reduction rates are used in this Study with the reducing rates or reduction as the NRW is gradually lowered, see **Table 3.13**. The base NRW for each district is assumed and based on 2009 values.

Table 3.13 - NRW Reduction Rates

NRW (%)	Annual Reduction (%)	5 years of Reductions (%)
>55	1.20	6.0
45 to 55	1.00	5.0
35 to 45	0.70	3.5
30 to 35	0.50	2.5
25 to 30	0.30	1.5
20 to 25	0.10	0.5
<20	0	0

(6) Special Factor 4 – Managed Demand

The Study considers the case where tight water demand management is implemented with full commitment and determination from all parties to reduce the PCC of domestic consumers. Domestic consumers constitute a large component of the total water demand and hence when properly managed, large water savings can be achieved. Only the domestic demand is subject to the managed PCC with the rest (industrial, institutional, commercial) remaining the same. The managed demand target areas are given in **Table 3.14**.

Table 3.14 - Target PCC for Managed Demand Case

	PCC l/c/d					
	2010	2015	2020	2030	2040	2050
Urban	230	215	200	180	165	150
Rural	160	145	130	110	95	80

From the NRW projections and service factors, water demand for the various cases of Low, Medium, High and Managed demands are derived as shown in **Table 3.15** and **Figure 3.7**.

Table 3.16 and **Figures 3.4, 3.5** and **3.6** show the difference between the projections from this Study with the projections from the previous studies found in the NRWS (2000) report and the East Malaysian reports.

The medium demand projection is then factored upwards (from 10% to 20%) to derive the planning demand for the development of WTPs and source works as shown in **Figure 3.7**.

Table 3.15 - Summary of Water Demand Projection

STATE	PROJECTED WATER DEMAND (m/l/d)																			
	LOW					MEDIUM					HIGH					MANAGED				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
Perlis	140	151	161	172	184	150	168	179	192	206	150	174	198	221	247	150	124	122	124	126
Kedah	1,245	1,346	1,438	1,523	1,618	1,333	1,529	1,630	1,738	1,855	1,333	1,609	1,861	2,046	2,276	1,333	1,298	1,286	1,306	1,331
Pulau Pinang	921	1,122	1,262	1,390	1,480	974	1,225	1,376	1,525	1,633	974	1,263	1,530	1,747	1,944	974	1,006	1,058	1,118	1,145
Perak	987	1,142	1,276	1,422	1,566	1,058	1,306	1,462	1,639	1,812	1,058	1,385	1,683	1,945	2,239	1,058	1,163	1,192	1,266	1,336
Selangor	3,771	4,297	4,692	5,176	5,589	4,037	4,896	5,371	5,975	6,477	4,037	5,167	6,166	7,116	8,068	4,037	4,087	4,153	4,410	4,619
Negeri Sembilan	682	692	689	694	702	731	790	786	802	814	731	837	905	951	1,009	724	757	623	586	569
Melaka	414	487	561	624	674	443	554	638	715	776	443	583	730	844	955	443	482	520	549	578
Johor	1,407	1,696	2,030	2,270	2,457	1,506	1,925	2,280	2,526	2,716	1,506	2,029	2,691	3,129	3,558	1,506	1,771	1,881	1,923	1,966
Pahang	910	914	944	982	1,042	974	1,054	1,099	1,156	1,231	974	1,125	1,281	1,404	1,555	974	1,014	983	949	946
Terengganu	591	863	969	1,064	1,149	632	971	1,094	1,211	1,319	632	1,021	1,244	1,421	1,612	630	776	830	884	920
Kelantan	369	499	652	801	944	395	564	745	933	1,118	395	594	858	1,122	1,419	395	561	707	805	879
Pen Malaysia	**11,437**	**13,209**	**14,674**	**16,118**	**17,405**	**12,233**	**14,982**	**16,660**	**18,412**	**19,957**	**12,233**	**15,787**	**19,147**	**21,946**	**24,882**	**12,224**	**13,039**	**13,355**	**13,920**	**14,415**
Sabah	980	1475	1742	1938	2060	1,049	1,695	2,005	2,250	2,405	1,050	1,804	2,324	2,687	2,994	1,124	1,227	1,417	1,600	1,689
FT Labuan	46	53	59	65	69	49	66	71	76	79	53	63	72	84	92	48	54	56	58	59
Sarawak	1,155	1,673	1,994	2,311	2,639	1,126	1,875	2,259	2,631	3,014	1,169	2,151	2,768	3,222	3,740	1,105	1,552	1,806	1,958	2,131
East Malaysia	**2,181**	**3,201**	**3,796**	**4,314**	**4,767**	**2,225**	**3,636**	**4,335**	**4,956**	**5,498**	**2,272**	**4,017**	**5,164**	**5,992**	**6,826**	**2,277**	**2,833**	**3,279**	**3,616**	**3,878**
Malaysia	**13,618**	**16,410**	**18,470**	**20,432**	**22,172**	**14,458**	**18,618**	**20,995**	**23,368**	**25,455**	**14,505**	**19,804**	**24,311**	**27,938**	**31,708**	**14,501**	**15,872**	**16,634**	**17,536**	**18,293**

Table 3.16 - Water Demand Projections from Previous NWRS (2000-2050) and East Malaysian Studies

STATE	LOW					PLANNING					HIGH				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
Perlis	116	138	163	192	220	123	153	187	226	265	131	171	214	263	315
Kedah	1,017	1,248	1,530	1,828	2,119	1,083	1,397	1,746	2,128	2,516	1,154	1,563	1,992	2,476	2,986
Pulau Pinang	1,061	1,428	1,871	2,352	2,836	1,188	1,640	2,261	2,918	3,584	1,307	1,804	2,487	3,210	3,942
Perak	1,308	1,471	1,709	1,932	2,108	1,567	1,880	2,292	2,700	3,068	1,724	2,171	2,699	3,243	3,758
Selangor	4,570	6,308	7,316	7,925	8,325	5,490	7,528	8,307	8,614	8,791	5,837	7,888	8,601	8,971	9,010
Negeri Sembilan	606	716	852	975	1,096	665	826	1,002	1,169	1,341	730	952	1,178	1,400	1,638
Melaka	394	477	553	618	672	572	777	948	1,097	1,219	604	861	1,071	1,264	1,433
Johor	1,489	2,096	2,623	3,144	3,542	2,079	2,780	3,429	4,062	4,687	2,185	3,072	3,863	4,668	5,494
Pahang	1,061	1,428	1,871	2,352	2,836	1,188	1,640	2,261	2,918	3,584	1,307	1,804	2,487	3,210	3,942
Terengganu	4,570	6,308	7,316	7,925	8,325	5,490	7,528	8,307	8,614	8,791	5,837	7,888	8,601	8,971	9,010
Kelantan	401	654	993	1,301	1,657	431	744	1,154	1,537	2,003	460	826	1,307	1,778	2,359
Pen. Malaysia (NWRS 2000-2050)	**16,593**	**22,272**	**26,797**	**30,544**	**33,736**	**19,876**	**26,893**	**31,894**	**35,983**	**39,849**	**21,276**	**29,000**	**34,500**	**39,454**	**43,887**
Sabah	661	856	1,128	1,506	2,019	774	1,002	1,320	1,762	2,363	1,157	1,498	1,974	2,636	3,534
FT Labuan	NA	NA	NA	NA	NA	53	63	77	89	100	NA	NA	NA	NA	NA
Sarawak	NA	NA	NA	NA	NA	1,079	1,989	3,017	4,555	6,218	NA	NA	NA	NA	NA
East Malaysia	**NA**	**NA**	**NA**	**NA**	**NA**	**1,906**	**3,053**	**4,413**	**6,406**	**8,681**	**NA**	**NA**	**NA**	**NA**	**NA**
Total Malaysia	**NA**	**NA**	**NA**	**NA**	**NA**	**21,782**	**29,946**	**36,307**	**42,389**	**48,530**	**NA**	**NA**	**NA**	**NA**	**NA**

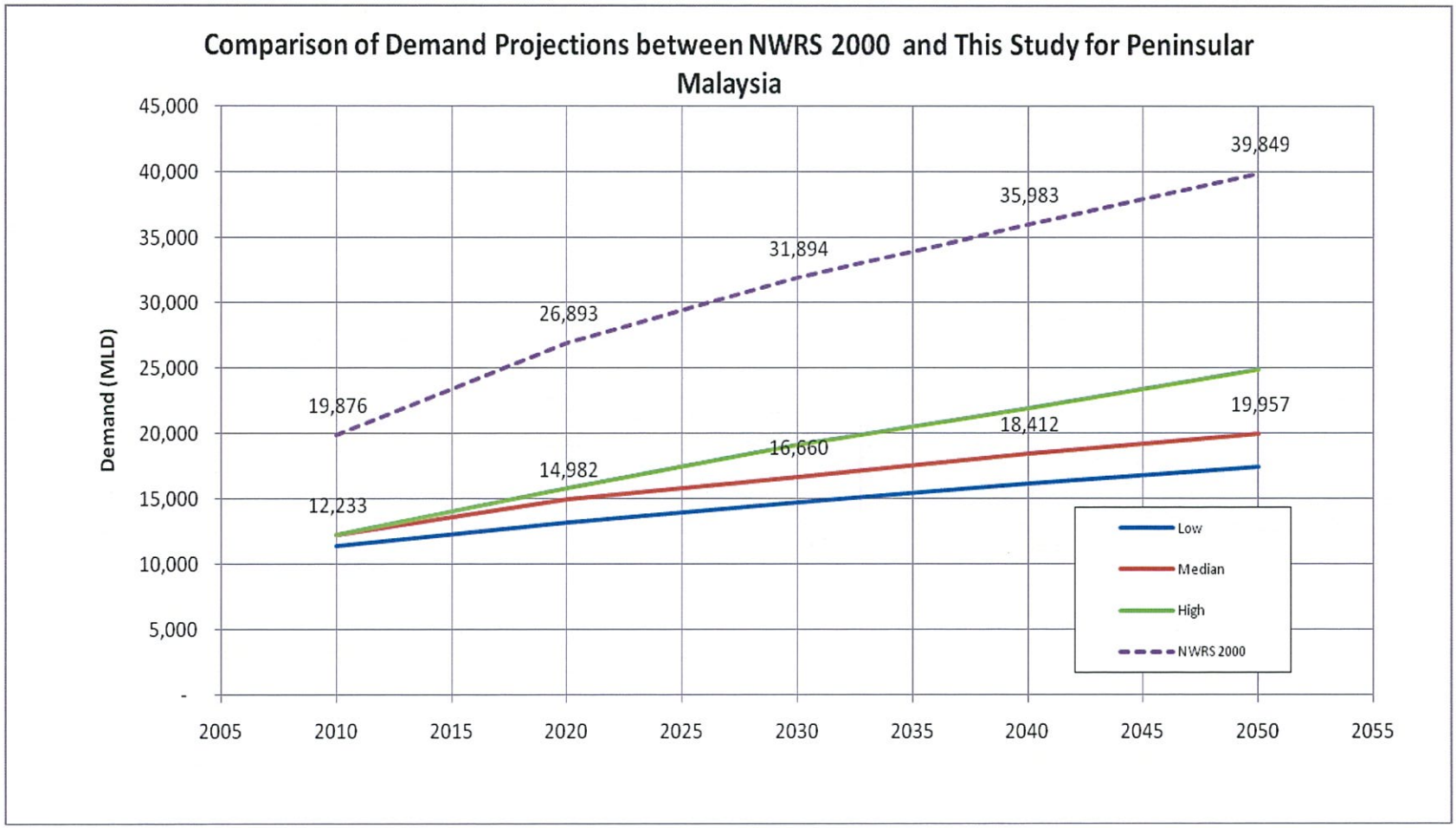


Figure 3.4 - Comparison of Water Demand Projections between This NWRS and Previous NWRS (2000-2050)

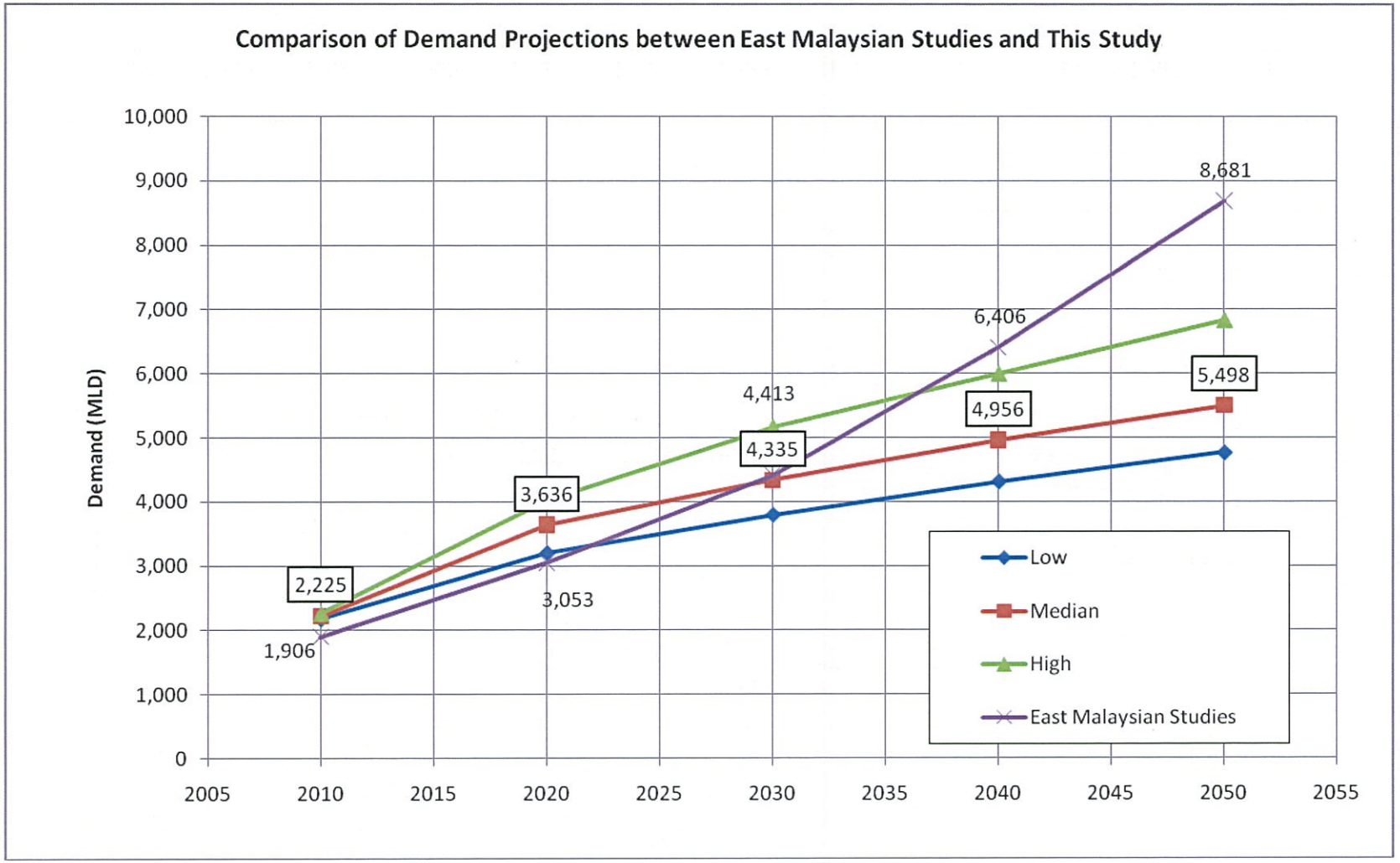


Figure 3.5 - Comparison of Water Demand Projections between East Malaysian Studies and this NWRS

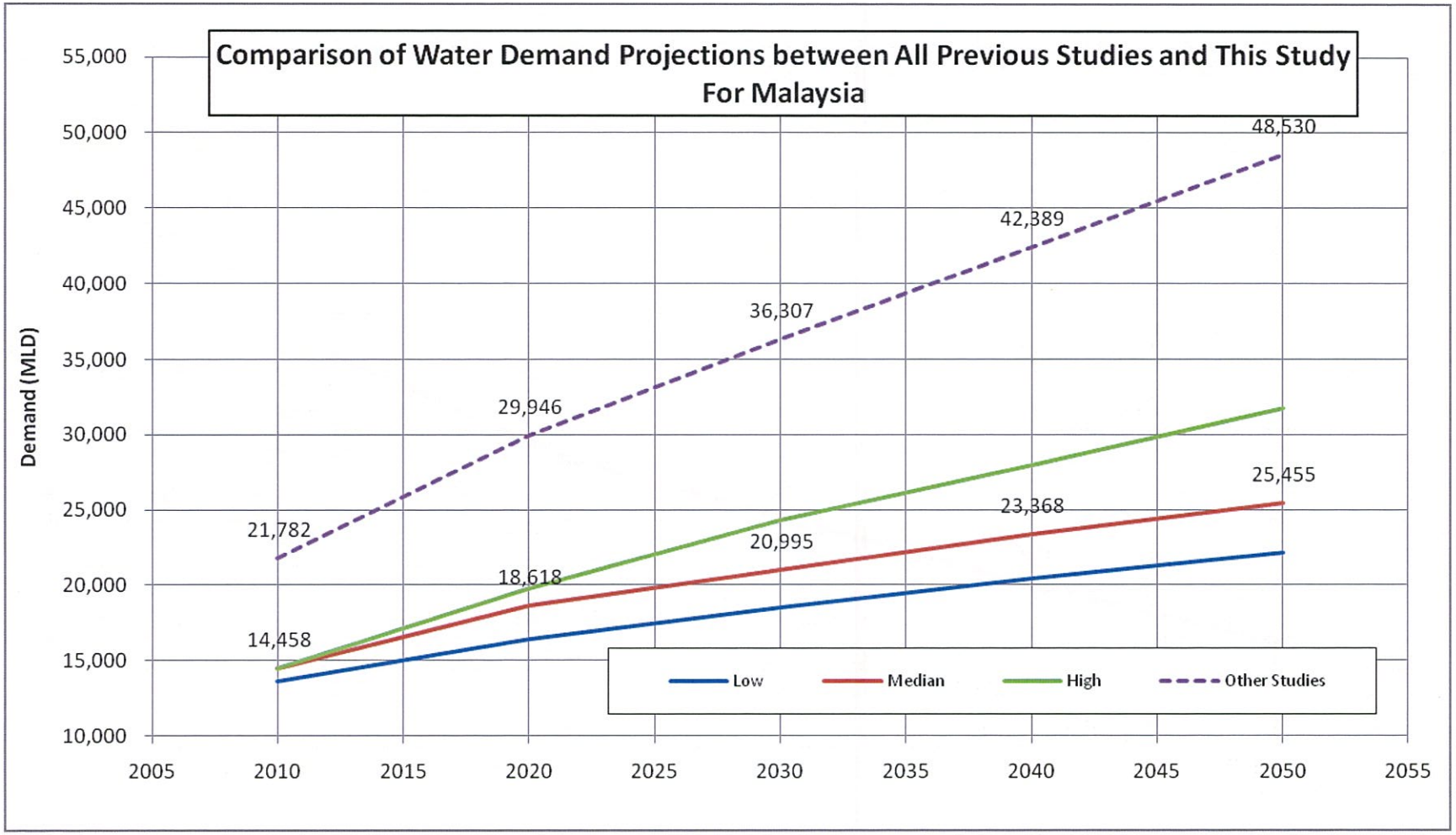


Figure 3.6 - Comparison of Water Demand Projections between All Previous Studies and this NWRS for Malaysia

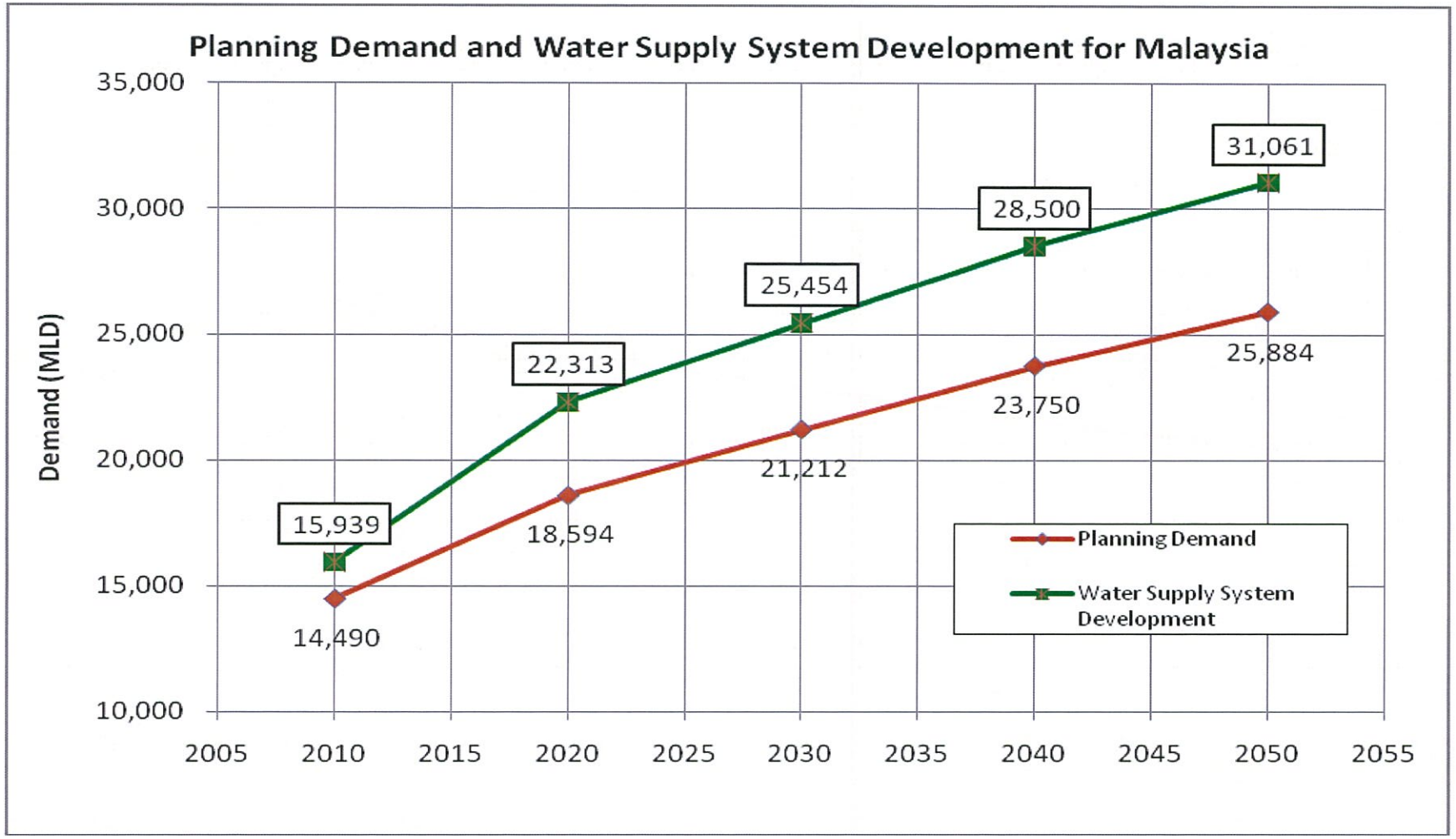


Figure 3.7 - Planning Demand and Water Supply System Development Capacity for Malaysia

3.2.3 Water Demand – Irrigated Paddy

(1) There are eight granary areas in the country with several mini and minor irrigation schemes. The granary schemes are mainly practising double-cropping while the others are mainly single-cropping depending on the rainfall and irrigation supplements. Irrigation efficiencies for the mini and minor schemes are low, due to lower level of management as compared with the main granaries areas where the irrigation structure and its accompanying institutional set-up are more sophisticated. **Table 3.17** provides a listing of the irrigated areas in the country.

Table 3.17 - Present Paddy Planting Areas in Malaysia

Region	States	Paddy Area (ha)			
		Granary Schemes		Mini Granary Schemes	Minor Irrigation Schemes
Northern Region	Perlis	Muda#	100,085	3,758	3,656
	Kedah			6,890	24,382
	Pulau Pinang	Pulau Pinang	10,138	-	2,580
	Kelantan	Kemubu	31,464	3,341	12,795
		Kemasin Semerak	6,175		
	Terengganu	Besut/Setiu	6,460	5,812	4,297
Central Region	Perak	Kerian	22,170	5,841	11,118
		Sg Manik	6,318		
		Seberang Perak	8,529		
	Selangor	Barat Laut Selangor	18,195	-	330
	Pahang	-		12,267	3,989
Southern Region	Negeri Sembilan	-		2,109	-
	Melaka	-		3,263	788
	Johor	-		2,050	121
East Malaysia	Sabah	-		17,734	2,887
	FT Labuan	-		-	-
	Sarawak	-		8,730	54,870
Total Irrigated paddy Schemes				**403,142**	

Muda granary scheme is inclusive of both Perlis and Kedah granary area

(2) The existing irrigation efficiencies vary from 40% to 70%; with MADA achieving the highest efficiency of 70%. The Study recommends efforts to improve irrigation efficiency following the model achieved by MADA as shown in **Table 3.18**.

Table 3.18 - Irrigation Efficiencies Adopted in Water Demand Projection

Irrigation Scheme	Irrigation Efficiencies (%)				
	2010	2020	2030	2040	2050
Granary Area	50	55	65	70	75
Muda*	70	70	75	75	75
Kemubu	55	60	65	70	75
Mini Granary	40	45	50	55	60
Minor Schemes	40	40	45	45	50

Source: *Integrated Water Resources Study in Northern Region, 2009

(3) Another water saving measure is in the area of water demand management; via:

(i) Improving and modifying farming practices.
(ii) Introduction of paddy strains with shorter growing periods.
(iii) Introduction of System of Rice Intensification (SRI) farming methods that reduce drastically the use of water (at the expense of more intensive labour).
(iv) Metering and pricing for use of actual irrigated water.

(4) The projected irrigation demands based on improved irrigation efficiencies for the various States are shown in **Table 3.19.**

Table 3.19 - Total Irrigation Water Demand Projection for Malaysia

Region	States	Projected Annual Irrigation Water Demand (mcm)				
		2010	2020	2030	2040	2050
Northern Region	Perlis	198	184	165	155	141
	Kedah	2,283	2,263	2,089	2,076	2,030
	Pulau Pinang	358	330	281	265	245
	Kelantan	1,190	1,112	1,010	948	873
	Terengganu	464	428	373	351	323
Central Region	Perak	1,476	1,352	1,160	1,084	1,010
	Selangor	720	655	555	516	482
	Pahang	330	514	436	405	379
Southern Region	Negeri Sembilan	45	41	37	34	32
	Melaka	86	86	62	62	62
	Johor	43	39	35	33	30
Peninsular Malaysia		**7,193**	**7,004**	**6,203**	**5,929**	**5,607**
East Malaysia	Sabah/Labuan	450	655	575	533	496
	Sarawak	623	1,453	1,271	1,179	1,102
Total		**8,266**	**9,112**	**8,049**	**7,641**	**7,205**

3.2.4 Water Demand – Non-paddy Agriculture

(1) The main non-paddy agriculture usually carried out on commercial scale comprises cultivation of oil palm, rubber, fruits, flowers and vegetables. These cultivations, although requiring water, are not normally served with irrigation structures akin to paddy growing. Nevertheless, they consume water and the spatial areas covered by these crops are projected as shown in **Table 3.20**.

Table 3.20 - National Crop Areas, 2007 – 2050 (ha)

State		2007	2010e	2020e	2030e	2040e	2050e
P Malaysia	Oil Palm	2,348,753	2,348,753	2,348,753	2,348,753	2,348,753	2,348,753
E Malaysia		1,942,856	2,086,379	2,564,789	3,043,199	3,521,609	4,000,000
Total		**4,291,609**	**4,435,132**	**4,913,542**	**5,391,952**	**5,870,362**	**6,348,753**
P Malaysia	Rubber	1,152,839	1,152,839	1,152,839	1,152,839	1,152,839	1,152,839
E Malaysia		228	228	228	228	228	228
Total		**1,153,067**	**1,153,067**	**1,153,067**	**1,153,067**	**1,153,067**	**1,153,067**
P Malaysia	Tobacco	6,678	6,678	6,678	6,678	6,678	6,678
E Malaysia		1,200	1,200	1,200	1,200	1,200	1,200
Total		**7,878**	**7,878**	**7,878**	**7,878**	**7,878**	**7,878**
P Malaysia	Fruits	228,017	228,017	228,017	228,017	228,017	228,017
E Malaysia		51,696	51,696	51,696	51,696	51,696	51,696
Total		**279,713**	**279,713**	**279,713**	**279,713**	**279,713**	**279,713**
P Malaysia	Vegetables	42,963	42,963	42,963	42,963	42,963	42,963
E Malaysia		8,090	8,090	8,090	8,090	8,090	8,090
Total		**51,053**	**51,053**	**51,053**	**51,053**	**51,053**	**51,053**
P Malaysia	Industrial crops	100,929	100,929	100,929	100,929	100,929	100,929
E Malaysia		97,015	97,015	97,015	97,015	97,015	97,015
Total		**197,944**	**197,944**	**197,944**	**197,944**	**197,944**	**197,944**
P Malaysia	Herbs	518.5	590.7	962.1	1,567.3	2,533.0	4,158.5
E Malaysia		0	0	0	0	0	0
Total		**518.5**	**590.7**	**962.1**	**1,567.3**	**2,533.0**	**4,158.5**
P Malaysia	Flowers	1,769	2,020	3,290	5,359	8,731	14,220
E Malaysia		97	113	184	300	488	796
Total		**1,866**	**2,133**	**3,474**	**5,659**	**9,219**	**15,016**

Note: Up to 2007, the figures are actual. From 2010 on, they are estimates.

(2) Water demands for the various crops are calculated based on their respective consumptive use and climatic factors, since much of the water requirement is derived from rainfall.

The total projected water demand for the crops is shown in **Table 3.21.** On a yearly basis, the water demand for the various States is shown in **Table 3.22.**

Table 3.21 – Projected National Monthly Water Requirements 2007 - 2050 (mcm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2007													
P M'sia	148	304	155	139	94	67	25	51	26	1	1	25	1,037
E M'sia	2	12	18	29	4	0.693	1	7	0.915	0	0	0	74
Total	**150**	**316**	**173**	**168**	**97**	**68**	**26**	**58**	**27**	**1**	**1**	**25**	**1,111**
2010													
P M'sia	148	304	155	139	94	68	25	51	26	1	1	25	1,039
E M'sia	2	12	18	29	4	0.698	1	7	0.922	0	0	0	74
Total	**150**	**317**	**173**	**168**	**98**	**68**	**26**	**58**	**27**	**1**	**1**	**25**	**1,113**
2020													
P M'sia	148	306	156	140	95	68	25	52	27	1	1	25	1,044
E M'sia	2	12	18	29	4	0.715	1	7	0.945	0	0	0	75
Total	**150**	**319**	**174**	**169**	**99**	**69**	**26**	**59**	**27.58**	**1**	**1**	**25**	**1,119**
2030													
P M'sia	149	309	157	140	96	69	26	53	27	1	2	25	1,054
E M'sia	2	13	18	29	4	0.735	1	7	0.971	0	0	0	76
Total	**151**	**322**	**176**	**169**	**100**	**70**	**27**	**60**	**28**	**1**	**2**	**25**	**1,130**
2040													
P M'sia	150	314	159	141	98	71	26	54	27	1	2	25	1,069
E M'sia	2	13	18	30	4	0.758	1	8	1	0	0	0	77
Total	**152**	**326**	**178**	**171**	**102**	**72**	**27**	**62**	**28**	**1**	**2**	**25**	**1,146**
2050													
P M'sia	151	321	163	143	101	73	27	57	28	1	2	25	1,094
E M'sia	2	13	19	30	4	0.8	1	8	1	0	0	0	78
Total	**153**	**334**	**181**	**173**	**106**	**74**	**28**	**65**	**29**	**1**	**2**	**25**	**1,172**

Table 3.22 - Annual Water Demand for Non- Paddy Crops

States	Land Area km²	Non-Paddy Crops Demand (mcm)				
		2010	2020	2030	2040	2050
Perlis	821	52	52	52	52	52
Kedah	9,500	146	146	146	147	148
Pulau Pinang	1,048	39	40	40	40	40
Perak	21,035	65	65	66	68	70
Selangor	8,396	36	37	39	43	48
Negeri Sembilan	6,686	24	24	24	24	24
Melaka	1,664	69	70	70	71	71
Johor	19,210	99	101	105	111	121
Pahang	36,137	33	33	35	36	39
Terengganu	13,035	184	184	184	185	185
Kelantan	15,099	292	292	292	293	294
Peninsular Malaysia	**132,388**	**1,039**	**1,044**	**1,054**	**1,069**	**1,094**
Sabah	73,631	73	73	74	75	77
FT Labuan	91	0	0	0	0	0
Sarawak	124,450	2	2	2	2	2
East Malaysia	**198,172**	**74**	**75**	**76**	**77**	**78**
Total Malaysia	**330,803**	**1,113**	**1,119**	**1,130**	**1,146**	**1,172**

3.2.5 Water Demand – Livestock

(1) Livestock comprises the following domestic animals as illustrated in **Table 3.23.**

Table 3.23 - Livestock Population (2005 – 2008) for Malaysia

Livestock Type	2005	2006	2007	2008
Buffalo	133,232	132,338	130,775	131,229
Cattle	781,316	774,402	863,293	871,892
Goat	287,670	333,962	428,263	477,480
Sheep	115,922	116,697	125,988	131,258
Hog	2,035,647	2,020,955	2,020,117	1,728,307
Poultry	174,694,165	185,097,807	188,383,841	192,693,703
Duck	8,052,997	8,138,777	8,261,647	7,120,994
Ostrich	1,137	797	641	740
Deer	13,955	16,033	12,659	14,894
Quail	1,945,060	1,828,441	2,368,597	2,580,372

(2) Water demands for livestock cover the three main areas of drinking, water for washings of livestock pens, and water used in abattoirs. Water demand for livestock is shown in **Table 3.24.**

Table 3.24 - Livestock Water Demand (mcm)

State	Uses	2010	2020	2030	2040	2050
Johor	Drinking	13	21	33	54	88
	Washing	10	15	24	39	63
	Abattoir	1	2	3	5	8
	Sub-Total	23	38	60	98	159
Melaka	Drinking	4	5	7	9	13
	Washing	2	3	4	6	8
	Abattoir	0	0	0	0	0
	Sub-Total	6	8	11	15	22
Negeri Sembilan	Drinking	3	4	6	8	11
	Washing	2	3	5	7	9
	Abattoir	0	0	0	0	1
	Sub-Total	5	8	11	15	21
Selangor	Drinking	4.5	5	7	10	15
	Washing	4.5	6	7	9	12
	Abattoir	0	0	1	1	1
	Sub-Total	9	11	15	20	28
Perak	Drinking	9	12	17	24	33
	Washing	12	15	20	25	33
	Abattoir	1	1	2	2	3
	Sub-Total	22	29	38	51	69
Pulau Pinang	Drinking	3	4	4	4	4
	Washing	8	8	8	9	9
	Abattoir	0	0	0	0	0
	Sub-Total	12	12	13	13	13
Kedah	Drinking	4	5	6	9	12
	Washing	3	3	4	6	8
	Abattoir	0	0	1	1	1
	Sub-Total	6	8	11	15	21
Perlis	Drinking	1	1	2	4	8
	Washing	0	1	1	2	4
	Abattoir	0	0	0	0	1
	Sub-Total	1	2	3	7	13
Kelantan	Drinking	3	4	6	9	14
	Washing	3	4	6	10	15
	Abattoir	0	0	0	0	0
	Sub-Total	6	9	12	19	29
Terengganu	Drinking	3	4	7	12	21
	Washing	2	4	5	8	13
	Abattoir	0	0	1	1	2
	Sub-Total	5	8	13	21	36
Pahang	Drinking	4	7	12	22	41
	Washing	4	7	13	26	50
	Abattoir	0	0	0	0	1
	Sub-Total	8	14	26	48	92
Pen. Malaysia	**Drinking**	**50**	**72**	**107**	**164**	**259**
	Washing	**50**	**70**	**99**	**146**	**226**
	Abattoir	**4**	**5**	**8**	**12**	**18**

State	Uses	2010	2020	2030	2040	2050
	Total	**104**	**147**	**214**	**322**	**503**
Sabah	Drinking	3	4	5	7	9
	Washing	4	4	6	7	9
	Abattoir	0	0	0	0	0
	Total	7	9	11	13	18
Sarawak	Drinking	8	10	13	18	23
	Washing	6	7	9	11	13
	Abattoir	1	1	2	2	3
	Total	15	19	24	30	39
Malaysia	Drinking	61	86	125	188	291
	Washing	60	82	113	164	249
	Abattoir	5	7	10	14	21
	Total	126	175	248	366	561

3.2.6 Water Demand – Fisheries

(1) Inland fisheries are an important economic activity at both commercial and subsistence levels in the various States; especially in Pahang, Johor, Perak, Sabah and Sarawak. Inland fisheries in the form of aquaculture have contributed significantly to the Malaysian economy. The fisheries sector (excluding hatcheries, ornamental fishes and related products) contributed about 0.33% of the Gross Domestic Product (GDP) for Malaysia in 2008 at a value of RM 528,311 million.

(2) **Table 3.25** summarizes the projected area involved in aquaculture production and volume of water required up to year 2050, based on the assumption that the depth of water in pond/tanks is 1.3m in use for 10 months in a year and continuous inflow of water to replace initial volume in 30 days.

Table 3.25 - Projected Area and Water Demand for Aquaculture in Malaysia

State	Projected Area (ha) / Estimated Volume (mcm) of Water Required in Pond/Tank Culture per Annum					
	Baseline	**2010**	**2020**	**2030**	**2040**	**2050**
Perlis	65.7 / 8.5	72.6 / 9.4	80.2 / 10.4	88.6 / 11.5	97.9 / 12.7	108.1 / 14.1
Kedah	277.3 / 36.0	285.7 / 37.1	331.6 / 43.1	384.8 / 50.0	446.6 / 58.1	518.3 / 67.3
Pulau Pinang	437.4 / 56.9	450.6 / 58.6	522.9 / 67.9	606.8 / 78.9	704.2 / 91.5	817.3 / 106.2
Perak	2382.8 / 309.8	2503.4 / 325.4	3204.6 / 416.6	4102.1 / 533.3	5251.0 / 682.6	6721.7 / 873.8
Selangor	1177.0 / 153.0	1224.6 / 159.2	1492.8 / 194.1	1819.7 / 236.6	2218.2 / 288.4	2704.0 / 351.5
Negeri Sembilan	411.8 / 53.5	424.2 / 55.1	492.3 / 64.0	571.3 / 74.3	663.0 / 86.2	769.4 / 100.0
Melaka	481.5 / 62.6	491.2 / 63.9	542.6 / 70.5	599.4 / 77.9	662.1 / 86.1	731.4 / 95.1
Johor	1171.1 / 152.2	1218.4 / 158.4	1810.5 / 235.4	2207.0 / 286.9	2690.3 / 349.7	3279.4 / 426.3
Pahang	1541.0 / 200.3	1587.6 / 206.4	1842.5 / 239.6	2138.3 / 277.9	2481.0 / 322.5	2880.0 / 374.4
Terengganu	260.4 / 33.9	270.9 / 35.2	330.2 / 42.9	402.5 / 52.3	981.3 / 127.8	1196.2 / 155.5
Kelantan	277.3 / 36.0	285.7 / 37.1	331.6 / 43.1	384.8 / 50.0	446.6 / 58.1	518.3 / 67.3
Sarawak	2000.3 / 260.0	2080.3 / 270.4	2496.4 / 324.5	2995.6 / 389.4	3594.8 / 467.3	4313.7 / 560.8
Sabah	2037.1 / 264.8	2118.6 / 275.4	2542.3 / 330.5	3050.8 / 396.6	3660.9 / 475.9	4393.1 / 571.1
Total	**12520.7 / 1627.5**	**13013.8 / 1691.6**	**16020.5 / 2082.6**	**19351.7 / 2515.6**	**23897.9 / 3106.9**	**28950.9 / 3763.4**

3.2.7 Total Water Availability and Demand for All Sectors

(1) **Table 3.26** shows the water resources availability in terms of rainfall for various States.

Table 3.26 - Available Rainfall in Malaysia

State	State Area (km^2)	Rainfall	Actual Evaporation	Groundwater Recharge	Surface Runoff
Perlis	821	1,880	1,290	120	470
Kedah	9,500	2,310	1,430	130	750
P Pinang	1,048	2,350	1,430	120	800
Perak	21,035	2,480	1,320	170	990
Selangor	8,396	2,190	1,280	150	760
Negeri Sembilan	6,686	1,830	1,210	130	490
Melaka	1,664	1,880	1,210	100	570
Johor	19,210	2,470	1,130	200	1,140
Pahang	36,137	2,470	1,250	120	1,100
Terengganu	13,035	3,310	1,470	150	1,690
Kelantan	15,099	2,600	1,290	140	1,170
Pen Malaysia	**132,631**	**2,495.5**	**1283.8**	**147.6**	**1064.0**
Sabah	73,631	2,560	1,190	190	1,180
Sarawak	124,450	3,640	1,250	240	2,150
FT Labuan	91	3,100	1,480	150	1,470
East Malaysia	**198,172**	**3,238.5**	**1,227.8**	**221.4**	**1,789.3**
Malaysia	**330,803**	**2,940.6**	**1,250.3**	**191.8**	**1,498.5**

(2) **Tables 3.27 to 3.32** show the water demand for various sectors. **Table 3.32** shows the total water demand in mm/year of rain as compared with the available runoff. It is noted that a large portion of surface runoff (as much as 70%) would be lost through floods, leaving a minimal from the balance available to meet water demands of various sectors. Certain States such as Perlis and Pulau Pinang are already dependent on Kedah to fulfill their water demand, as the States' rainfall would not be sufficient.

(3) **Figure 3.8** shows the water demand for various sectors in mm of rainfall per year. A well-managed potable water demand strategy is required to be introduced to curtail the rising trend.

Table 3.27 - Water Demand For Potable Water

States	Land Area km²	Projected Potable Water Demand (m/l/d)					Potable Water demand (mm)				
		2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
Perlis	821	150	168	179	192	206	66.7	74.7	79.6	85.4	91.6
Kedah	9,500	1,333	1,529	1,630	1,738	1,855	51.2	58.7	62.6	66.8	71.3
Pulau Pinang	1,048	974	1,225	1,376	1,525	1,633	339.2	426.6	479.2	531.1	568.7
Perak	21,035	1,058	1,306	1,462	1,639	1,812	18.4	22.7	25.4	28.4	31.4
Selangor	8,396	4,037	4,896	5,371	5,975	6,477	175.5	212.8	233.5	259.8	281.6
Negeri Sembilan	6,686	731	790	786	802	814	39.9	43.1	42.9	43.8	44.4
Melaka	1,664	443	554	638	715	776	97.2	121.5	139.9	156.8	170.2
Johor	19,210	1,506	1,925	2,280	2,526	2,716	28.6	36.6	43.3	48.0	51.6
Pahang	36,137	974	1,054	1,099	1,156	1,231	9.8	10.6	11.1	11.7	12.4
Terengganu	13,035	632	971	1,094	1,211	1,319	17.7	27.2	30.6	33.9	36.9
Kelantan	15,099	395	564	745	933	1,118	9.5	13.6	18.0	22.6	27.0
Pen Malaysia	**132,631**	**12,233**	**14,982**	**16,660**	**18,412**	**19,957**	**33.7**	**41.2**	**45.8**	**50.7**	**54.9**
Sabah	73,631	1,049	1,695	2,005	2,250	2,405	5.2	8.4	9.9	11.2	11.9
FT Labuan	91	53.1	72.2	83.9	92.5	100.6	197.7	264.3	285.0	304.0	318.0
Sarawak	124,450	1,126	1,875	2,259	2,631	3,014	3.3	5.5	6.6	7.7	8.8
East Malaysia	**198,172**	**2,225**	**3,636**	**4,335**	**4,956**	**5,498**	**4.1**	**6.7**	**8.0**	**9.1**	**10.1**
Total Malaysia	**330,803**	**14,458**	**18,618**	**20,995**	**23,368**	**25,455**	**16.0**	**20.5**	**23.2**	**25.8**	**28.1**

Table 3.28 - Water Demand For Irrigated Paddy Cultivation

States	Land Area km²	Projected Irrigation Water Demand (mcm)					Irrigation Water Demand (mm)				
		2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
Perlis	821	198	184	165	155	141	241.2	224.1	201.0	188.8	171.7
Kedah	9,500	2,283	2,263	2,089	2,076	2,030	240.3	238.2	219.9	218.5	213.7
Pulau Pinang	1,048	358	330	281	265	245	341.6	314.9	268.1	252.9	233.8
Perak	21,035	1,476	1,352	1,160	1,084	1,010	70.2	64.3	55.1	51.5	48.0
Selangor	8,396	720	655	555	516	482	88.3	80.3	68.1	63.3	59.1
Negeri Sembilan	6,686	45	41	37	34	32	6.7	6.1	5.5	5.1	4.8
Melaka	1,664	86	86	62	62	62	51.7	51.7	37.3	37.3	37.3
Johor	19,210	43	39	35	33	30	2.2	2.0	1.8	1.7	1.6
Pahang	36,137	330	514	436	405	379	9.1	14.2	12.1	11.2	10.5
Terengganu	13,035	464	428	373	351	323	35.6	32.8	28.6	26.9	24.8
Kelantan	15,099	1,190	1,112	1,010	948	873	78.8	73.6	66.9	62.8	57.8
Pen Malaysia	**132,631**	**7,193**	**7,004**	**6,203**	**5,929**	**5,607**	**54.3**	**52.9**	**46.9**	**44.8**	**42.4**
Sabah	73,631	450	655	575	533	496	6.1	8.9	7.8	7.2	6.7
FT Labuan	91	0	0	0	0	0	-	-	-	-	-
Sarawak	124,450	623	1,453	1,271	1,179	1,102	5.0	11.7	10.2	9.5	8.9
East Malaysia	**198,172**	**1,073**	**2,108**	**1,846**	**1,712**	**1,598**	**5.4**	**10.6**	**9.3**	**8.6**	**8.1**
Total Malaysia	**330,803**	**8,266**	**9,112**	**8,049**	**7,641**	**7,205**	**25.0**	**27.6**	**24.3**	**23.1**	**21.8**

Table 3.29 - Water Demand For Non-Paddy Crops

States	Land Area km²	Non-Paddy Crops Demand (mcm)					Non-Paddy Crops Demand (mm)				
		2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
Perlis	821	51.9	52.0	52.1	52.2	52.4	63.25	63.31	63.42	63.57	63.84
Kedah	9,500	145.9	146.1	146.5	147.0	148.0	15.36	15.38	15.42	15.48	15.58
Pulau Pinang	1,048	39.5	39.5	39.6	39.8	40.1	37.65	37.72	37.83	38.01	38.29
Perak	21,035	64.9	65.4	66.3	67.7	69.9	3.08	3.11	3.15	3.22	3.32
Selangor	8,396	36.0	37.3	39.4	42.7	48.2	4.29	4.44	4.69	5.09	5.73
Negeri Sembilan	6,686	23.6	23.7	23.8	24.0	24.4	3.53	3.54	3.56	3.59	3.65
Melaka	1,664	69.3	69.6	69.9	70.5	71.5	41.66	41.80	42.01	42.37	42.96
Johor	19,210	99.0	101.3	104.9	110.9	120.7	5.15	5.27	5.46	5.77	6.28
Pahang	36,137	32.8	33.4	34.6	36.3	39.3	0.91	0.93	0.96	1.01	1.09
Terengganu	13,035	183.9	184.1	184.3	184.6	185.2	14.11	14.12	14.14	14.16	14.20
Kelantan	15,099	292.0	292.0	292.0	293.0	294.0	19.34	19.34	19.34	19.41	19.47
Pen Malaysia	**132,631**	**1038.8**	**1044.3**	**1053.3**	**1068.8**	**1093.6**	**7.83**	**7.87**	**7.94**	**8.06**	**8.25**
Sabah	73,631	72.6	73.3	74.2	75.2	76.6	0.99	1.00	1.01	1.02	1.04
FT Labuan	91	0	0	0	0	0	0	0	0	0	0
Sarawak	124,450	5.1	5.4	5.5	5.8	5.9	0.04	0.04	0.04	0.05	0.05
East Malaysia	**198,172**	**77.7**	**78.8**	**79.7**	**81.0**	**82.5**	**0.40**	**0.40**	**0.40**	**0.40**	**0.40**
Total Malaysia	**330,803**	**1,117**	**1,123**	**1,113**	**1,150**	**1,176**	**3.38**	**3.40**	**3.43**	**3.48**	**3.55**

* Note: Figure need not be exact due to rounding up adjustments

Table 3.30 - Water Demand for Livestock

States	Land Area km²	Livestock (mcm)					Livestock (mm)				
		2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
Perlis	821	0.9	1.7	3.3	6.5	12.8	1.07	2.09	4.07	7.97	15.62
Kedah	9,500	6.5	8.4	11.2	15.2	21.3	0.68	0.89	1.18	1.60	2.24
Pulau Pinang	1,048	11.9	12.2	12.5	12.8	13.1	11.35	11.64	11.93	12.23	12.54
Perak	21,035	22.1	28.6	38.5	51.2	69.4	1.05	1.36	1.83	2.43	3.30
Selangor	8,396	8.6	11.3	14.9	20.2	27.9	1.00	1.30	1.80	2.40	3.30
Negeri Sembilan	6,686	4.9	8.1	10.8	14.8	21.1	0.74	1.21	1.61	2.22	3.16
Melaka	1,664	6.0	8.1	11.1	15.4	22.0	3.58	4.86	6.65	9.27	13.22
Johor	19,210	23.4	37.8	60.5	97.8	158.6	1.22	1.97	3.15	5.09	8.26
Pahang	36,137	8.1	14.2	25.7	47.9	91.6	0.22	0.39	0.71	1.33	2.54
Terengganu	13,035	5.1	8.1	12.9	21.4	36.5	0.39	0.62	0.99	1.64	2.80
Kelantan	15,099	6.1	8.7	12.1	18.8	28.5	0.40	0.58	0.80	1.25	1.89
Pen Malaysia	**132,631**	**103.6**	**147.2**	**213.6**	**322.1**	**502.9**	**0.78**	**1.11**	**1.61**	**2.43**	**3.80**
Sabah	73,631	6.9	8.5	10.7	13.8	18.5	0.09	0.12	0.10	0.17	0.25
FT Labuan	91	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Sarawak	124,450	18.3	24.2	32.1	42.7	56.9	0.15	0.19	0.26	0.34	0.46
East Malaysia	**198,172**	**25.2**	**32.7**	**42.8**	**56.5**	**75.4**	**0.13**	**0.17**	**0.22**	**0.29**	**0.38**
Total Malaysia	330,803	128.8	179.9	256.4	378.6	578.3	0.39	0.54	0.78	1.14	1.75

Table 3.31 - Water Demand for Fisheries

States	Land Area sq km	Fisheries Water Demand (MCM)					Fisheries Water Demand (mm)				
		2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
Perlis	821	9.4	10.4	11.5	12.7	14.1	11.5	12.7	14.0	15.5	17.1
Kedah	9,500	136.1	157.9	183.2	212.7	246.8	14.3	16.6	19.3	22.4	26.0
Pulau Pinang	1,048	58.6	68.0	78.9	91.5	106.2	55.9	64.9	75.3	87.3	101.4
Perak	21,035	325.4	416.6	533.3	682.6	873.8	15.5	19.8	25.4	32.5	41.5
Selangor	8,396	159.2	194.1	236.6	288.4	351.5	19.5	23.8	29.0	35.4	43.1
Negeri Sembilan	6,686	55.1	64.0	74.3	86.2	100.0	8.2	9.6	11.1	12.9	15.0
Melaka	1,664	63.9	70.5	77.9	86.1	95.1	38.4	42.4	46.8	51.7	57.1
Johor	19,210	158.4	235.4	286.9	349.7	426.3	8.2	12.3	14.9	18.2	22.2
Pahang	36,137	206.4	239.6	278.0	322.5	374.4	5.7	6.6	7.7	8.9	10.4
Terengganu	13,035	35.2	42.9	52.3	127.6	155.5	2.7	3.3	4.0	9.8	11.9
Kelantan	15,099	37.1	43.1	50.0	58.1	67.4	2.5	2.9	3.3	3.8	4.5
Pen Malaysia	**132,631**	**1,245**	**1,543**	**1,863**	**2,318**	**2,811**	**9.4**	**11.7**	**14.1**	**17.5**	**21.2**
Sabah	73,631	21.1	25.3	30.4	36.5	43.8	0.3	0.3	0.4	0.5	0.6
FT Labuan	91	-	-	-	-	-	-	-	-	-	-
Sarawak	124,450	20.7	24.9	29.9	35.8	43.0	0.2	0.2	0.2	0.3	0.3
East Malaysia	**198,172**	**42**	**50**	**60**	**72**	**87**	**0.2**	**0.3**	**0.3**	**0.4**	**0.4**
Total Malaysia	**330,803**	**1,287**	**1,593**	**1,923**	**2,390**	**2,898**	**3.9**	**4.8**	**5.8**	**7.2**	**8.8**

Table 3.32 - Total consumptive Water Demand Against Total Surface Water Availability For All Sectors

States	Land Area sq km	Total Consumptive Water demand (MCM)					Total Consumptive Water demand (mm)					Effective rain (mm)	Excess/deficit (mm) - Unregulated Flows				
		2010	2020	2030	2040	2050	2010	2020	2030	2040	2050		2010	2020	2030	2040	2050
Perlis	821	306	299	286	284	281	372.1	364.2	348.1	345.7	342.8	70.5	(301.6)	(293.7)	(277.6)	(275.2)	(272.3)
Kedah	9,500	2,922	2,976	2,842	2,873	2,876	307.6	313.2	299.1	302.4	302.8	112.5	(195.1)	(200.7)	(186.6)	(189.9)	(190.3)
Pulau Pinang	1,048	765	829	835	874	894	729.9	790.9	797.1	834.2	853.3	120.0	(609.9)	(670.9)	(677.1)	(714.2)	(733.3)
Kelantan	15,099	1,632	1,619	1,586	1,600	1,604	108.1	107.2	105.0	106.0	106.2	175.5	67.4	68.3	70.5	69.5	69.3
Terengganu	13,035	884	975	970	999	1,026	67.8	74.8	74.4	76.6	78.7	253.5	185.7	178.7	179.1	176.9	174.8
Perak	21,035	1,949	1,923	1,798	1,801	1,811	92.7	91.4	85.5	85.6	86.1	139.5	46.8	48.1	54.0	53.9	53.4
Selangor	8,396	2,238	2,491	2,570	2,760	2,922	266.6	296.6	306.1	328.7	348.0	114.0	(152.6)	(182.6)	(192.1)	(214.7)	(234.0)
Pahang	36,137	726	946	897	911	959	20.1	26.2	24.8	25.2	26.5	165.0	144.9	138.8	140.2	139.8	138.5
Negeri Sembilan	6,686	340	361	358	366	374	50.9	54.0	53.6	54.7	56.0	73.5	22.6	19.5	19.9	18.8	17.5
Melaka	1,664	323	366	376	409	439	194.1	219.9	225.9	245.7	263.7	85.5	(108.6)	(134.4)	(140.4)	(160.2)	(178.2)
Johor	19,210	715	881	1,033	1,164	1,301	37.2	45.8	53.8	60.6	67.7	171.0	133.8	125.2	117.2	110.4	103.3
Pen Malaysia	**132,631**	**12,800**	**13,664**	**13,551**	**14,040**	**14,488**	**96.5**	**103.0**	**102.2**	**105.9**	**109.2**	**159.0**	**62.5**	**56.0**	**56.8**	**53.1**	**49.8**
Sabah	73,631	912	1,356	1,392	1,442	1,469	12.4	18.4	18.9	19.6	20.0	177.0	164.6	158.6	158.1	157.4	157.0
Sarawak	124,450	1,054	2,162	2,125	2,175	2,247	8.5	17.4	17.1	17.5	18.1	220.5	212.0	203.1	203.4	203.0	202.4
WP Labuan	91	18	24	26	28	29	197.7	264.3	285.0	304.0	318.0	322.5	124.8	58.2	37.5	18.5	4.5
East Malaysia	**198,172**	**1,985**	**3,541**	**3,542**	**3,645**	**3,745**	**10.0**	**17.9**	**17.9**	**18.4**	**18.9**	**268.5**	**258.5**	**250.6**	**250.6**	**250.1**	**249.6**
Total Malaysia	**330,803**	**14,785**	**17,205**	**17,093**	**17,685**	**18,233**	**44.7**	**52.0**	**51.7**	**53.5**	**55.1**	**225.0**	**180.3**	**173.0**	**173.3**	**171.5**	**169.9**

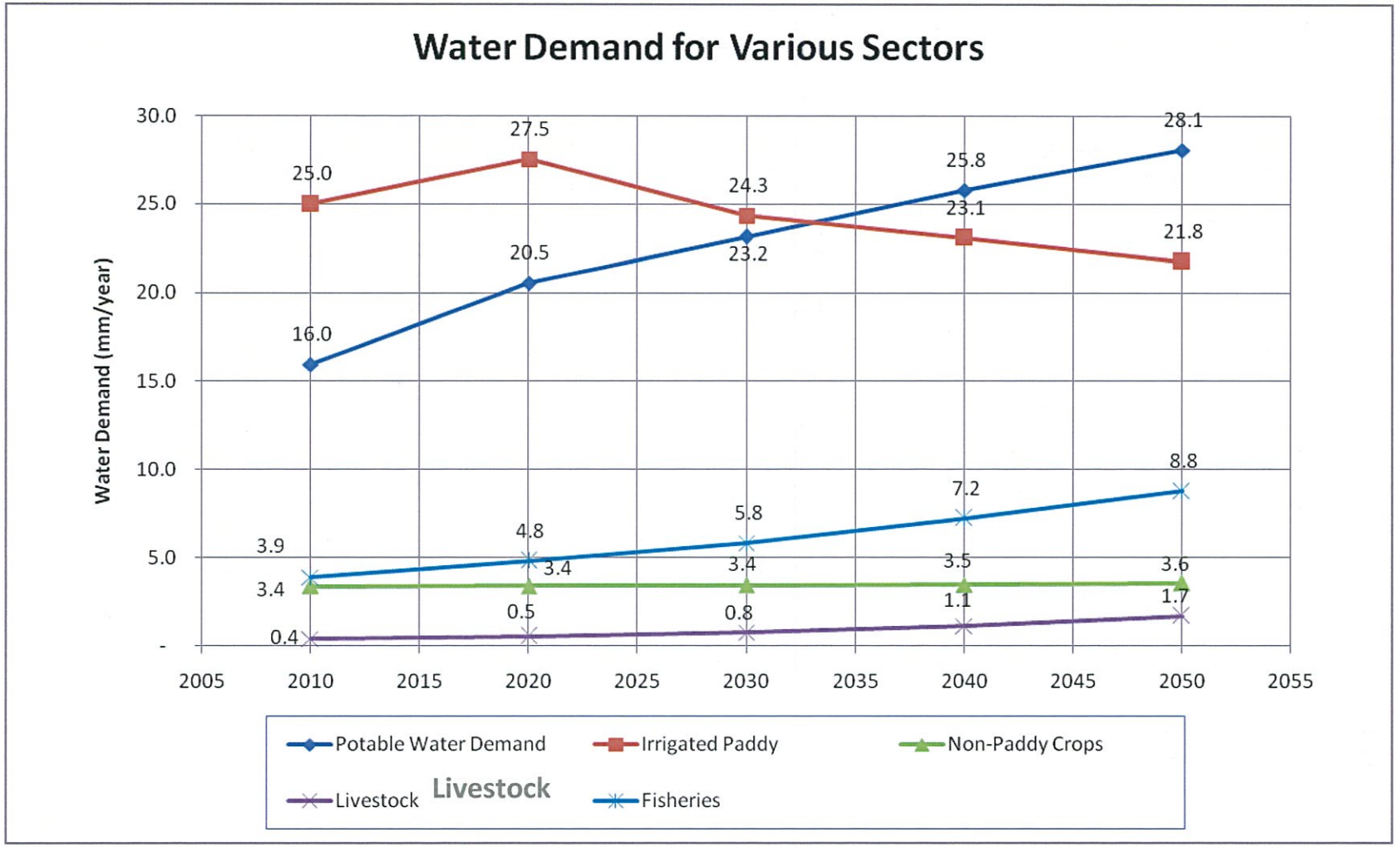


Figure 3.8 - Water Demand for all Sectors (mm rainfall)

3.3 SEWAGE

3.3.1 Impacts on Water Quality

(1) Sewage is one of the main contributors of water pollution in Malaysia that puts raw water out of reach from potential users in addition to threatening the ecosystem.

(2) In Malaysia, whilst many parts of the country enjoy the benefits of centralized sewerage systems, there are also other parts where untreated or partially treated sewage is discharged directly into the watercourses. A reliable and efficient sewerage system in the developed areas is a vital contributing factor towards the preservation of natural water resources, improvement in environmental health and mitigation of waterborne diseases. Centralised sewerage systems enable proper management and monitoring of wastewater.

(3) **Tables 3.33 and 3.34** provide an inventory of the types of sewerage facilities in the country and the areas served by Indah Water Konsortium Sdn Bhd (IWK) respectively.

Table 3.33 - Percentage PE of Sewerage Facilities by State

State	Connected, % PE	ISTs, % PE	Pour Flush, % PE	%Total PE
Selangor, FT Kuala Lumpur, FT Putrajaya	89.1	9.6	1.3	100
Negeri Sembilan	61.2	21.3	17.5	100
Melaka	68.6	24.0	7.4	100
Johor	65.2	23.6	11.2	100
Perlis	17.7	30.9	51.4	100
Kedah	29.4	33.1	37.5	100
Pulau Pinang	83.3	1.81	14.9	100
Perak	52.2	31.2	16.6	100
Pahang	35.9	20.9	43.2	100
Terengganu	16.6	10.8	72.6	100
Kelantan	25.4	29.2	45.4	100
FT Labuan	70.2	18.9	10.9	100
Sabah	N/A	N/A	N/A	N/A
Sarawak	9.7	90.3	0.0	100
TOTAL	**66.0**	**17.9**	**16.1**	**100**

Note: N/A:Data Not Available; PE: Population Equivalent

Table 3.34 – Profile of Sewage Treatment Facilities in Malaysia

STATE	Regional Plants (STP)				Multi-point Plants (STP)				ISTs		Pour Flush	
	IWK Plants		Not Served by IWK		IWK Plants		Not Served by IWK		Private on site facilities		Private on site facilities [b]	
	No.	PE	No.	PE	No.	PE	No.	PE	No.	PE	No.	PE
Selangor, FT KL, FT Putrajaya	46	3,032,735	3	156,000	2,549	5,637,094	322	447,816	200,481	1,002,405	26,244	131,220
Negeri Sembilan	9	216,111	0	0	893	630,430	152	59,821	63,031	315,155	51,829	259,145
Melaka	0	0	1	12,000	724	576,570	334	260,558	59,305	296,525	18,436	92,180
Johor	8	459,926	0	0	944	1,999,806	660	407,860	208,019	1,040,095	98,133	490,665
Perlis	1	1,000	0	0	36	16,726	416	20,758	13,401	67,005	22,339	111,695
Kedah	3	7,697	0	0	730	560,099	1,157	123,040	155,589	777,945	176,571	882,855
Pulau Pinang	17	1,266,085	0	0	559	855,763	593	146,837	9,878	49,390	81,292	406,460
Perak	0	0	0	0	1,304	1,341,852	710	247,914	189,902	949,510	101,445	507,225
Pahang	4	54,788	0	0	471	268,136	413	244,075	65,931	329,655	136,388	681,940
Terengganu	0	0	0	0	217	72,969	229	91,829	21,286	106,430	143,761	718,805
Kelantan	0	0	0	0	0	0	965	319,621	73,568	367,840	114,424	572,120
FT Labuan	1	20,701	0	0	24	21,988	51	44,433	4,682	23,410	2,718	13,590
Sabah	0	0	19	510,000	0	0	158	216,488	N/A	N/A	N/A	N/A
Sarawak	0	0	0	0	0	0	11	182,374	338,671	1,693,355	N/A	N/A
TOTAL	**89**	**5,059,043**	**23**	**678,000**	**8,451**	**11,981,433**	**6,171**	**2,813,424**	**1,403,744**	**7,018,720**	**973,580**	**4,867,900**

Note: N/A : Data Not Available; PE: Population Equivalent

(4) The quality of the affluent from various sewage systems is given in **Table 3.35** below.

Table 3.35 - Final Effluent BOD Loads (Calculated Based on Assumptions Above) Discharged from Treatment/Sanitary Systems

State	Connected Services, IWK, kg.BOD/d	Connected Services, Non-IWK, kg.BOD/d	ISTs, kg.BOD/d	Pour Flush, kg.BOD/d	TOTAL kg.BOD/d
Selangor, FT Kuala Lumpur, FT Putrajaya	97,536	20,379	15,036	3,149	136,100
Negeri Sembilan	9,524	2,019	4,727	6,219	22,489
Melaka	6,486	9,199	4,448	2,212	22,345
Johor	27,672	13,765	15,601	11,776	68,815
Perlis	199	701	1,005	2,681	4,586
Kedah	6,388	4,153	11,669	21,189	43,398
Pulau Pinang	24,176	5,695	870	7,936	38,676
Perak	15,096	8,367	14,243	12,173	49,879
Pahang	3,633	8,238	4,945	16,367	33,182
Terengganu	821	3,099	1,596	17,251	22,768
Kelantan	0	10,787	5,518	13,731	30,036
FT Labuan	480	1,500	351	326	2,657
Sabah	0	24,519	N/A	N/A	24,519
Sarawak	0	6,155	25,400	N/A	31,555
TOTAL	**192,011**	**118,574**	**105,410**	**115,010**	**531,005**

Source: IWK N/A – Not Available

3.3.2 Outstanding Issues Requiring Immediate Attention

(1) Sullage

Sullage, presently discharging into open drains, is required to be collected and treated by appropriate treatment facilities. This will involve redesigning of the plumbing system to achieve the desired outcome, failing which a lesser effective solution of grease traps should be installed, maintained and serviced. The premises include restaurants, food outlets, wet markets, motor repair workshops and the like. Local Authorities should be empowered to enforce maintenance of grease traps through the annual business license renewal.

(2) Small STPs and ISTs

There are about 14,000 small multi-point sewage treatment plants and they are creating logistics problems in proper operations and maintenance, increased cost of operations and maintenance and greater risk of plant failure and consequent failure to meet the effluent discharge standards.

In addition, there are more than 1.3 million Individual Septic Tanks (ISTs) and close to one million Pour Flush systems in both urban and non-urban areas.

Both of these systems discharge high quantities of pollutants to receiving water and rivers (16% BOD pollution load from ISTs; 27% from Pour Flush).

It is recommended that these systems are to be discontinued in the areas where sewer networks can be feasibly provided and connected to centralized systems.

Private plants are estimated to contributing about 22% of the pollution load. More stringent and closer monitoring and enforcement by the regulators are necessary to bring about improvement by the private plant owners and operators.

The new Sewage Effluent Regulations (effective December, 2009) stipulated that existing treatment plants should be upgraded in two timelines 2016 and 2019, to meet the more stringent standard. The Government should allocate the required resources to enable IWK to meet the objectives and timelines.

(3) Planned Sewerage Infrastructure

Numerous small multipoint sewage treatment plants carry higher risk of plant failure and effluent non-compliance.

There is a need for the Government to commit to a planned sewerage infrastructure implementation program rather than the current *ad-hoc* development. It is thus necessary for the Government through SPAN to formulate a National Sewerage Policy, develop a National Sewerage Strategy and prescribe a National Sewerage Implementation Schedule, which will prescribe targets and time-lines for sewers, network pump stations and Regional Sewage Treatment Plants on the basis of regionalization, high growth areas and river water quality. CAPEX budget allocations will have to match the prescribed implementation schedule. To this end the Catchment Plans and Strategies prepared by IWK should be actively pursued to form the basis for strategy formulation.

The National Sewerage Strategy will enable focusing on the problem areas including the need to extend sewer networks in areas with high CSTs and ISTs. It will also prescribe other activities including the scheduled desludging of septic tanks.

(4) Reuse of Sewage Effluent

Sewage effluent reuse can help to reduce the demand for potable water. Such efforts have been used in other countries for reuse in parks, landscape irrigation, golf course and nurseries. Government intervention and directive can enforce such reuse through municipalities. Nevertheless, return flow will be the preferred option where effluent is discharged to river system. Such return flows will recharge the river, provide the dilution required and improve the quality of river water.

Sewage sludge is a valuable and beneficial resource for its methane formed during digestion and its fertilizing value with its high nitrogen content. Very little of the sludge is put to beneficial use presently, with mostly discharging to trenching sites or municipal sanitary landfills. There is a need to be a driver to lead the move towards reuse of sludge. It is not commercially viable on a small scale and incentives should be given for the sludge reuse. Such moves can only be initiated and carried through by the Government.

3.4 FLOOD MITIGATION

3.4.1 Causes of Flooding

(1) **Table 3.36** shows the flood-prone areas in Malaysia. Flooding causes public inconvenience and inflicting economic losses in damaged properties.

Table 3.36 – Flood-Prone Areas with Respect to Landuse

State	Flood-prone Areas w.r.t. Landuse				Total Flood Affected Area (Km^2)
	Urban (Km^2)	Agriculture (Km^2)	Forest (Km^2)	Others (Km^2)	
Perlis	5.12	17.03	0.33	4.26	26.74
Kedah	12.13	180.17	5.77	11.38	209.45
Pulau Pinang	57.06	129.35	5.32	15.10	206.83
Perak	36.30	429.37	10.10	187.07	662.84
Selangor	95.01	1,133.53	69.58	490.57	1,788.69
FT Kuala Lumpur	13.16	-	0.01	0.01	13.18
Negeri Sembilan	3.66	75.98	5.68	44.16	129.48
Melaka	3.05	52.67	1.33	23.80	80.85
Johor	51.42	993.77	539.05	782.47	2,366.71
Pahang	69.85	2,303.47	2,560.43	1,337.87	6,271.62
Terengganu	53.66	966.73	463.10	739.38	2,222.87
Kelantan	63.33	1,293.64	67.34	216.07	1,640.38
Sabah	92.65	944.39	899.47	1,347.54	3,284.05
Sarawak	249.33	3,772.46	472.59	6,401.13	10,895.51
TOTAL	805.73	12,292.56	5,100.10	11,600.8	29,799.20

Source: National Register of River Basins, JPS – 2003

(2) The severity of flooding is aggravated by the following factors:

(i) Land clearing activities for agriculture and development resulting in higher stormwater discharge.

(ii) Urbanization of river catchment rendering higher imperviousness of ground surfaces resulting in higher stormwater runoff.

(iii) Increase in sediment loads in river channels from land clearing, construction and agriculture development, thereby reducing river channel storage and conveyance capacity.

(iv) Disposal of solid wastes into waterways choking-up river channels and impeding flow.

(v) Development on floodplains and encroachment into river reserves reducing river storage and conveyance capacity.

3.4.2 Flood Management Strategies

(1) Two approaches for mitigating floods:

(i) Structural measures (curative measures):

- River improvements works;
- Flood bunds, walls and flood proofing
- Flood detention dams;
- Flood detention ponds;
- Flood diversion channels; and
- Tidal barrages.

(ii) Non-structural measures (preventive measures):

- Integrated Flood Management (ISM)
- Floods risk zoning;
- Landuse zoning; and
- River basin management.

(2) Floodwater discharges in a river catchment if not intercepted by retention facilities, will be lost to the sea eventually. Floodwater, therefore, can contribute as a large source of water for various uses and users if it is captured by dams, ponds and lakes, etc. The Integrated Flood Management Plan (IFMP) thus should advocate multi-purpose flood mitigation dams and flood detention ponds with conjunctive uses for water supply, and hydro-electric power generation, where feasible.

(3) Flood management should entail components of:

- Flood forecasting and warning system;
- Participatory approach;
- Integrated land and water management;
- Water cycle management;
- Integrated hazard management strategies;
- Adopt environment enhancement;
- National flood management policy;

- Flood plain / river corridor management;

(4) Implementation of stormwater management based on MSMA.

(5) **Table 3.37** shows the flood management strategies framework that can be adopted.

Table 3.37 - Flood Management Strategies Framework

		Measures	Details of Measures	Administrative Organisation
Prevention of Inundation		**Control of flooding (maintenance of facilities for flood control)**	Widening of rivers and adjustment of river flows using dams and retarding basins.	River management (national and state governments)
		Safe ways of living	Restrictions and guidance on land usage (urbanization control areas, hazard maps)	River management. Local authorities.
		Inhibiting increases in flooding water	Development permits. Permits for rain water infiltration prevention activities.	State governments
Disaster limiting activities in cases of flooding (emergency responses)	Responsive action for emergencies	**Flood prevention activities**	Repairs of emergency facilities and provision of precise information. Responsive action to deal with scouring damage and leaking bunds.	River management. Flood prevention teams.
		Evacuation and rescue	Evacuation, rescue and provision of relief for residents	Local authorities. Organization of national and state governments, defense forces, etc.
	Responses implemented during normal periods	**Guidance and instructions to residents**	Dissemination of information regarding evacuation assembly points and evacuation routes. Dissemination of information regarding flood danger.	Local authorities. River management.
		Formulation of disaster prevention plans	Systemization of various implementations with assumption of flooding. Allocation of roles and clarification of responsibilities.	National and regional public organizations. Designated organizations, etc.
		Sustaining appropriate functions of facilities	Management with consideration for changes in river beds. Maintenance of evacuation assembly points.	River management. State and local governments.

Source: DID Manual Vol.1

3.5 RIVER SEDIMENTATION

(1) River sedimentation is caused by soil loading in river systems attributable to erosion of land surfaces that occur naturally or through man-induced activities such as land clearing for development purposes. Massive land movement such as slumps, landslides and mudflows are possible causes if massive uncontrolled deforestation and massive land clearance and movement are taking place in watersheds. The impacts include:

(i) Constriction of river channels that will cause flooding
(ii) Affecting river fauna and flora
(iii) Loss of navigation
(iv) Loss of storage in reservoirs
(v) Siltation of estuaries
(vi) Siltation at water intakes
(vii) Transportation of pollutants

(2) Industries and landuse as sources of sedimentation include:

(i) Agriculture industry

- Massive land clearing for plantation crops
- Highland farming

(ii) Mining Industry

(iii) Logging industry

Removal of tree covers and the construction of jungle tracks in steep area

(iv) Real estate Industry.

Main cause of sedimentation and deterioration of urban rivers.

(v) Sand Mining Industry

Excessive mining causes degradation of rivers leading to unstable river banks

(3) Remedial measures include:

(i) Catchment management
(ii) Dredging and/or hydro-siphoning
(iii) Check dams
(iv) Watershed conservation plan
(v) Watershed soil erosion plan
(vi) Controlled forestry activities

(vii) Conservation agricultural practices
(viii) Contouring trenching
(ix) Stream bank stabilization

3.6 RIVER TRANSPORTATION

3.6.1 Existing River Transportation

(1) The main users of rivers for river transportation are fishermen as reflected by the number of fisheries districts. Other user groups include commercial, passenger services, and recreational and tourism

(2) While inland river transportation has given way to other modes of transport in Peninsular Malaysia due to the well-developed land transport network of highways, roads and railways, the same cannot be said for the interior areas of Sabah and Sarawak. For example, Sg Rajang is a main lifeline into the interior heartlands of the State of Sarawak, and even in Kuching where water taxis ply the river to ferry tourists and people between villages and towns.

(3) There are more than 100 river basins in Peninsular Malaysia, and more than 50 river basins in Sabah and Sarawak combined. Some rivers begin within the upper catchment areas of the river basins and these generally constitute the major rivers of a basin for water extraction and flood control, while other minor/smaller rivers are in the lower reaches of river basins and are more influenced by tidal effects in the sea.

3.6.2 Impacts of River Transportation on River Regime

(1) The main impacts on river navigation include:

(i) Oil and grease spills/pollution; and

(ii) Erosion of riverbanks brought about by the wake of passing motorized boats.

(2) Recommendations for wider benefits including the promotion of safe and effective river transportation including:

(i) Phasing in and use of trash rakes for priority areas by 2015 once a detailed needs assessment study has been carried out; and

(ii) Deployment in a sustainable manner floating dredges to dispose of spoils to designated areas in order to mitigate or alleviate damage to navigable river corridors. Such deployment would be best conducted by the appropriate EIA procedural processes.

(3) **Table 3.38** summarises the existing navigable rivers in Malaysia.

Table 3.38 - Navigable Rivers in Malaysia

State	Navigable Rivers	Functions	Issues
Perlis	Sg Perlis Sg Baru Sg Sanglang	Centre for ferry service to Langkawi. Fisherman base	Navigation limited to 1km - 1.5km from rivermouth. Sedimentation affects draft.
Kedah	Sg Kedah Sg Jerlun Sg Yan Sg Merbok Sg Muda	Commercial & ferry service to Langkawi. Fisherman base at rivermouth & aquaculture farm users upstream. Small leisure crafts.	Upstream navigation limited by barrage (12km). Sedimentation at rivermouth.
Kedah (Langkawi)	Sg Melaka Sg Cenang	Local fisherman base & small crafts.	River crafts congestion and sedimentation
Pulau Pinang (mainland)	Sg Perai Sg Juru Sg Nipah Sg Ara	Riverine link between industrial land and the straits; also fishery use Fisherman base.	Limited navigation by tidal gate 8.5km upstream. River is generally shallow and limits safe navigation.
Pulau Pinang (island)	Sg Pinang Sg Air Hitam	Fisherman base	
Perak	Sg Perak Sg Dinding Sg Beruas Sg Tg. Piandang Sg Gula Sg Sangga Sg Larut Sg Batu Sg Lekir	Used for recreational, fishery and commercial purposes. Lumut Maritime terminal, commercial, ferry terminal to Pangkor and naval base Large fisherman base.	Navigation by commercial craft until Teluk Intan and small craft further upstream due to shallow water depths and sedimentation. Periodic maintenance dredging to maintain deep water depths. Periodic maintenance dredging to maintain water depths.
Selangor	Sg Kelang Sg Langat Sg Selangor Sg Sepang Kecil Sg Kapar Besar Sg Bagan Kajang Sg Besar Sg Sepang	Major ports, commercial shipbuilding, marina and jetties at the estuary of the river. Commercial shipbuilding, transhipment of raw material for Amsteel and fisherman base. Fisherman base at rivermouth & ecotourism (fire flies). Fisherman base.	Upstream navigation limited to small crafts due to low bridge headroom. Sedimentation at river estuary requires regular maintenance dredging. Rapid sedimentation and frequent maintenance dredging to maintain navigability. Navigable at high tide by fishing boats. Navigable at high tide by fishing boats.
FT Putrajaya	Putrajaya Lake	Recreational crafts	Nil
Negeri Sembilan	Sg Linggi Sg Lukut Sg Raya	Barter trade port, local fisherman base at rivermouth; upstream tourism & small crafts. Fisherman base	Nil

State	Navigable Rivers	Functions	Issues
Melaka	Sg Melaka Sg Umbai Sg Baru Sg Duyung Sg Merlimau	Used for recreational tourism and marina at rivermouth. Ferry to offshore island and fisherman base. Fisherman base near rivermouth.	Periodic maintenance dredging to maintain deep water depths. Sedimentation limits water depths for navigation.
Johor	Sg Muar Sg Batu Pahat Sg Pulai Sg Johor Sg Sebana Sg Mersing Sg Parit Jawa Sg Sarang Buaya Sg Senggarang Sg Rengit Sg Benut Sg Sedili Besar	Large fisherman base & small crafts. Barge terminal and fisherman base. Major port, marine police base, coal jetty for power plant and fisherman base. Minor port, fisherman base Marina. Fisherman base and ferry to Pulau Tioman and other islands. Fisherman base.	Upstream navigation limited until NSE bridge crossing (low headroom). Sedimentation requires periodic maintenance dredging to maintain navigability. Periodic maintenance dredging to maintain deep water depths for port use. Navigation at high tide only and limited to near rivermouth.
Pahang	Sg Endau Sg Pahang Sg Kuantan Sg Pontian Sg Rompin Sg Merchong Sg Nenasi Sg Beserah	Ferry terminal to Tioman and fisherman base. Fisherman base & river fishing. Fisherman base, commercial and small leisure crafts. Fisherman base.	Navigation and limited to near rivermouth at nearby road bridge limits headroom. Periodic maintenance dredging to maintain navigable water depths at rivermouth. Sedimentation limits water depths for navigation at rivermouth.
Terengganu	Sg Kemaman Sg Terengganu Sg Marang Sg Kerteh Sg Besut	Fisherman base, marine police base, offshore supply vessels. Commercial and fishing boats base, ferry terminal to offshore islands, Monsoon Cup base, traditional boat builders base. Fisherman base.	Upstream navigation limited until bridge crossing passable only to fisherman boats. Sedimentation requires periodic maintenance dredging to maintain navigability at rivermouth. Periodic maintenance dredging to maintain deep water depths for port use. Upstream navigation limited until bridge crossing 1.5km from rivermouth.

State	Navigable Rivers	Functions	Issues
Kelantan	Sg Golok Sg Kelantan Sg Semerak Sg Kemasin Sg Pengkalan Datu	Riverine transportation of goods and passengers between Malaysia and Thailand. Commercial, fishing boats base, marine police base, sand dredgers and recreational boats. Fisherman base and small shipyard. Fisherman base	Nil
Sarawak	32 with a combined length of 3,300km The main navigable waterways Batang Rajang, Batang Baram, Batang Lupar, Batang Kemena, Batang Limbang	Used by general cargo vessels, passenger express boats, fishing vessels, motor launchers, tugboats and barges and some other specialized crafts. Also numerous unlicensed crafts (long boats, wooden motor launches and outboard motor crafts) used by the rural dwellers.	Remarks : Sarawak is the only State which has a governing body pertaining to river transportation - Sarawak River Board.
Sabah	11 major rivers Sg Kinabatangan, Sg Inanam, Sg Tuaran, Sg Bandau, Sg Bongan, Sg Sugut, Sg Segama, Sg Kalumpang, Sg Tawau, Sg Umas–umas and Sg Kalabakan	Commercial (larger rivers only for CPO and logging) and fisherman base.	Nil

3.7 COASTAL ASPECTS

3.7.1 Impacts of Water Resources Development

(1) The coastline of Peninsular Malaysia is characterized into two distinct main characteristics. In the east coast, it consists of 860 km long, predominantly sandy beaches. The west coast is 1,100 km long comprising low elevation coastal plains dominated by muddy sediments. There are few sandy beaches in the west coast, where pocket beaches are found between rocky headlands. The Sarawak coastline of about 1,040 km long generally consists of sandy beaches in the north-eastern half, whilst the south-western half consists of mangrove-fringed muddy shores. Sabah has a long coastline of approximately 1,500 km in length, mostly rugged and sheltered by

numerous off-shore islands and coral reefs, with numerous bays. Sandy beaches are found along the western coast whilst muddy coasts dominate along the north-eastern and south-western coast.

(2) The impacts of water resources development on river outlets and adjacent coastline include the following:

(i) Any proposed development works in rivers involving water impoundment and regulated river flow either by the construction of dams or barrages will have impacts on the coastal ecosystem.

(ii) The extent of the impacts will depend on the extent of areas affected by storage dams constructed in river catchments to the overall total river catchment area, along with bed material characteristics, flood discharge and the extent of river sediment contribution to the overall sediment budget.

3.7.2 Recommendations in Relation to Policy and Legislation

(1) Two primary recommendations are proposed in relation to the coastal aspects for water resources management. These are firstly, EIA conditions should include the requirement for post-construction monitoring. Secondly, ISMP program should continue to be implemented for the remaining regions of Malaysia where it is not yet promulgated.

(2) **Table 3.39** summarises the coastal profiles for the various States.

Table 3.39 – Coastal Profiles for States

State	Shoreline	Coastal Type	Major Coastal Outlets	Existing Dams/Barrages & Significant Impacts	Existing Significant Issues
Perlis	20km	Mangrove fringed	Sg Perlis Arau Canal	Constant dredging at rivermouth Saline intrusion 15km	Sedimentation at port entrance affecting river navigation.
Kedah	85km (mainland)	Mangrove fringed	Sg Kedah Sg Merbok Sg Muda	2 Dams and 1 Barrage Saline Intrusion 12km Dredging at Rivermouth necessary 2 Dams and 1 Barrage Saline Intrusion 10km	Sedimentation at port entrance affecting river navigation.
	99 islands including Langkawi	Mangrove fringed & rocky outcrop with pocket beaches			

State	Shoreline	Coastal Type	Major Coastal Outlets	Existing Dams/Barrages & Significant Impacts	Existing Significant Issues
P Pinang	57km (mainland)	Mangrove fringed	Sg Perai Sg Juru Sg Junjung Sg Jawi Sg Kerian Sg Muda	1 Dam & 1 Barrage Saline intrusion 8.5km (see Kedah above)	WQ but improving.
	80km (island)	Mangrove fringed & rocky outcrop with pocket beaches	Sg Pinang Sg Relau Sg Keluang Sg Kongsi	2 Dams	WQ pollution problem.
Perak	174km	Mangrove fringed	Sg Kurau Sg Perak Sg Bernam	4 Dams Saline intrusion 50km	
Selangor	200km	Mangrove fringed	Sg Bernam Sg Selangor Sg Klang Sg Langat	1 Headworks 2 Dams Saline intrusion 25km 2 Dams 2 Dams Saline intrusion 90km	Some WQ issues & sedimentation at rivermouth due to intensive urban landuse.
Negeri Sembilan	50km	Mangrove fringed, sandy beaches at Port Dickson	Sg Linggi Sg Lukut	2 Dams Saline intrusion 20km	
Melaka	73km	Sandy beach (north) mangrove fringe (south)	Sg Melaka Sg Kesang	2 Dams & 1 Barrage Saline intrusion 5km 1 Barrage	Extensive reclamation being carried out.
Johor	436km	Mangrove fringe (west), pocket beaches and rock outcrop (east)	Sg Kesang Sg Muar Sg Batu Pahat Sg Benut Sg Pontian Sg Pulai Sg Johor Sg Sedili Besar Sg Mersing Sg Endau	1 Barrage 1 Dam Saline intrusion 60km 2 Dams Saline intrusion 40km 1 Dam 2 Dams Saline intrusion 70km Saline intrusion 80km	Severe erosion at Tg. Piai coastal areas. Sedimentation at kuala Sg Mersing affects river navigation.
Pahang	202km	Hook shape bays (north) & sandy beaches (south)	Sg Rompin Sg Bebar Sg Kuantan Sg Pahang Pulau Tioman + numerous small islands	1 Dam & 1 Barrage Saline intrusion 25km Saline intrusion 25km	Dynamic sandbars formation at rivermouth affect river navigation - rivermouth training structures being built.

State	Shoreline	Coastal Type	Major Coastal Outlets	Existing Dams/Barrages & Significant Impacts	Existing Significant Issues
Terengganu	228km	Sandy beaches (north) & hook shape bays (south)	Sg Kemaman Sg Kerteh Sg Paka Sg Dungun Sg Marang Sg Terengganu Sg Setiu Sg Besut	Saline intrusion 25km Saline intrusion 20km 1 Dam Saline intrusion 25km 1 Barrage, 1 Headworks	Maintenance dredging at Sg Kerteh, Sg Dungun, Sg Merchang, Sg Marang, Sg Terengganu and Sg Merang and more recently Sg Kemaman for navigation. Severe erosion north of airport beach.
Kelantan	48km	Sandy beaches	Sg Kelantan Sg Kemasin Sg Semerak Sg Golok	Saline intrusion 20km	Maintenance dredging at Sg Kelantan and Sg Pengkalan Chepa at Kuala Pak Amat for navigation. Severe erosion at PCB beach.
Sarawak	1,040km	Generally straight sandy beaches Predominantly mangrove fringed with many river estuaries and low lying deltas and large bays	Sg Kayan Sg Sarawak Sg Samarahan Sg Sadong Sg Lupar Sg Saribas Sg Krian Sg Rajang Sg Oya Sg Mukah Sg Balingian Sg Tatau Sg Kemena Sg Similajau Sg Suai Sg Niah Sg Sibuti Sg Baram Sg Limbang Sg Lawas Sg Miri	1 Barrage at Sg Sarawak and saline intrusion 50km to 150km upriver	

State	Shoreline	Coastal Type	Major Coastal Outlets	Existing Dams/Barrages & Significant Impacts	Existing Significant Issues
Sabah	1,500km	Irregular and mostly mangroved fringed with isolated sandy beaches	Sg Tawau Sg Balung Sg Kalabakan Sg Kalumpang Sg Sapulut Sg Mengalung Sg Lakutan Sg Sagama Sg Padas Sg Kinabatangan Sg Papar Sg Labuk Sg Moyog Sg Tungud Sg Tuaran Sg Sugut Sg Kadamaian Sg Bongan Sg Bengkoka		
FT Labuan	48km + 6 smaller islands				Erosion on the northeast & eastern coast

3.8 WATER RESOURCES DEVELOPMENT

(1) Presently only surface water is developed in a major way as the information with regard to rainfall and streamflow are available for all major river basins. While ground water is developed in some ways, its resource in the form of water availability in the various under ground aquifers are basically unknown in contrast with surface water where the river basins are equipped with rainfall, evaporation and streamflow stations and hence information is abundant. Other forms of alternative water resource likewise are not determinable as they are dependent on the level of development, as in the case of recycled sewerage, the extent of which is indeterminate.

(2) Hence, until the quantity of ground water and alternative water resources can be determined within a level of confidence, they are presently at a stage where they cannot be included in the overall water resource planning and development.

(3) Surface water resource development is hence the focus of the study until more definitive data are obtained from the other water resources.

(4) There are about 189 river basins in Malaysia. The exact number of river basin are not known due to numerous small river basins that discharges direct into the sea. Very often they are lumped together as a single group of river basins.

(5) The water resources of the State is analysed at the point of interest; defined as the location where the quantity of water is available for use. The point of interest has been suggested to be the respective river basins. However after much deliberation, the point of interest has been chosen in favour of river basins to be at the intake points of WTPs or irrigation headworks due to the following reasons:

(i) River basin is defined as the area drained by the river and its tributaries from its headwater to estuary meeting the sea. Deriving the water resource at the estuary would not reflect the actual water availability of the river basin as the river is subject to saline intrusion until the end of the salinity wedge, which could be a few kilometres upstream.

(ii) Due to pollution, river yields would be realisable only up to the point where the water quality is acceptable for use of treatment for potable water or irrigation.

(iii) River yields vary along river reaches and it is only at the intake points that the yields are relevant. To derive a yield at the river mouth, which encompasses the upstream basin areas would give misleading indication of the actual amount of water resources availability of the river basin.

(6) As such, the point of interest in the water resources simulation is the raw water intake points. For presentation, the intake points will be arranged accordance with the river and the river basin.

(7) The water resources are also defined by the acceptable risk. For water resources purposes it can be considered to comprise to two parts for the various water demand sectors, namely:

(i) Run-of-river flows normally accepted as the 7-day low flow with the design risk of 2% (1 in 50-year drought) for potable water supply and 20% (1 in 5-year drought) for paddy irrigation.

(ii) Regulated flow from a storage dam or a series of dams with design risk of 2% for potable water supply and 20% for paddy irrigation.

3.8.1 Water Resources Simulation

(1) The objectives of the water resources simulation are to:

(i) Identify the water resources availability in the country on a state-by-state basis.

(ii) Develop improvement works to meet water demand (This is done by comparing the yields of the various water resources such as rivers, dams, etc on an apple-to-apple basis).

(2) The tool used for thi was Hec_ResSim, a water resources computer simulation model developed by the Hydrologic Engineering Center of the US Army Corps of Engineers.

(3) Water resources can be divided into resources for potable water supply, irrigation, agriculture, hydroelectricity and environmental flows. Hydroelectricity is dealt with in another section. Environmental flows have been assumed to be 10% of the mean annual flow though this will have to be ascertained during the Environmental Impact Assessment stage of the water resources development.

3.8.2 Water Resources of Perlis

(1) The Sg Perlis is the only major river basin in the state.

(2) The main dam in Perlis is the Timah Tasoh dam. The present storage capacity of the dam is 33 MCM but it is currently being raised to 70 MCM. Once the dam is raised to storage of 70 MCM, then 100% of the first year crops can be supplied with water during the 1 in 5-year drought. The simulation runs assumed that the demand for potable water supply (205.7 Mld in the year 2050) was satisfied before the allocation for irrigation was made.

3.8.3 Water Resources of Kedah

(1) There are 3 major river basins in Kedah, namely, Sg Kedah, Sg Muda and Sg Merbok. Sg Muda and Sg Merbok has been exploited to a large extend for irrigation.

(2) There are total of six existing dams in Kedah State, comprising Muda Dam, Pedu Dam, Ahning Dam, Beris Dam, Padang Saga Dam and Malut Dam. These dams are mainly for irrigation and potable water supply to the whole State. In 2010, the Integrated Water Resources Study for the Northern States recommended additional dams (Sari Dam, Tawar-Muda Dam, Padang Gaong Dam, Naok Dam, Reman Dam, raising of Mengkuang dam) to augment water resources on Kedah as well as in Perlis and Pulau Pinang.

(3) Irrigation requirements were taken account after deducting the yields from the various water treatment plants. With the additional dams proposed, the irrigation water requirements can be met for the first 2 years of the 1 in 5-year ARI design drought but in the 3rd year, there will be a shortfall of 20% in the water needed.

3.8.4 Water Resources of Pulau Pinang

(1) There are 3 main river Basins in Pulau Pinang, namely, Sg Pinang, Sg Juru and Sg Perai. They are located on the mainland. The river basins in the island are small.

(2) There are six existing dams in Pulau Pinang supplying potable water to the State. Air Itam Dam and Teluk Bahang Dam are in the Pulau Pinang Island while the rest of the

dams (Mengkuang Dam, Bukit Pancur Dam, Cherok Tok Kun Dam, Bukit Berapit Dam) are located in Seberang Prai.

(3) The 2050 annual irrigation water demand for Pulau Pinang is 245 MCM and the potable water demand is 600 MCM (1633 Mld). Currently the main source of water for Pulau Pinang is the Sg Dua treatment plant, which obtains its water from Sg Muda. With the additional Tawar Muda Dam, Naok Dam, Sari Dam and Reman Dam and the proposed raising of Mengkuang Dam in the system, the yield at Sg Dua WTP will be increased from 470 Mld to 900 Mld, slightly more than the present plant capacity of 886 Mld. Therefore, the Sg Dua WTP is not recommended for future expansion.

(4) The overall system yield also increases from 1,210 Mld to 2,060 Mld. Nevertheless, with the increase demand in the year 2050, there is still a deficit of about 70 MCM (194 Mld). The Sg Perak Transfer Scheme recommended in the Pulau Pinang Water Resource Master Plan Study (2009 Master Plan) would be the most feasible scheme to be implemented to meet the future water demand of Pulau Pinang. The scheme when implemented will be able to provide an additional 1,000 Mld to meet the Pulau Penang water demand until year 2050.

(5) The proposed Raising of Mengkuang Dam, Tawar Muda Dam should be implemented immediately to relieve the present water stress in Pulau Pinang.

3.8.5 Water Resources of Perak

(1) There are 4 main river basins in Perak, namely, Sg Perak, Sg Kerian, Sg Kurau and Sg Bernam. Sg Perak ios the largest river basin.

(2) Excluding the hydroelectric dams, which are dealt with in another section, there are three existing dams in Perak; Sultan Azlan Shah Dam (formerly called "Kinta Dam"), Kuning Dam and Bukit Merah Dam. There are three other dams being proposed; Raya Dam, Nyior Dam and Ijok Dam.

(3) Potable water supply requirements in Perak can be met by the four potable water supply dams, i.e. Sultan Azlan Shah Dam, Kuning Dam, Raya Dam and Nyior Dam, and from run-of-river systems.

(4) Bukit Merah and Ijok dams are both dual-purpose, i.e. for both water supply and irrigation. These dams can supply all the potable and water supply requirements in their respective demand areas by the year 2050. Ijok Dam is required now but may not be necessary in the future as irrigation requirements in the year 2050 are projected to be less than the present irrigation requirements.

3.8.6 Water Resources of Selangor

(1) There are 7 main river basins in Selangor, namely, Sg Bernam, Sg Tengi, Sg Selangor, Sg Buloh, Sg Klang, Sg Langat and Sg Sepang. Only the Sg Klang, Sg Selangor and Sg Langat has been exploited to a large extend.

(2) There are seven existing dams in Selangor, which are Langat, Semenyih, Klang Gates, Batu, Subang, Tinggi and Selangor. They are all used for potable water supply, except for Batu Dam, which is dual-purpose for water supply and flood mitigation. The total reliable yield from these dams is 4,105 Mld and the existing run-of-river yields are totaled 1,41.7 Mld

(3) With improvement works, the additional yields are as shown in the table below:

Table 3.40 - Summary of the Additional Yields for Water Supply Systems

	Existing / Proposed Source Works	Additional Yield (Mld)	Cumulative Net Reliable Yield (Mld)
1.	Total existing water source	-	4246
2.	Labu Off-River Storage Reservoir	105*	4351
3.	BRH WTP (Booster Pumping Station)	25	4376
4.	Upgrading of Batu Dam and Pumped Raw Water Transfer from Batu Flood Detention Pond to Batu Dam	129	4505
5.	Interbasin Transfer from Sg Bernam (Stage 1a)	216	4721
6.	Pahang-Selangor Raw Water Transfer and Langat 2 (Phase 1)	1130*	5851
7.	Interbasin Transfer from Sg Bernam (Stage 1b)	163	6014
8.	Langat 2 (Phase 2)	760*	6774
9.	Interbasin Transfer from Sg Bernam (Stage 2)	879	7653

3.8.7 Water resources of Negeri Sembilan

(1) There are 5 main river basins in Negeri Sembilan, namely, Sg Muar river basin, Sg Triang river basin, Sg Linggi river basin, Sg Rembau river basin and Sg Broga river basin.

(2) There are five existing dams in Negeri Sembilan; namely Terip, Kelinchi, Upper Muar, Gemencheh and Beringin/Pedas, with another two under construction; namely Triang and Batu Hampar dams. They are all used for water supply. The regulated yield from these dams is 890 Mld while run-of-river systems cater an additional yield of 136 Mld, providing enough water requirements for Negeri Sembilan.

3.8.8 Water Resources of Melaka

(1) There are 2 main river basins in Melaka, namely, Sg Melaka and Sg Kesang.

(2) There are three existing dams in Melaka, i.e. Jus, Durian Tunggal and Asahan, with an additional Batang Melaka Dam being proposed.

(3) There are two main river basins that contribute to the flows in Melaka, i.e. Sg Melaka and the Sg Kesang. The existing dams on Sg Melaka (Jus and Durian Tunggal) have large storage capacity but in small catchment areas. For this reason, it is recommended that excess flows in the Sg Kesang system be pumped to the dam on Sg Melaka. Without pumping, the regulated yield from all the four dams is 171 Mld. With pumping, the yield will be increased to 455 Mld. If the run-of-river yields are factored in, the total yield from the Melaka rivers is 540 Mld. Any deficits would have to be made up by an inter-state transfer from Johor through the Sg Muar system.

3.8.9 Water Resources of Johor

(1) There are 10 main river basins in Johor, namely Sg Kesang, Sg Muar, Sg Batu Pahat, Sg Benut, Sg Pontian, Sg Pulai, Sg Johor, Sg Sedili Besar, Sg Mersing and Sg Endau.

(2) There are presently 15 existing dams in Johor, namely Gunung Ledang,Juaseh, Lower Pengkalan Bukit, Upper Pengkalan Bukit, Bekok, Semberong, Macap, Pontian Kecil, Gunong Pulai, Linggiu, Lower Layang, Upper Layang, Lebam, Congkok, Labong) and another 11 dams are proposed (Jengeli, Lebak, Sayong, Seng Heng, Seluyut, Ulu Sedili Besar, Merek, Segamat, Meda, Kahang and Mersing. These dams are all used for potable water supply.

(3) The 50-year ARI (2%) yields of the water supply systems is 7,315 Mld comprising run-of-river yields of 326 Mld, regulated yields of 6,611 Mld and direct supply yields of 378 Mld.

3.8.10 Water resources of Kelantan

(1) There are 4 main river Basins in Kelantan, namely, Sg Kelantan, Sg Golok, Sg Kemasin and Sg Semarak.

(2) There is only one existing water supply dam in Kelantan, that is Bukit Kwong Dam supplying irrigation water to the Rantau Panjang irrigation scheme (this excludes the hydroelectricity and flood mitigation dams).

(3) The water resources simulation results show that there is no need for additional dam for water supply or irrigation and that the run-of-river yield and groundwater sources are able to cater for Kelantan's potable water supply needs.

3.8.11 Water Resources of Terengganu

(1) There are 8 main river Basins in Terengganu, namely Sg Kemaman, Sg Kerteh, Sg Paka, Sg Dungun, Sg Marang, Sg Terengganu, Sg Setiu and Sg Besut.

(2) Excluding the hydroelectricity dams, there is one multi-purpose dam, i.e. Paya Peda Dam in Terengganu, which is presently under construction. The dam is to be used for both potable water supply (260 Mld) and irrigation. During the 1 in 50-year ARI

drought, in the year 2050, there will be not enough water to supply both irrigation and potable water supply need. In that case, part of the irrigation scheme be supplied by the dam (the Angga Canal Irrigation Scheme would have to be abandoned during the second and third year of the drought.) The run-of-river schemes for the rest of Terengganu account for 1,056 Mld.

3.8.12 Water Resources of Pahang

(1) There are 6 main river Basins in in Pahang, namely, Sg Pahang, Sg Kuantan, Sg Bebar, Sg Merchong, Sg Rompin and Sg Endau. Sg Pahang is the largest river basin in the state.

(2) There are three existing dams in Pahang, namely Chereh, Pontian and Anak Endau. The Chereh Dam is designed for potable water supply while Pontian and Anak Endau dams are multipurpose supplying both irrigation and potable water.

(3) Chereh Dam has a reliable yield of 1,859 Mld and is able to meet the Kuantan's projected water demands till after the year 2050. For the 1 in 5-year drought, besides the requirements of the existing Sepayang WTP and irrigation water demand for 886 ha of granary area, Pontian Dam is still capable to supply water for another extra 3,714 ha of irrigation scheme. During the 1 in 5-year drought, Anak Endau dam is unable to meet the irrigation water demand. The granary area will have to reduce to 1,500ha for Anak Endau dam to operate without fail during the 1 in 5-year drought.

(4) The potable water yields including run-of-river for Pahang is 2,977 Mld.

3.8.13 Water Resources of Sarawak

(1) Thetre are 22 major river basins in Sarawak, namely, Sg Lawas, Sg Trusan, Sg Limbang, Sg Baram, Sg Miri, Sg Sibuti, Sg Niah, Sg Buai, Sg Similajau, Sg Kemena, Sg Tatau, Sg Balingian, Sg Mukah, Sg Oya, Sg Rajang, Sg Kerian, Sg Saribas, Sg Lupar, Sg Sadong, Sg Sarawak, Sg Samarahan and Sg Kayan

(2) Due to the large expanse of land in Sarawak, it is proposed that for the purpose of water resources study, the State is divided into Regional Development Zones (RDZ) with each RDZ being supplied by a main / regional water supply scheme within the RDZ (more information on RDZs can be found in Volume 20 Sarawak State Report.) There are 16 RDZs and the proposed works are as follows:

RDZ 1 - Kuching: Construction of the proposed Bengoh Dam is currently on-going. The augmented flow is sufficient meet the water demands of the Kuching RDZ.

RDZ 2 - Serian: It is proposed that an off river storage be constructed.

RDZ 3 - Simunjan/Sebuyau: The run-of-river yields is adequate to meet the demands.

RDZ 4 - Sri Aman: A raw water transfer from Btg Lupar to Btg Undup is proposed. Bayai WTP can then abstract water from the transfer for treatment.

RDZ 5 - Batang Ai: The existing run-of-river yield is adequate to meet water demands.

RDZ 6 - Betong: An off river storage is proposed.

RDZ 7 - Saratok: A pumping scheme from the Sg Kerian is needed to fulfil the demands of this RDZ.

RDZ 8 - Sarikei: The on-going Gerugu dam will increase the yield to 140 Mld. The proposed Upper Sarikei dam should be constructed to give an additional 74 Mld. With this the total yield of raw water will be 214 Mld, enough to meet the requirements up to 2050.

RDZ 9 - Sibu: The run-of-river yields is adequate to meet the demands of this region.

RDZ 10 - Mukah: The run-of-river yields is adequate to meet the demands of this region.

RDZ 11 - Tatau: The proposed Jelai Dam should be built to increase the yield by 130 Mld. This will satisfy the demand for this region.

RDZ 12 - Kapit: The existing run-of-river yield is adequate to meet the demands.

RDZ 13 - Bintulu: The existing dams in the RDZ are Sika Dam and Assyakirin Dam. However the yields from these dams are insufficient to cater for the demands. A raw water transfer from Pandan to Samalaju and Bintulu is proposed to cater for the shortfall.

RDZ 14 - Miri: The existing run-of-river yields from Sg Liku is not sufficient. An inter-basin transfer scheme from Sg Bakong has been commissioned. Due to peaty soil in Sg Bakong, an alternative is proposed to transfer raw water from Btg Baram to Btg Bakong. This will increase the yield by 1,400 Mld, which should meet the demands of this RDZ.

RDZ 15 - Limbang: The existing run-of-river yield is adequate to meet the demands.

RDZ 16 - Lawas: The existing run-of-river yield is adequate to meet the demands.

3.8.14 Water Resources of Sabah

(1) There are 25 major river basins in Sabah, namely Sg Pensiangan, Sg Serudong, Sg Kalabakan, Sg Brantian, Sg Umas Umas, Sg Merotai Besar, Sg Tawau, Sg Kalumpang, Sg Silibukan, Sg Segama, Sg Kinabatangan, Sg Segaliud, Sg Labuk, Sg Sugut, Sg Paitan, Sg Bengkoka, Sg Bongan, Sg Kadamaian, Sg Tuaran, Sg Putatan, Sg Papar, Sg Kimanis, Sg Membakut, Sg Padas and Sg Lakutan. Sg Kinabatangan being the largest river basin.

(2) Excluding the hydroelectric dams, there are presently seven existing dams in Sabah; namely Babagon, Pinangsoo, Sepagaya, Timbangan, Telibung2, Milau, Betotan. There are eight dams being proposed; namely Bongol, Kaiduan, Tawau, Balung, Merotai Besar, Kawag, Malati, and Kadamaian Dams. The existing dams are all used for potable water supply with the exception of Babagon Dam, which is a dual-purpose dam for both water supply and flood mitigation. The proposed dams are all for potable water supply with the exception of Kadamaian Dam, which is to be used for both potable water supply and irrigation.

(3) The proposed potable water supply dams are all in the pre-feasibility stage providing insufficient details for a meaningful water resource simulation at this master plan study.

(3) The regulated yields from the dams for potable water supply are 302 Mld. In the year 2050, the proposed Kadamaian dam can only meet the requirements for 91% and 95% of the water needed for the off-season and main season crops respectively during the first year of a 1 in 5 year ARI drought.

3.8.15 Water Resources of FT Labuan

(1) The Sg Benuwa is the major basib in FT Labuan.

(2) There are three existing dams in FT Labuan, i.e. Bkt Kuda, Kerupang and Pagar Dams. In addition, three submarine pipelines are proposed from Sg Padas at Beaufort, Sabah. This will increase the amount of water supplied to FT Labuan by 114 Mld.

3.9 DEVELOPMENT WORKS FOR POTABLE WATER SUPPLY

(1) The potable water supply projects until 2050 is proposed as follows:

(i) A total of 326 Source Works and Water Supply System costing RM 42.07 billion has been proposed to meet the potable water demands from 2010 to 2050 by States, see **Table 3.41**. Each Water Supply System comprises a water treatment plant, transmission reservoirs and bulk transmission mains in part or in full.

(ii) Out of RM 42.07 billion, RM 7.7 billion is proposed for source works comprising dams, off-river bunded storages, barrages and low weirs. Some of the projects are already funded by the regional development corridor authorities and such projects are not included in the costing.

(iii) The scheduling of projects over the planning period 2010 to 2050 is given in **Table 3.42** while the project listing is shown in **Table 3.43.**

(2) The immediate Water Supply Works for implementation in RMK10 is summarised below:

(i) A total of 168 projects comprising source works and water supply systems is proposed with a total cost of RM 24.5 billions as shown in **Table 3.44** and **Table 3.45.**

State	Connected Services, IWK, kg.BOD/d	Connected Services, Non-IWK, kg.BOD/d	ISTs, kg.BOD/d	Pour Flush, kg.BOD/d	TOTAL kg.BOD/d
Selangor, FT Kuala Lumpur, FT Putrajaya	97,536	20,379	15,036	3,149	136,100
Negeri Sembilan	9,524	2,019	4,727	6,219	22,489
Melaka	6,486	9,199	4,448	2,212	22,345
Johor	27,672	13,765	15,601	11,776	68,815
Perlis	199	701	1,005	2,681	4,586
Kedah	6,388	4,153	11,669	21,189	43,398
Pulau Pinang	24,176	5,695	870	7,936	38,676
Perak	15,096	8,367	14,243	12,173	49,879
Pahang	3,633	8,238	4,945	16,367	33,182
Terengganu	821	3,099	1,596	17,251	22,768
Kelantan	0	10,787	5,518	13,731	30,036
FT Labuan	480	1,500	351	326	2,657
Sabah	0	24,519	N/A	N/A	24,519
Sarawak	0	6,155	25,400	N/A	31,555
TOTAL	**192,011**	**118,574**	**105,410**	**115,010**	**531,005**

Table 3.41 - Proposed Projects until 2050

State	Additional WTP Capacity Mld	Number of Projects	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
Perlis	25.0	1	-	31.3	15.0	25.0	71.3
Kedah	1,103.0	28	328.0	1,378.8	661.8	1,103.0	3,471.6
Pulau Pinang	800.0	7	348.0	1,000.2	480.0	800.0	2,628.2
Kelantan	928.4	51	-	1,161.7	557.0	928.4	2,647.1
Terengganu	704.7	23	-	881.0	422.8	704.6	2,008.4
Pahang	435.3	10	-	86.3	41.4	69.0	196.7
Perak	770.0	33	840	962.5	462.0	770.0	3,034.5
Selangor	3,623.0	13	1,843.5	1,642.5	831.6	1,694.0	6,011.6
Negeri Sembilan	33.0	2	-	41.3	19.8	33.0	94.1
Melaka	860.0	8	327.0	562.7	270.0	450.0	1,609.7
Johor	1,271.6	29	1,515.0	1,552.9	709.6	1,374.7	5,152.2
Sabah	1,708.0	64	1,795.0	2,796.8	1,398.4	2,097.6	8,087.8
FT Labuan	20.0	1	-	32.0	16.0	50.0	98.0
Sarawak	2,191.0	56	708.0	2,410.1	1,215.5	2,629.2	6,962.8
Malaysia	**14,473**	**326**	**7,705**	**14,540**	**7,101**	**12,729**	**42,074**

Table 3.42 - Project Implementation Schedule until 2050

Commissioning years	WTP capacity MLD	No of Projects	Project Costs (RM million)				
			Source Works	Water Treatment Plant	Reservoirs	Bulk Distribution Mains	Total
2010-2015	5,907	128	4,631	5,001	2,454	4,623	16,709
2016-2020	2,166	59	856	2,375	1,171	2,116	6,518
2021-2025	1,262	33	413	1,622	780	1,321	4,136
2026-2030	1,950	31	256	1,568	756	1,341	3,920
2031-2035	923	25	348	1,209	584	976	3,118
2036-2040	1,885	38	1,201	2,291	1,127	1,972	6,592
2041-2045	380	12	-	475	228	380	1082
2046-2050	-	-	-	-	-	-	-
Total	**14,473**	**326**	**7,705**	**14,540**	**7,101**	**12,729**	**42,074**

Table 3.43 – Project List and Costing for Development Works until 2050

Scheme	WTP Capacity Mld	Year of Commission	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
Perlis							
Upgrading Timah Tasoh WTP	25	2012	-	31.25	15	25	71.25
Total Perlis	**25**	**-**	**-**	**31.25**	**15**	**25**	**71.25**
Kedah							
Northern Kedah							
Pelubang WTP Upgrading	60	2012	-	75	36	60	171
New Bukit Pinang WTP Phase II	100	2012	-	125	60	100	285
Bukit Jenun Baru WTP Upgrading	25	2012	-	31.25	15	25	71.25
Jeneri WTP Upgrading	25	2012	-	31.25	15	25	71.25
New Bukit Jenun Baru WTP Phase II	25	2012	-	31.25	15	25	71.25
New Pelubang WTP Phase II	20	2016	-	25	12	20	57
New Bukit Pinang WTP Phase III	40	2018	-	50	24	40	114
New Bukit Jenun Baru WTP Phase III	25	2019	-	31.25	15	25	71.25
Pelubang WTP Phase II Upgrading	20	2025	-	25	12	20	57
Tawar – Muda Dam (110 MCM)	-	2015	282	-	-	-	282
Sari Dam (54 MCM)	-	2015	26	-	-	-	26
Reman Dam (283 MCM)	-	2020	20	-	-	-	20
Total (Northern Kedah)	**340**	**-**	**328**	**425**	**204**	**340**	**1297**
Central Kedah							
Bukit Jenun Baru WTP Upgrading	130	2012	-	162.5	78	130	370.5
New Air Sg Petani WTP Phase II	55	2015	-	68.75	33	55	156.75
New Air Sg Petani WTP Phase III	55	2025	-	68.75	33	55	156.75
Batu 5 WTP Upgrading	10	2035	-	12.5	6	10	28.5
New Air Sg Petani WTP Phase IV	55	2040	-	68.75	33	55	156.75
Total (Central Kedah)	**305**	**-**	**-**	**381.25**	**183**	**305**	**869.25**
Southern Kedah							

Scheme	WTP Capacity Mld	Year of Commission	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
Mahang WTP Upgrading	10	2012	-	12.5	6	10	28.5
Kulim Hi-Tech WTP Upgrading	150	2012	-	187.5	90	150	427.5
Bikan WTP Upgrading	3	2012	-	3.75	1.8	3	8.55
Sg Limau WTP Upgrading	20	2015	-	25	12	20	57
New Kulim Hi-Tech WTP Phase II	35	2021	-	43.75	21	35	99.75
New Baling 2 WTP	20	2027	-	25	12	20	57
New Kulim Hi-Tech WTP Phase III	35	2032	-	43.75	21	35	99.75
Kulim Hi-Tech WTP Phase III Upgrading	35	2041	-	43.75	21	35	99.75
Total (Southern Kedah)	**308**	-	-	**385**	**184.8**	**308**	**877.8**
Langkawi							
New Sg Baru WTP Phase II	50	2012	-	62.5	30	50	142.5
New Sg Baru WTP Phase III	50	2019	-	62.5	30	50	142.5
New Sg Baru WTP Phase IV	50	2040	-	62.5	30	50	142.5
Total (Langkawi)	**150**	-	-	**187.5**	**90**	**150**	**427.5**
Total Kedah	**1103**		**328**	**1378.75**	**661.8**	**1103**	**3471.5**
Pulau Pinang							
Sg Perak Transfer Scheme (800 Mld)	-	2014	348	-	-	-	348
Sg Kerian WTP Phase 1 Stage 1	125	2014	-	156.3	75	125	356.3
Sg Kerian WTP Phase 1 Stage 2	200	2017	-	250	120	200	570
Sg Kerian WTP Phase 2	125	2022	-	156.3	75	125	356.3
Sg Kerian WTP Phase 3	125	2029	-	156.3	75	125	356.3
Sg Kerian WTP Phase 4	125	2036	-	156.3	75	125	356.3
Sg Kerian WTP Phase 5	100	2044	-	125	60	100	285
Total Pulau Pinang	**800**	-	**348**	**1000.2**	**480**	**800**	**2628.2**
Kelantan							
Kota Bahru							
Merbau Chondong	25	2012	-	31.3	15	25	71.3
Pintu Geng	20	2012	-	25	12	20	57

Scheme	WTP Capacity Mld	Year of Commission	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
Tg Mas	20	2015	-	25	12	20	57
Pintu Geng	15	2017	-	18.8	9	15	42.8
Aur Duri (Tunjung)	50	2018	-	62.5	30	50	142.5
Merbau Chondong	60	2024	-	75	36	60	171
Merbau Chondong	30	2032	-	37.5	18	30	85.5
Merbau Chondong	60	2036	-	75	36	60	171
Aur Duri (Tunjung)	50	2044	-	62.5	30	50	142.5
Total (Kota Bharu)	**330**	-	-	**412.6**	**198**	**330**	**940.6**
Bachok							
Kg Chap	8	2012	-	10	4.8	8	22.8
Aur Duri(Tunjung)	10	2018	-	12.5	6	10	28.5
Kg Chap	15	2024	-	18.8	9	15	42.8
Aur Duri(Tunjung)	20	2033	-	25	12	20	57
Total (Bachok)	**53**	-	-	**66.3**	**31.8**	**53**	**151.1**
Machang							
Merbau Chondong	15	2014	-	18.8	9	15	42.8
Merbau Chondong	15	2024	-	18.8	9	15	42.8
Merbau Chondong	15	2036	-	18.8	9	15	42.8
Total (Machang)	**45**	-	-	**56.4**	**27**	**45**	**128.4**
Pasir Puteh							
Wakaf Bunut	8	2011	-	10	4.8	8	22.8
Merbau Chondong	15	2014	-	18.8	9	15	42.8
Merbau Chondong	15	2024	-	18.8	9	15	42.8
Merbau Chondong	15	2036	-	18.8	9	15	42.8
Wakaf Bunut	7.5	2045	-	9.4	4.5	7.5	21.4
Total (Pasir Puteh)	**60.5**	-	-	**75.8**	**36.3**	**60.5**	**172.6**
Tumpat							
Wakaf Baru	8	2012	-	10	4.8	8	22.8
Kelar	15	2012	-	18.8	9	15	42.8
Kelar	20	2017	-	25	12	20	57
Kelar	20	2025	-	25	12	20	57
Kelar	20	2034	-	25	12	20	57
Kelar	20	2043	-	25	12	20	57
Total (Tumpat)	**103**	-	-	**128.8**	**61.8**	**103**	**293.6**
Pasir Mas							
Kelar	23.9	2012	-	29.9	14.3	23.9	68.1
Kelar	25	2017	-	31.3	15	25	71.3
Kelar	25	2025	-	31.3	15	25	71.3
Kelar	25	2034	-	31.3	15	25	71.3
Kelar	20	2043	-	25	12	20	57
Total (Pasir Mas)	**118.9**	-	-	**148.8**	**71.3**	**118.9**	**339**
Tanah Merah							

Scheme	WTP Capacity Mld	Year of Commission	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
Bt. Remah	15	2012	-	18.8	9	15	42.8
Bt. Remah	10	2017	-	12.5	6	10	28.5
Bt. Remah	10	2023	-	12.5	6	10	28.5
Bt. Remah	10	2028	-	12.5	6	10	28.5
Bt. Remah	10	2034	-	12.5	6	10	28.5
Bt. Remah	10	2040	-	12.5	6	10	28.5
Total (Tanah Merah)	**65**	-	-	**81.3**	**39**	**65**	**185.3**
Jeli							
Jeli 2 (New)	7	2015	-	8.8	4.2	7	20
Jeli 2 (New)	7	2023	-	8.8	4.2	7	20
Jeli 2 (New)	7	2034	-	8.8	4.2	7	20
Jeli 2 (New)	7	2042	-	8.8	4.2	7	20
Total (Jeli)	**28**	-	-	**35.2**	**16.8**	**28**	**80**
Kuala Krai							
Pahi	20	2012	-	25	12	20	57
Kg Tualang	15	2018	-	18.8	9	15	42.8
Kg Tualang	15	2029	-	18.8	9	15	42.8
Kg Tualang	15	2040	-	18.8	9	15	42.8
Total (Kuala Krai)	**65**	-	-	**81.4**	**39**	**65**	**185.4**
Gua Musang							
Chiku	10	2012	-	12.5	6	10	28.5
Ketil	15	2018	-	18.8	9	15	42.8
Bertam Bharu	10	2027	-	12.5	6	10	28.5
Felda Aring	10	2035	-	12.5	6	10	28.5
Limau Kasturi	15	2041	-	18.8	9	15	42.8
Total (Gua Musang)	**60**	-	-	**75.1**	**36**	**60**	**171.1**
Total Kelantan	**928.4**	-	-	**1,161.70**	**557.00**	**928.40**	**2,647.1**
Terengganu							
Besut							
Bt Bunga	13.2	2032	-	16.5	7.9	13.2	37.6
Bt Bunga	10	2044	-	12.5	6	10	28.5
Total (Besut)	**23.2**	-	-	**29**	**13.9**	**23.2**	**66.1**
Kemaman							
Bt Sah	162	2012	-	202.5	97.2	162	461.7
Bt Sah	70	2018	-	87.5	42	70	199.5
Kg Cherul	15	2028	-	18.8	9	15	42.8
Bt Sah	45	2032	-	56.3	27	45	128.3
Bt Sah	40	2041	-	50	24	40	114
Total (Kemaman)	**332**	-	-	**415.1**	**199.2**	**332**	**946.3**
Dungun – Ketengah							
Serdang	23.1	2018	-	28.8	13.8	23	65.6
Serdang	11	2025	-	13.8	6.6	11	31.4
Bt Bauk	10	2025	-	12.5	6	10	28.5
Bt Bauk	20	2035	-	25	12	20	57
Serdang	20	2040	-	25	12	20	57
Total (Dungun - Ketengah)	**84.1**	-	-	**105.1**	**50.4**	**84**	**239.5**
Kuala Terengganu – Marang							
Utara KT	46.8	2015	-	58.5	28.1	46.8	133.4
Marang	60	2018	-	75	36	60	171
Kepong	20	2025	-	25	12	20	57
Utara KT	20	2025	-	25	12	20	57
Marang	30	2035	-	37.5	18	30	85.5

Scheme	WTP Capacity Mld	Year of Commission	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
Kepong	30	2040	-	37.5	18	30	85.5
Kepong	20	2045	-	25	12	20	57
Total (KT - Marang)	**226.8**	-	-	**283.5**	**136.1**	**226.8**	**646.4**
Hulu Terengganu							
Hulu Terengganu	10	2018	-	12.5	6	10	28.5
Total (Hulu Terengganu)	**10**	-	-	**12.5**	**6**	**10**	28.5
Setiu							
Sg Tong	13.6	2016	-	17	8.2	13.6	38.8
Sg Tong	10	2027	-	12.5	6	10	28.5
Sg Tong	5	2040	-	6.3	3	5	14.3
Total (Setiu)	**28.6**	-	-	**35.8**	**17.2**	**28.6**	**81.6**
Total Terengganu	**704.6**		-	**881**	**422.8**	**704.6**	**2008.4**
Pahang							
Kuantan							
Panching WTP	160	2014	Contract awarded by the East Coast Economic Region Development Council on 29 July 2010				
Pekan							
Ganchong WTP	160	2015	Contract awarded by the East Coast Economic Region Development Council on 1 September 2010				
Raub							
Tersang WTP	5.46	2010	Remark: Completed in June 2010				
Upgrade Teras WTP	1.87	2012	Remark: Work under implementation				
Rompin							
Muadzam Shah WTP	11.25	2011	Remark: Work under implementation				
New WTP	25	2030	-	31.3	15	25	71.3
Maran							
Upgrade Jengka Utama WTP	14	2013	-	17.5	8.4	14	39.9
Upgrade Pekan Tajau WTP	30	2020	-	37.5	18	30	85.5
Bentong							
Gapoi WTP	2.73	2012	Remark: Work under implementation				
Temerloh							
Seberang Temerloh WTP	25	2012	Remark: Work under implementation				
Total Pahang	**435.31**		-	**86.3**	**41.4**	**69**	**196.7**
Perak							
West Region Perak							
Phase 1 upgrading works for Gunong Semanggol WTP	40	2012	-	50	24	40	114
Upgrading works for Air Kuning WTP	10	2015	-	12.5	6	10	28.5
Phase 1 upgrading works for Trong WTP	20	2015	-	25	12	20	57

Scheme	WTP Capacity Mld	Year of Commission	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
New Sg Kerian WTP	20	2016	-	25	12	20	57
Phase 2 upgrading works for Gunong Semanggol WTP	40	2018	-	50	24	40	114
Upgrading works for Selama WTP	10	2018	-	12.5	6	10	28.5
New Phase 2 Sg Kerian WTP	20	2025	-	25	12	20	57
New Jalan Baru WTP	25	2037	-	31.25	15	25	71.25
Phase 3 upgrading works for Gunong Semanggol WTP	40	2037	-	50	24	40	114
Phase 2 upgrading works for Trong WTP	20	2037	-	25	12	20	57
Ijok Dam	-	2015	122	-	-	-	122
Nyior Dam	-	2015	533	-	-	-	533
Total West Region Perak	245	-	655	306.25	147	245	1353.2
North Region Perak							
Phase 1 upgrading works for Kota Lama Kiri WTP	15	2012	-	18.75	9	15	42.75
Upgrading works for Kg Jong WTP	15	2018	-	18.75	9	15	42.75
Upgrading works for Felda Nenering WTP	5	2018	-	6.25	3	5	14.25
Phase 2 upgrading works for Kota Lama Kiri WTP	15	2018	-	18.75	9	15	42.75
Upgrading works for Grik V WTP	15	2037	-	18.75	9	15	42.75
Total North Region Perak	65			81.25	39	65	185.25
Center Region Perak							
New Phase 1 Sg Raya WTP	60	2015	-	75	36	60	171
Phase 1 upgrading works for MUC SIS II WTP	30	2015	-	37.5	18	30	85.5
Upgrading works for Sg	25	2015	-	31.25	15	25	71.25

Scheme	WTP Capacity Mld	Year of Commission	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
Kampar WTP							
Phase 1 upgrading works for Teluk Kepayang WTP	30	2017	-	37.5	18	30	85.5
New Phase 2 BBSI WTP	15	2018	-	18.75	9	15	42.75
New Phase 2 Kg Gajah WTP	10	2018	-	12.5	6	10	28.5
Phase 2 upgrading works for Teluk Kepayang WTP	30	2024	-	37.5	18	30	85.5
New Phase 2 Sg Raya WTP	60	2025	-	75	36	60	171
Phase 2 upgrading works for MUC SIS II WTP	30	2025	-	37.5	18	30	85.5
Phase 1 upgrading works for Kg Paloh WTP	20	2028	-	25	12	20	57
Phase 3 upgrading works for Teluk Kepayang WTP	30	2033	-	37.5	18	30	85.5
New Phase 3 Sg Raya WTP	60	2037	-	75	36	60	171
Phase 3 upgrading works for MUC SIS II WTP	30	2037	-	37.5	18	30	85.5
Phase 1 upgrading works for Kg Gajah WTP	10	2038	-	12.5	6	10	28.5
Phase 2 upgrading works for Kg Paloh WTP	20	2038	-	25	12	20	57
Raya Dam		2015	185				185
Total Central Region	**460**			**575**	**276**	**460**	**1496**
Total Perak	**770**		**840**	**962.5**	**462**	**770**	**3034.5**
Selangor							
Bulk Transfer to Klang	-	2011	-	-	-	116	116
Labu Off-River Storage Reservoir and Labu WTP	105	Mid of 2011	Remark: Works under construction.				
BRH WTP (Phase 1) – Booster Station	25	2012	-	-	-	5	5

Scheme	WTP Capacity Mld	Year of Commission	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
Upgrading of Raw Water Pumping System to SSP1 / SSP2	217	Mid of 2012	215	-	-	-	215
Bulk Transfer to Wangsa Maju	-	Mid of 2012	-	-	-	187	187
Upgrading of Batu Dam and Batu WTP and Pumped Raw Water Transfer from Batu Detention Pond to Batu Dam	136	2013	157	80	81.6	136	454.6
Interbasin Transfer from Sg Bernam (Stage 1a) and New WTP	250	2014	452.5	312.5	150	250	1165
Pahang-Selangor Raw Water Transfer Scheme and Langat 2 Phase 1	1130	2015	Remark: Raw water transfer works is in the process of award, estimated cost is RM 3.9 billion. The Langat 2 is still under design stage.				-
Interbasin Transfer from Sg Bernam (Stage 1b) and New WTP	250	2025	47.5	312.5	150	250	760
Langat 2 Phase 2	760	2030	Remark: Budget allocated.				-
Interbasin Transfer from Sg Bernam (Stage 2) and New WTP							
Sg Bernam Dam		2040	304				304.4
Raw Water Transfer Works (Tunnel , rawa wter mains and pumping system)		2040	667.5	-	-	-	667.5
Treated water System	750	2040	-	937.5	450	750	2137.5
Total Selangor	**3623**	**-**	**1843.9**	**1642.5**	**831.6**	**1694**	**6012**
Negeri Sembilan							
Kuala Pilah and Jempol Districts	-	-	-	-		-	-
Talang Package WTP	13	2010	-	16.25	7.8	13	37.05
Kuala Jelai WTP Phase 2	20	2015	-	25	12	20	57
Total Negeri Sembilan	**33**	**-**	**-**	**41.25**	**19.8**	**33**	**94.05**
Melaka							

Scheme	WTP Capacity Mld	Year of Commission	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
Bertam DAF WTP Phase 2	120	2013	-	150	72	120	342
Inter-state transfer from Sg Muar, Johor Phase 3	160	2013	192	-	-	-	192
Gadek WTP Phase 2	55	2017	-	68.8	33	55	156.8
Batang Melaka Dam	250	2020	135	-	-	-	135
Merlimau WTP Phase 2	55	2020	-	68.8	33	55	156.8
Gadek WTP Phase 3	55	2026	-	68.8	33	55	156.8
Bertam DAF Phase 3,	110	2032	-	137.5	66	110	313.5
New WTP	55	2045	-	68.8	33	55	156.8
Total Melaka	**860**	**-**	**327**	**562.7**	**270**	**450**	**1609.7**
Johor							
Johor Bahru							
Semangar WTP Stage 2	159	2012	-	142	20	138	300
Existing Pulai WTP to supply Pontian	-	2012	-	-	-	17	17
Jengeli Dam	-	2012	114	-	-		114
Seng Heng Barrage	-	2012	75	-	-		75
Existing Skudai WTP increased production	-	2016	-	-	-	70	70
Sayong Dam	-	2016	61	-	-	-	60.8
Sayong - Linggiu Raw Water Pump Transfer Scheme Stage 1	-	2016	210	-	-	-	210
New Sg Johor WTP Stage 1 with Sayong – Linggiu Raw Water Transfer Scheme Stage 2	200	2019	210	250	120	200	780
New Sg Johor WTP Stage 2 with Lebak Dam	200	2026	201	250	120	200	771
New Sg Sedili Besar WTP Stage 1 with Ulu Sedili Besar Dam	227	2035	212	283.8	136.2	227	859
Kota Tinggi							

Scheme	WTP Capacity Mld	Year of Commission	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
Sg Lebam augmentation and Sg Lebam raw water transfer scheme to Lebam Dam	23	2021	46	28.8	13.8	23	111.6
Seluyut WTP Stage 1 with Seluyut Dam	60	2027	55	75	36	60	226
Pontian							
Sg Pontian Besar to Pontian Kecil Dam Pump Transfer Stage 1		2013	87	20	22	37	166
Segamat							
Buloh Kasap WTP Stage 1	30.35	2015	-	37.9	18.2	30.4	86.5
Buloh Kasap WTP Stage 2	19.75	2038	-	24.7	11.9	19.8	56.4
Muar							
Segamat Dam		2013	106				106
New Muar Water Supply Scheme Stage 1	45.5	2015	-	56.9	27.3	45.5	129.7
New Muar Water Supply Scheme Stage 2	45.5	2020	-	56.9	27.3	45.5	129.7
New Muar Water Supply Scheme Stage 3	30	2040	-	37.5	18	30	85.5
Batu Pahat							
Bekok Dam Spillway Extension	-	2011	10	-	-	-	10
New Batu Pahat Water Supply Scheme Stage 1	50	2016	-	62.5	30	50	142.5
New Batu Pahat Water Supply Scheme Stage 2	50	2025	-	62.5	30	50	142.5
Keluang							
Sembrong Dam Spillway Extension	-	2011	4	-	-	-	4
Inflatable Rubber Weir across Sg Sembrong Timur	-	2011	4	-	-	-	4

Scheme	WTP Capacity Mld	Year of Commission	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
Kahang WTP Stage 1 with Kahang Dam	45.5	2014	71	56.9	27.3	45.5	200.7
Kahang WTP Stage2	30	2025	-	37.5	18	30	85.5
Kahang WTP Stage 3	30	2038	-	37.5	18	30	85.5
Mersing							
New Mersing WTP Stage 2 with Mersing Dam	10	2022	49	12.5	6	10	77.7
New Mersing WTP Stage 3	16	2033	-	20	9.6	16	45.6
Total Johor	**1,271.6**	**-**	**1,515.0**	**1,552.9**	**709.6**	**1,374.7**	**5,152.2**
Sabah							
Kota Kinabalu							
Teliboong WTP 2a	120	2012	-	192	96	144	432
Kogopon 2	180	2015	-	288	144	216	648
Kogopon 3	150	2027	-	240	120	180	540
Sg Bongol Dam	-	2013	195	-	-	-	195.2
Kaiduan Dam	-	2015	274	-	-	-	274.2
Total Kota Kinabalu	450	-	469.4	720	360	540	2089.4
Sandakan							
Segaliud WPT Ph 2	80	2013	-	128	64	96	288
Segaliud WPT Ph 3	80	2021	-	128	64	96	288
Segaliud WPT Ph 4	80	2035	-	128	64	96	288
Kg Muanad 2	15	2013	-	24	12	18	54
Kg Muanad 2	15	2020	-	24	12	18	54
Kg Muanad 4	20	2027	-	32	16	24	72
Bukit Garam 2	60	2022	-	96	48	72	216
Bukit Garam 3	60	2032	-	96	48	72	216
Raw Water Transfer from Sg Kinabatangan at Bukit Garam 1	-	2013	90	-	-	-	90
Raw Water Transfer from Sg Kinabatangan at Bukit Garam 2	-	2021	90	-	-	-	90
Raw Water Transfer from Sg Kinabatangan at Bukit Garam 3	-	2035	90	-	-	-	90
Total Sandakan	410	-	270	656	328	492	1746
Tawau							

Scheme	WTP Capacity Mld	Year of Commission	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
Cinta Mata Ph 2	40	2013	-	64	32	48	144
Merotai Ph 2	60	2013	-	96	48	72	216
Apas Balung	80	2015	-	192	96	144	432
Sg Tawau Dam	-	2014	476	-	-	-	475.7
Sg Merotai Kanan Dam	-	2015	178	-	-	-	177.9
Sg Balung Dam	-	2015	182	-	-	-	181.8
Total Tawau	180	-	835.4	352	176	264	1627.4
Lahad Datu							
Segama 2	30	2014	-	48	24	36	108
Segama 3	40	2018	-	64	32	48	144
Segama 4	40	2028	-	64	32	48	144
Semporna 2	40	2012	-	64	32	48	144
Semporna 3	25	2018	-	40	20	30	90
Semporna 4	25	2028	-	40	20	30	90
Kalumpang 2	20	2012	-	32	16	24	72
Kalumpang 3	20	2014	-	32	16	24	72
Kalumpang 4	30	2032	-	48	24	36	108
Sg Kawag Dam	-	2018	71	-	-	-	70.8
Sg Malati Dam	-	2018	149	-	-	-	149.4
Total Lahad Datu	270	-	220.2	432	216	324	1192.2
Beaufort							
Limbawang	8	2026	-	12.8	6.4	9.6	28.8
Menbakut	8	2026	-	12.8	6.4	9.6	28.8
Total Beaufort	16	-	-	25.6	12.8	19.2	57.6
Keningau							
Kg Keningau 2	30	2013	-	48	24	36	108
Kg Bingkor 2	30	2013	-	48	24	36	108
Kg Bingkor 3	40	2016	-	64	32	48	144
Kg Keningau 3	25	2026	-	40	20	30	90
Kg Bingkor 4	25	2026	-	40	20	30	90
ABJV 2	8	2011	-	12.8	6.4	9.6	28.8
ABJV 3	8	2020	-	12.8	6.4	9.6	28.8
Tenom 2	6	2014	-	9.6	4.8	7.2	21.6
Tenom 3	6	2025	-	9.6	4.8	7.2	21.6
Nabawan 2	4	2013	-	6.4	3.2	4.8	14.4
Sook 2	2	2013	-	3.2	1.6	2.4	7.2
Nabawan 3	4	2029	-	6.4	3.2	4.8	14.4
Sook	2	2029	-	3.2	1.6	2.4	7.2
Total Keningau	190	-	-	304	152	228	684
Ranau							
Ranau 3	10	2014	-	16	8	12	36
Kg Kimolohing	10	2014	-	16	8	12	36
Ranau 4	10	2028	-	16	8	12	36
Telupid	10	2028	-	16	8	12	36
Kuala Tongod	3	2012	-	4.8	2.4	3.6	10.8
Kg Pinangah	3	2012	-	4.8	2.4	3.6	10.8
Kuala Tongod	3	2020	-	4.8	2.4	3.6	10.8
Kg Pinangah	3	2020	-	4.8	2.4	3.6	10.8
Total Ranau	52	-	-	83.2	41.6	62.4	187.2
Kudat							
Kg Simpangan	15	2013	-	24	12	18	54
Pinangsoo	25	2013	-	40	20	30	90

Scheme	WTP Capacity Mld	Year of Commission	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
Bandau	20	2017	-	32	16	24	72
Pinangsoo	20	2031	-	32	16	24	72
Pitas 2	10	2012	-	16	8	12	36
Pitas 3	10	2025	-	16	8	12	36
Total Kudat	100	-	-	160	80	120	360
Kota Belud							
Bayayat 2	20	2014	-	32	16	24	72
Bayayat 3	20	2022	-	32	16	24	72
Total Kota Belud	40	-	-	64	32	48	144
Total Sabah	**1708**	-	**1795**	**2796.8**	**1398.4**	**2097.6**	**8087.8**
FT Labuan							
Beautort	20	2029	-	32	16	50	98
Total FT Labuan	**20**	-	-	**32**	**16**	**50**	**98**
Sarawak							
Kuching							
Batu Kitang Module 9	150	2013		165	75	180	420
Batu Kitang Module 10	150	2018	-	165	75	180	420
Batu Kitang Module 11	120	2027	-	132	60	144	336
Batu Kitang Module 12	120	2038	-	132	60	144	336
Total Kuching	540	-	-	594	270	648	1512
Samarahan							
Slabi	15	2036	-	16.5	7.5	18	42
Total - Samarahan	15	-	-	16.5	7.5	18	42
Serian							
Slabi WTP 3	15	2036	-	16.5	7.5	18	42
Off river storage	-	2036	20				20
Total Serian	15	-	20	16.5	7.5	18	62
Simunjan/Sebuyan							
Simunjan 2 (with Intake at Rantau Muara Sampang)	10	2011		16	5	15	36
Simunjan 3 (plus upgrade pumphouse)	10	2018		6	5	9	20
Total Simunjan/Sebuyan	20			22	10	24	56
Sri Aman 0							
Bayai Module 4	20	2014	-	22	10	24	56
Bayai Module 5	20	2037	-	22	10	24	56
Raw water Transfer (pumped)	-	-	-	-	-	-	-
Btg Lupar-Btg Undup 1 (20 MLD)	-	2014	30	-	-	-	30

Scheme	WTP Capacity Mld	Year of Commission	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
Btg Lupar-Btg Undup 1 (20 MLD)	-	2037	30	-	-	-	30
Total Sri Aman	40	-	60	44	20	48	172
Batang Ai							
Lubok Antu 2	8	2012	-	8.8	4	9.6	22.4
Lubok Antu 3	8	2027	-	8.8	4	9.6	22.4
Total Batang Ai	16	-	-	17.6	8	19.2	44.8
Betong							
Layar 2	15	2012	-	16.5	7.5	18	42
Layar 3	15	2030	-	16.5	7.5	18	42
Off river storage to supply full requirements until 2050	-	2012	20	-	-	-	20
Total Betong	30	-	20	33	15	36	104
Sarikei							
Bayong 2	60	2012	-	66	30	72	168
Bayong 3	45	2018	-	49.5	22.5	54	126
Bayong 4	45	2033	-	49.5	22.5	54	126
Gerudu Dam (ongoing) (140 MLD)	-	2011	-	-	-	-	-
Upper Sarikei Dam (74 MLD)	-	2033	46	-	-	-	45.6
Total Sarikei	150	-	45.6	165	75	180	465.6
Sibu							
Salim WTP 2 (urgent)	75	2012	-	82.5	37.5	90	210
Salim WTP 3	75	2013	-	82.5	37.5	90	210
Salim WTP 4	100	2018	-	110	50	120	280
Salim WTP 5	120	2030	-	132	60	144	336
Total Sibu	370	-	-	407	185	444	1036
Mukah							
Mukah WTP 2 (urgent)	30	2013	-	33	15	36	84
Mukah WTP 3	30	2018	-	33	15	36	84
Mukah WTP 4	30	2033	-	33	15	36	84
Total Mukah	90	-	-	99	45	108	252
Tatau							
Tatau WTP 2 (urgent)	30	2012	-	33	15	36	84
Tatau WTP 3	15	2019	-	16.5	7.5	18	42
Tatau WTP 4	15	2036	-	16.5	7.5	18	42
Sg Jelai Dam	-	2014	52	-	-	-	52
Total Tatau	60	-	52	66	30	72	220
Kapit							
Kapit WTP 2 (urgent)	15	2012	-	16.5	7.5	18	42
Kapit WTP 3	15	2019	-	16.5	7.5	18	42
Kapit WTP 4	10	2036	-	11	5	12	28
Total Kapit	40	-	-	44	20	48	112
Bintulu							
Nyabau	80	2013	-	88	40	96	224
Pandan 1	120	2013	-	132	60	144	336
Pandan 2	120	2020	-	132	60	144	336
Pandan 3	120	2036	-	132	60	144	336

Scheme	WTP Capacity Mld	Year of Commission	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
High Level Reservoir at Pandan 1 (40 ML)	-	2013	-	-	20	-	20
High Level Reservoir at Pandan 2 (40 ML)	-	2020	-	-	20	-	20
High Level Reservoir at Pandan 3 (40 ML)	-	2036	-	-	20	-	20
Terminal reservoirs at Bintulu and Samalaju (40 ML) 1	-	2013	-	-	20	-	20
Terminal reservoirs at Bintulu and Samalaju (40 ML) 2	-	2020	-	-	20	-	20
Terminal reservoirs at Bintulu and Samalaju (40 ML) 3	-	2036	-	-	20	-	20
Total Bintulu	440	-	-	484	340	528	1352
Miri							
Lambir 3	100	2015	-	110	50	120	280
Lambir 4	120	2022	-	132	60	144	336
Lambir 5	120	2036	-	132	60	144	336
Btg Baram-Btg Bakong Transfer 1 (100MLD)	-	2015	150	-	-	-	150
Btg Baram-Btg Bakong Transfer 2 (120 MLD)	-	2022	180	-	-	-	180
Btg Baram-Btg Bakong Transfer 3 (120 MLD)	-	2036	180	-	-	-	180
Total Miri	340	-	510	374	170	408	1462
Limbang							
Berawan3	10	2017	-	11	5	12	28
Berawan 4	15	2027	-	16.5	7.5	18	42
Total Limbang	25	-	-	27.5	12.5	30	70
Lawas (No Projects)							
Total Sarawak	**2,191**	**-**	**708**	**2,410**	**1,216**	**2,629**	**6,962**
Total Malaysia	**14,473**	**-**	**7,705**	**14,540**	**7,101**	**12,729**	**42,074**

Table 3.44 - Project Costing according to States for Immediate Water Supply Works under RMK10

Scheme	WTP Capacity (Mld)	No of Projects	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
Perlis	25	1	0	31.25	15	25	71.25
Kedah	713	16	308	891.25	427.8	713	2340.05
Pulau Pinang	325	3	348	406.3	195	325	1274.3
Kelantan	369.9	22	0	462.9	221.9	369.9	1054.7
Terengganu	385.5	7	0	481.8	231.3	371.8	1084.9
Pahang	380.31	8	0	17.5	8.4	14	39.9
Perak	360	19	840	450	216	190	1696
Selangor	1863	8	824.5	392.5	231.6	694	2142.6
Negeri Sembilan	33	2	0	41.25	19.8	33	94.05
Melaka	335	3	192	218.8	105	175	690.8
Johor	330.4	16	742.0	376.2	144.8	433.4	1,696.4
Sabah	986	37	1615	1641.6	820.8	1231.2	5308.6
FT Labuan	0	-	0	0	0	0	0
Sarawak	2,266	26	664	2,493	1,133	2,719	7,009
Total Malaysia	**8,372**	**168**	**5,534**	**7,904**	**3,770**	**7,295**	**24,502**

Table 3.45 – Project List and Costing for Immediate Water Supply Works under RMK10

Scheme	WTP Capacity (Mld)	Year of Commission	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
Perlis							
Upgrading Timah Tasoh WTP	25	2012	-	31.25	15	25	71.25
Total Perlis	**25**	**-**	**0**	**31.25**	**15**	**25**	**71.25**
Kedah							
Northern Kedah							
Pelubang WTP Upgrading	60	2012	-	75	36	60	171
New Bukit Pinang WTP Phase II	100	2012	-	125	60	100	285
Bukit Jenun Baru WTP Upgrading	25	2012	-	31.25	15	25	71.25
Jeneri WTP Upgrading	25	2012	-	31.25	15	25	71.25
New Bukit Jenun Baru WTP Phase II	25	2012	-	31.25	15	25	71.25
Tawar – Muda Dam (110 MCM)	-	2015	282	-	-	-	282
Sari Dam (54 MCM)	-	2015	26	-	-	-	26
New Pelubang WTP Phase II	20	2016	-	25	12	20	57

Scheme	WTP Capacity (Mld)	Year of Commission	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
New Bukit Pinang WTP Phase III	40	2018	-	50	24	40	114
Total (Northern Kedah)	295	-	308	368.75	177	295	1148.75
Central Kedah							
Bukit Jenun Baru WTP Upgrading	130	2012	-	162.5	78	130	370.5
New Air Sg Petani WTP Phase II	55	2015	-	68.75	33	55	156.75
Total (Central Kedah)	185	-	0	231.25	111	185	527.25
Southern Kedah							
Mahang WTP Upgrading	10	2012	-	12.5	6	10	28.5
Kulim Hi-Tech WTP Upgrading	150	2012	-	187.5	90	150	427.5
Bikan WTP Upgrading	3	2012	-	3.75	1.8	3	8.55
Sg Limau WTP Upgrading	20	2015	-	25	12	20	57
Total (Southern Kedah)	183	-	0	228.75	109.8	183	521.55
Langkawi							
New SgBaru WTP Phase II	50	2012	-	62.5	30	50	142.5
Total Langkawi	50	-	0	62.5	30	50	142.5
Total Kedah	**713**		**308**	**891.25**	**427.8**	**713**	**2340.05**
Pulau Pinang							
Sg Perak Transfer Scheme (800 Mld)	-	2014	348	-	-	-	348
Sg Kerian WTP Phase 1 Stage 1	125	2014	-	156.3	75	125	356.3
Sg Kerian WTP Phase 1 Stage 2	200	2017	-	250	120	200	570
Total Pulau Pinang	**325**	**-**	**348**	**406.3**	**195**	**325**	**1274.3**
Kelantan							
Kota Bahru							
Merbau Chondong	25	2012	-	31.3	15	25	71.3
Pintu Geng	20	2012	-	25	12	20	57
Tg Mas	20	2015	-	25	12	20	57
Pintu Geng	15	2017	-	18.8	9	15	42.8
Aur Duri (Tunjung)	50	2018	-	62.5	30	50	142.5
Total (Kota Bharu)	130	-	0	162.6	78	130	370.6
Bachok							
Kg Chap	8	2012	-	10	4.8	8	22.8
Aur Duri(Tunjung)	10	2018	-	12.5	6	10	28.5
Total (Bachok)	18	-	0	22.5	10.8	18	51.3
Machang							

Scheme	WTP Capacity (Mld)	Year of Commission	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
Merbau Chondong	15	2014	-	18.8	9	15	42.8
Total (Machang)	15	-	0	18.8	9	15	42.8
Pasir Puteh							
Wakaf Bunut	8	2011	-	10	4.8	8	22.8
Merbau Chondong	15	2014	-	18.8	9	15	42.8
Total (Pasir Puteh)	23	-	0	28.8	13.8	23	65.6
Tumpat							
Wakaf Baru	8	2012	-	10	4.8	8	22.8
Kelar	15	2012	-	18.8	9	15	42.8
Kelar	20	2017	-	25	12	20	57
Total (Tumpat)	43	-	0	53.8	25.8	43	122.6
Pasir Mas							
Kelar	23.9	2012	-	29.9	14.3	23.9	68.1
Kelar	25	2017	-	31.3	15	25	71.3
Total (Pasir Mas)	48.9	-	0	61.2	29.3	48.9	139.4
Tanah Merah							
Bt. Remah	15	2012	-	18.8	9	15	42.8
Bt. Remah	10	2017	-	12.5	6	10	28.5
Total (Tanah Merah)	25	-	0	31.3	15	25	71.3
Jeli							
Jeli 2 (New)	7	2015	-	8.8	4.2	7	20
Total (Jeli)	7	-	0	8.8	4.2	7	20
Kuala Krai							
Pahi	20	2012	-	25	12	20	57
Kg Tualang	15	2018	-	18.8	9	15	42.8
Total (Kuala Krai)	35	-	0	43.8	21	35	99.8
Gua Musang							
Chiku	10	2012	-	12.5	6	10	28.5
Ketil	15	2018	-	18.8	9	15	42.8
Total (Gua Musang)	25	-	0	31.3	15	25	71.3
Total Kelantan	**369.9**	**-**	**0**	**462.9**	**221.9**	**369.9**	**1054.7**
Terengganu							
Besut							
Total (Besut)	**0**		**0**	**0**	**0**	**0**	**0**
Kemaman							
Bt Sah	162	2012	-	202.5	97.2	162	461.7
Bt Sah	70	2018	-	87.5	42	70	199.5
Total (Kemaman)	232	-	0	290	139.2	232	661.2
Dungun – Ketengah							
Serdang	23.1	2018	-	28.8	13.8	23	65.6
Total (Dungun - Ketengah)	23.1	-	0	28.8	13.8	23	65.6
Kuala Terengganu – Marang							
Utara KT	46.8	2015	-	58.5	28.1	46.8	133.4
Marang	60	2018	-	75	36	60	171
Total (KT - Marang)	106.8	-	0	133.5	64.1	106.8	304.4
Hulu Terengganu							
Hulu	10	2018	-	12.5	6	10	28.5

Scheme	WTP Capacity (Mld)	Year of Commission	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
Terengganu							
Total (Hulu Terengganu)	10	-	0	12.5	6	10	28.5
Setiu							
Sg Tong	13.6	2016	-	17	8.2		25.2
Total (Setiu)	13.6	-	0	17	8.2	0	25.2
Total Terengganu	**385.5**		**0**	**481.8**	**231.3**	**371.8**	**1084.9**
Pahang							
Kuantan							
Panching WTP	160	2014	Contract awarded by the East Coast Economic Region Development Council on 29 July 2010				
Pekan							
Ganchong WTP	160	2015	Contract awarded by the East Coast Economic Region Development Council on 1 September 2010				
Raub							
Tersang WTP	5.46	2010	Remark: Completed in June 2010				
Upgrade Teras WTP	1.87	2012	Remark: Work under implementation				
Rompin							
Muadzam Shah WTP	11.25	2011	Remark: Work under implementation				
Maran							
Upgrade Jengka Utama WTP	14	2013	-	17.5	8.4	14	39.9
Bentong							
Gapoi WTP	2.73	2012	Remark: Work under implementation				
Temerloh							
Seberang Temerloh WTP	25	2012	Remark: Work under implementation				
Total Pahang	**380.31**		**0**	**17.5**	**8.4**	**14**	**39.9**
Perak							
West Region Perak							
Phase 1 upgrading works for Gunong Semanggol WTP	40	2012	-	50	24	40	114
Upgrading works for Air Kuning WTP	10	2015	-	12.5	6	10	28.5
Phase 1 upgrading works for Trong WTP	20	2015	-	25	12	20	57
New Sg Kerian WTP	20	2016	-	25	12	20	57
Phase 2 upgrading works for Gunong Semanggol WTP	40	2018	-	50	24	40	114
Upgrading works for Selama WTP	10	2018	-	12.5	6	10	28.5
Ijok Dam	-	2015	122	-	-	-	122
Nyior Dam	-	2015	533	-	-	-	533
Total West Region Perak	140	-	655	175	84	140	1054
North Region Perak							

Scheme	WTP Capacity (Mld)	Year of Commission	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
Phase 1 upgrading works for Kota Lama Kiri WTP	15	2012	-	18.75	9	15	42.75
Upgrading works for Kg Jong WTP	15	2018	-	18.75	9	15	42.75
Upgrading works for Felda Nenering WTP	5	2018	-	6.25	3	5	14.25
Phase 2 upgrading works for Kota Lama Kiri WTP	15	2018	-	18.75	9	15	42.75
Total North Region Perak	50		0	62.5	30	50	142.5
Center Region Perak							
New Phase 1 Sg Raya WTP	60	2015	-	75	36		111
Phase 1 upgrading works for MUC SIS II WTP	30	2015	-	37.5	18		55.5
Upgrading works for Sg Kampar WTP	25	2015	-	31.25	15		46.25
Phase 1 upgrading works for Teluk Kepayang WTP	30	2017	-	37.5	18		55.5
New Phase 2 BBSI WTP	15	2018	-	18.75	9		27.75
New Phase 2 Kg Gajah WTP	10	2018	-	12.5	6		18.5
Raya Dam		2015	185				185
Total Central Perak	170		185	212.5	102	0	499.5
Total Perak	**360**		**840**	**450**	**216**	**190**	**1696**
Selangor							
Bulk Transfer to Klang	-	2011	-	-	-	116	116
Labu Off-River Storage Reservoir and Labu WTP	105	Mid of 2011	Remark: Works under construction.				
BRH WTP (Phase 1) – Booster Station	25	2012	-	-	-	5	5
Upgrading of Raw Water Pumping System to SSP1 / SSP2	217	Mid of 2012	215	-	-	-	215
Bulk Transfer to Wangsa Maju	-	Mid of 2012	-	-	-	187	187

Scheme	WTP Capacity (Mld)	Year of Commission	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
Upgrading of Batu Dam and Batu WTP and Pumped Raw Water Transfer from Batu Detention Pond to Batu Dam	136	2013	157	80	81.6	136	454.6
Interbasin Transfer from Sg Bernam (Stage 1a) and New WTP	250	2014	452.5	312.5	150	250	1165
Pahang-Selangor Raw Water Transfer Scheme and Langat 2 Phase 1	1130	2015	Remark: Raw water transfer works is in the process of award, estimated cost is RM 3.9 billion. The Langat 2 is still under design stage.				
Interbasin Transfer from Sg Bernam (Stage 2) and New WTP							
(Tunnel , rawa wter mains and pumping system)							
Total Selangor	**1863**	**-**	**824.5**	**392.5**	**231.6**	**694**	**2142.6**
Negeri Sembilan							
Kuala Pilah and Jempol Districts	-	-	-	-		-	-
Talang Package WTP	13	2010	-	16.25	7.8	13	37.05
Kuala Jelai WTP Phase 2	20	2015	-	25	12	20	57
Total Negeri Sembilan	**33**	**-**	**0**	**41.25**	**19.8**	**33**	**94.05**
Melaka							
Bertam DAF WTP Phase 2	120	2013	-	150	72	120	342
Inter-state transfer from Sg Muar, Johor Phase 3	160	2013	192	-	-	-	192
Gadek WTP Phase 2	55	2017	-	68.8	33	55	156.8
Total Melaka	**335**	**-**	**192**	**218.8**	**105**	**175**	**690.8**
Johor							
Johor Bahru							
Semangar WTP Stage 2	159	2012	-	142	20	138	300
Existing Pulai WTP to supply Pontian	-	2012	-	-	-	17	17
Jengeli Dam	-	2012	114	-	-		114
Seng Heng Barrage	-	2012	75	-	-		75

Scheme	WTP Capacity (Mld)	Year of Commission	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
Existing Skudai WTP increased production	-	2016	-	-	-	70	70
Sayong Dam	-	2016	61	-	-	-	61
Sayong - Linggiu Raw Water Pump Transfer Scheme Stage 1	-	2016	210	-	-	-	210
Sg Pontian Besar to Pontian Kecil Dam Pump Transfer Stage 1		2013	87	20	22	37	166
Segamat							
Buloh Kasap WTP Stage 1	30.35	2015	-	37.9	18.2	30.4	86.5
Muar							
Segamat Dam		2013	106				106
New Muar Water Supply Scheme Stage 1	45.5	2015	-	56.9	27.3	45.5	129.7
Batu Pahat							
Bekok Dam Spillway Extension	-	2011	10	-	-	-	10
New Batu Pahat Water Supply Scheme Stage 1	50	2016	-	62.5	30	50	142.5
Keluang							
Sembrong Dam Spillway Extension	-	2011	4	-	-	-	4
Inflatable Rubber Weir across Sg Sembrong Timur	-	2011	4	-	-	-	4
Kahang WTP Stage 1 with Kahang Dam	45.5	2014	71	56.9	27.3	45.5	200.7
Total Johor	**330.35**	**-**	**742.00**	**376.20**	**144.80**	**433.40**	**1,696.40**
Sabah							
Kota Kinabalu							
Teliboong WTP 2a	120	2012	-	192	96	144	432
Kogopon 2	180	2015	-	288	144	216	648
Sg Bongol Dam	-	2013	195	-	-	-	195
Kaiduan Dam	-	2015	274	-	-	-	274
Total Kota Kinabalu	300	-	469	480	240	360	1549
Sandakan							
Segaliud WPT Ph 2	80	2013	-	128	64	96	288
Kg Muanad 2	15	2013	-	24	12	18	54
Raw Water Transfer from Sg Kinabatangan at Bukit Garam 1	-	2013	90	-	-	-	90
Total Sandakan	95	-	90	152	76	114	432
Tawau							
Cinta Mata Ph 2	40	2013	-	64	32	48	144

Scheme	WTP Capacity (Mld)	Year of Commission	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
Merotai Ph 2	60	2013	-	96	48	72	216
Apas Balung	80	2015	-	192	96	144	432
Sg Tawau Dam	-	2014	476	-	-	-	476
Sg Merotai Kanan Dam	-	2015	178	-	-	-	178
Sg Balung Dam	-	2015	182	-	-	-	182
Total Tawau	180	-	836	352	176	264	1628
Lahad Datu							
Segama 2	30	2014	-	48	24	36	108
Segama 3	40	2018	-	64	32	48	144
Semporna 2	40	2012	-	64	32	48	144
Semporna 3	25	2018	-	40	20	30	90
Kalumpang 2	20	2012	-	32	16	24	72
Kalumpang 3	20	2014	-	32	16	24	72
Sg Kawag Dam	-	**2018**	**71**	-	-	-	71
Sg Malati Dam	-	2018	149	-	-	-	149
Total Lahad Datu	175	-	220	280	140	210	850
Beaufort							
Total Beaufort	0	-	0	0	0	0	0
Keningau							
Kg Keningau 2	30	2013	-	48	24	36	108
Kg Bingkor 2	30	2013	-	48	24	36	108
Kg Bingkor 3	40	2016	-	64	32	48	144
ABJV 2	8	2011	-	12.8	6.4	9.6	28.8
Tenom 2	6	2014	-	9.6	4.8	7.2	21.6
Nabawan 2	4	2013	-	6.4	3.2	4.8	14.4
Sook 2	2	2013	-	3.2	1.6	2.4	7.2
Total Keningau	120	-	0	192	96	144	432
Ranau							
Ranau 3	10	2014	-	16	8	12	36
Kg Kimolohing	10	2014	-	16	8	12	36
Kuala Tongod	3	2012	-	4.8	2.4	3.6	10.8
Kg Pinangah	3	2012	-	4.8	2.4	3.6	10.8
Total Ranau	26	-	0	41.6	20.8	31.2	93.6
Kudat							
Kg Simpangan	15	2013	-	24	12	18	54
Pinangsoo	25	2013	-	40	20	30	90
Bandau	20	2017	-	32	16	24	72
Pitas 2	10	2012	-	16	8	12	36
Total Kudat'	70	-	0	112	56	84	252
Kota Belud							
Bayayat 2	20	2014	-	32	16	24	72
Total Kota Belud	20	-	0	32	16	24	72
Total Sabah	**986**	**-**	**1615**	**1641.6**	**820.8**	**1231.2**	**5308.6**
FT Labuan							
Total FT Labuan	**0**	**-**	**0**	**0**	**0**	**0**	**0**
Sarawak							
Kuching							
Batu Kitang Module 9	150	2013		165	75	180	420
Batu Kitang Module 10	150	2018	-	165	75	180	420
Total Kuching	300	-	0	330	150	360	840
Samarahan							
Total - Samarahan	0	-	0	0	0	0	0

Scheme	WTP Capacity (Mld)	Year of Commission	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
Serian							
Total Serian	0	-	0	0	0	0	0
Simunjan/Sebuyan							
Simunjan 2	10	2011	-	11	5	12	28
Simunjan 3	10	2018	-	11	5	12	28
Total Simunjan/ Sebuyan	20	-	-	22	10	24	56
Sri Aman							
Bayai Module 4	20	2014	-	22	10	24	56
Raw water Transfer (pumped)	-	-	-	-	-	-	
Btg Lupar-Btg Undup 1 (20 MLD)	-	2014	30	-	-	-	30
Total Sri Aman	20	-	30	22	10	24	86
Batang Ai							
Lubok Antu 2	8	2012	-	8.8	4	9.6	22.4
Total Batang Ai	8	-	0	8.8	4	9.6	22.4
Betong							
Layar 2	15	2012	-	16.5	7.5	18	42
Off river storage to supply full requirements until 2050	-	2012	20	-	-	-	20
Total Betong	15	-	20	16.5	7.5	18	62
Sarikei							
Bayong 2	60	2012	-	66	30	72	168
Bayong 3	45	2018	-	49.5	22.5	54	126
Gerudu Dam (ongoing) (140 MLD)	-	2011	-	-	-	-	-
Total Sarikei	105	-	0	115.5	52.5	126	294
Sibu							
Salim WTP 2 (urgent)	75	2012	-	82.5	37.5	90	210
Salim WTP 3	75	2013	-	82.5	37.5	90	210
Salim WTP 4	100	2018	-	110	50	120	280
Total Sibu	250	-	0	275	125	300	700
Mukah							
Mukah WTP 2 (urgent)	30	2013	-	33	15	36	84
Mukah WTP 3	30	2018	-	33	15	36	84
Total Mukah	60	-	0	66	30	72	168
Tatau							
Tatau WTP 2 (urgent)	30	2012	-	33	15	36	84
Sg Jelai Dam	-	2014	52	-	-	-	52
Total Tatau	30	-	52	33	15	36	136
Kapit							
Kapit WTP 2 (urgent)	15	2012	-	16.5	7.5	18	42
Total Kapit	15	-	0	16.5	7.5	18	42
Bintulu							
Nyabau	80	2013	-	88	40	96	224
Pandan 1	120	2013	-	132	60	144	336
High Level Reservoir at Pandan 1 (30	-	2013	20	-	-	-	20

Scheme	WTP Capacity (Mld)	Year of Commission	Cost (RM million)				
			Source Works	Treatment Works	Bulk Reservoirs	Bulk Distribution Works	Total Cost
ML)							
Terminal reservoirs at Bintulu and Samalaju (120 ML)	-	-	60	-	-	-	60
Total Bintulu	200	-	80	220	100	240	640
Miri							
Lambir 3	100	2015	-	110	50	120	280
Btg Baram-Btg Bakong Transfer 1 (100MLD)	-	2015	150	-	-	-	150
Total Miri	100	-	150	110	50	120	430
Limbang							
Berawan3	10	2017	-	11	5	12	28
Total Limbang	10	-	0	11	5	12	28
Lawas (No Projects)							
Total Sarawak	**2,266**	**-**	**664**	**2,493**	**1,133**	**2,719**	**7,009**
Total Malaysia	**8,372**	**-**	**5,534**	**7,904**	**3,770**	**7,295**	**24,502**

3.10 DEVELOPMENT WORKS – GROUNDWATER

(1) The actual potential of groundwater is currently unknown, as it has not been explored extensively like surface water. Therefore, it is not possible to develop a groundwater development program for potable water, irrigation and agriculture. It is proposed to undertake a concerted exploration program to systematically explore all the river basins for their groundwater potential. As the river basins are large in numbers, only the developed ones are earmarked for exploration in the immediate future. Two areas are explored:

(i) Areas covered by the five development corridors.

(ii) All the 13 States and Federal Territories.

(2) It is proposed to carry out the exploration covering a 10-year period until 2020 spanning the RMK10 and RMK11 periods. Further exploration until 2050 will be depend on the development and outcome of the exploration as what follows could be groundwater development replacing surface water in addition to exploration in certain demand areas.

(3) **Table 3.46** indicates the proposed roungdwater exploratory program and the expected budgets.

Table 3.46 - Proposed Groundwater Exploratory Program, 2011 to 2020

State	River Basin	Cost (RM million)
Kedah	Sg Melaka, Langkawi,	20
	Sg Muda Basin	20
Pulau Pinang	Sg Kerian Basin	20
	Sg Perai	20
Perak	Sg Kerian Basin	20
	Sg Perak Basin	20
Selangor	Sg Bernam Basin	20
	Sg Selangor Basin	20
	Sg Langat Basin	20
Negeri Sembilan	Sg Linggi Basin	20
Melaka	Sg Melaka Basin	20
Johor	Sg Muar Basin	20
	Sg Johor Basin	20
	Sg Endau Basin	20
Pahang	Sg Pahang Basin	20
	Sg Bebar	20
	Sg Rompin	20
Terengganu	Sg Terengganu	20
	Sg Kemaman Basin	20
Kelantan	Sg Kelantan Basin	20
Sarawak	Sg Sarawak	20
	Batang Rajang	20
	Mukah River	20
	Miri River	20
	Kemena River	20
	Batang Baram	20
Sabah	Sg Kinabatangan	20
States Total		**540**
5 Development Corridor		
Northern Corridors Economic Region (NCER)		12.5
East Coast Economic Region (ECER)		12.5
Iskandar Malaysia		12.5
Sarawak Corridors of Renewable Energy (SCORE)		12.5
Sabah Development Corridor(SDC)		12.5
Corridor Total		62.5
Total		**602.5**

3.11 FINANCIAL STUDIES

3.11.1 Objective

(1) The objective of the financial study is to provide a perspective on the pricing mechanism for water resources, which is closely linked to the water services sector, environmental cost and the costs to sustain water resources in river basins. This includes an overview of the various aspects of pricing mechanisms, approaches and alternatives within a broad water policy framework having the types of water tariff structures to support the NWR Policy statements. The study culminates to a recommendation for a uniform pricing and tariff regime for water that takes into consideration actions that sustain water resources and the environment in river basins.

3.11.2 Main Findings

(1) In line with the draft NWR Policy, a framework for a national water resources pricing initiative that can lead to the formulation of a national water resources pricing mechanism is needed to meet the commitments of the proposed National Water Resources Policy.

(2) The water sector can be divided into two sub-sectors: the water resources sector and the water services sector. Water pricing is predicated on a set of economic and financial principles, which deal mainly with the water services sector such as in the functions to abstract, treat and distribute the processed water to the consumers. It has a tariff structure catering mainly to the various categories of consumers (domestic and industries).

(3) In the water resources sector where water is considered a natural resource, water pricing is not at all developed, and this Study recommends that it should be developed in future because water has an economic value just like any other natural resources such as minerals and timber (from forests). The development of an economic value of water resources has considered the non-financial components such as the environment, which is often difficult to monetize but is nevertheless important in the overall water pricing mechanism.

(4) The water pricing mechanism for the water resources sector will differ from the mechanism in service sector, as the former caters to sustain and conserve water resources and the environment, while the latter caters basically to consumers. The different emphasis placed on the two water sub-sectors will therefore have a fundamental effect on the economic value of water.

(5) *Current Water Tariff Status in Malaysia*

Malaysia has one of the lowest water tariffs among the newly industrialized nations. It has a graduated or varying water tariff structure. Currently, there is no uniform water tariff in the water sector in the country. As far as the water services sector is

concerned, different States have their own water tariff structures. **Table 3.47** and **Table 3.48** shows the industrial and domestic water tariffs by States for 2009.

Table 3.47 – Industrial Water Tariff by States, 2009

State	Average Water Tariff (RM/m^3)	Tariff Rank
Sabah	0.9	1
FT Labuan	0.9	1
Pulau Pinang	0.94	2
Kuching	1.06	3
Limbang	1.06	3
Terengganu	1.15	4
Sarawak	1.19	5
Kedah	1.2	6
Bintulu	1.21	7
Kelantan	1.25	8
Perlis	1.3	9
Pahang	1.45	10
Melaka	1.47	11
Negeri Sembilan	1.59	12
Perak	1.6	13
Selangor	2.27	14
Johor	2.93	15

Source: Jabatan Bekalan Air, Kementerian Tenaga, Teknologi Hijau & Air (KeTTHA)

Table 3.48 - Domestic Water Tariff by States and Areas, 2009

State	Average Water Tariff (Domestic) (RM/M3)	Tariff Rank (Domestic)
Pulau Pinang	0.31	1
Terengganu	0.52	2
Kedah	0.53	3
Kelantan	0.55	4
Sarawak	0.56	5
Perlis	0.57	6
Pahang	0.57	6
Bintulu	0.61	7
Kuching	0.62	8
Limbang	0.62	8
Negeri Sembilan	0.68	9
Melaka	0.72	10
Perak	0.73	11
Selangor	0.77	12
FT Labuan	0.9	13
Sabah	0.9	13
Johor	0.98	14

Source: Jabatan Bekalan Air, Kementerian Tenaga, Teknologi Hijau & Air (KeTTHA)

(6) *Water Subsidy*

Generally, water subsidies lower the price of water relative to the price of other consumptive goods. It is expected that water subsidies to households will have a small impact on the rest of the pricing system and the economy because the expenditures for water in the household are very low as compared to energy. The impacts of subsidy on the production / supply side will be more significant. **Table 3.49** provides a general indication of the groups that need water subsidy. Of the four groups, 95% households will not need subsidy for piped water; while the rest will be in Group 2. This is based on the assumption that the low-income group accounts for less than 6% of the total households[1].

Table 3.49 - Public Interventions in Subsidy

Households		Group	Need for Subsidy
Could Afford Connection	Could Pay Monthly Bill		
Yes	Yes	1	Group does not need subsidies
Yes	No	2	Water needs to be provided at low tariffs
No	Yes	3	Need for connection subsidies, or payment facilitation
No	No	4	Subsidized provision needed

Source: David le Blanc (2007), A Framework for Analyzing Tariffs and Subsidies in Water Provision to Urban Households in Developing Countries, United Nations

(7) There is a distinction between connection subsidy and consumption subsidy. In Malaysia, the connection subsidy is a non-issue. The practice of consumption cross-subsidy is in the supply of potable water through higher tariffs and water prices for industrial users to cross subsidize domestic users. Malaysia will continue to practise the cross subsidy until the public is willing to accept the increase in water tariff towards full cost recovery in future.

3.11.3 Recommendations for Pricing Water Resources

(1) It is recommended in this Study to adopt a uniform pricing and tariff regime for water supply taking into consideration of actions that can sustain water resources and the environment in river basins. Although different States have their own supply and service providers, an equitable uniform price and tariff structure will be much easier to enforce. Below are some recommendations and guiding principles for pricing that take into consideration water resources and the environment.

(2) **National Water Resource Pricing Guidelines**

In line with the draft NWR Policy, a set of national water pricing guidelines is recommended to be developed by the Federal and State Governments to conserve

1 Tenth Malaysia Plan (RMK-10) indicates that incidence of poverty in Malaysia is 5.7%

and sustain water resources. The guidelines shall set out the types of pricing mechanisms, the factors for determining fair and affordable tariffs taking into consideration of the price of sustaining water resources from abstraction to production throughout the country.

(3) **National Water Tariff Policy**

In accordance with the national water resources pricing guidleines, the existing water tariff policy and structures can be re-formulated for implementation by the States. The policy is likely to include the main objective of ensuring long-term availability, sustainability and conservation of water resources for all consumers, in addition to those caterring to water service sector.

(4) **Pricing for Potable Water**

The key objective of investing money in infrastructure projects is the returns on investment. Fair pricing for potable water shall now have to take into consideration of the domestic consumers' affordability[1] and the environment. The aims are to:

- ensure water utility companies bear for the costs of introducing improved water treatment technology when managing drinking water;
- ensure quality drinking water to meet the public health standards;
- allow water for different users including industries and agriculture;
- ensure water suppliers and service providers continue to invest in the improvement of supply and quality including the source areas;
- include agreed approaches in pricing policies to offset or avoid negative environmental impacts;
- raise awareness and expectations of customers in relation to value for money services.

(5) **Pricing for Agricultural Water**

The need to improve agricultural productivity puts a great pressure on water resources as agriculture is the main consumer of water among all sectors. If the Government decides that farmers have to pay for agricultural water (a policy and strategic decision), it will need to consider appropriate guiding principles that will assist in reducing the potential socio-economic problems arising from the implementation of the policy.

The fact that in agricultural areas water is charged at a very low rate is not reflective of the true value of water. Thus, to get the true value of water in agricultural areas, many factors have to be considered; chief among them are the costs incurred from

abstraction to distribution and restoration of water quality and quantity in the receiving rivers, in which the return flows, often polluted, are discharged back into river systems. As far as paddy cultivation is concerned, an overall water-pricing regime based on the true value of irrigation water is unlikely to be implemented, as it will generate negative social and economic impacts. There will be a need for awareness creation and capacity building among the farming community that there is a cost attached to irrigation water and that subsidized water cannot last forever.

(6) **Pricing for Groundwater**

Groundwater is an important source of water and needs protection from over-abstraction and contamination. Groundwater abstraction, treatment and distribution have not been fully developed, except for Kelantan where the abstraction is for consumption. Manufacturers dealing with water such as mineral water production are increasing and the volume of groundwater abstraction is likely to increase exponentially in future. Given this scenario, the true cost of groundwater has to be established and the prices should be regulated based on market forces.

(7) **Water Subsidy**

Presently, water is highly subsidized for the benefit of consumers. The policy of full cost recovery is only realized by water corporations and privatized utilities, with subsidy from the Federal and State Government.

In the case of agriculture and potable water, the Study does not advocate the application of cross-subsidy from the non-agriculture to agriculture sectors. However, the Study proposes an indirect subsidy for the poor households who are unable to pay for water. Indirect subsidy, however, does not indicate a change in the water tariff and pricing. These are measures taken that are unrelated to water tariff and pricing, such as water bills being paid for by the Government or respective agencies (such as Welfare Department, District Offices, local authority or water authority) on behalf of the poor households. Alternatively, the bill is offset by the water supplier. The users must, however, declare their status and register with the respective agency to be accorded with such subsidy treatment.

(8) **Water Equity**

The present Study takes into account of the characteristics of water as a resource, regulatory jurisdiction development, relevant Federal and State Government policies and statutory responsibilities of the respective authorities. To achieve effective water equity for all consumers with fair prices, however, there is a need to consider some of the prerequisites as follows:

- **Cost Reflection**

  The first key principle in pricing water is that prices of water delivered to the end users should be cost reflective; that is, it should reflect the costs of

providing the service and, usually, where the demand for water exceeds its supply, potentially incorporate a value for the resource. In many communities, water has traditionally been regarded as an essential commodity and is provided without reference to the costs associated with its delivery or use. In some areas this has resulted in excessive use, over-investment in infrastructure and environmental degradation. Thus, the price of water must reflect the total cost of producing quality water, deliveries and maintenance. The capital cost on infrastructure and facilities must also be reflected.

- **Forward Looking**

  The water tariff should be forward-looking. It should represent the least cost, which would now be incurred in providing the requisite level of service over the relevant period. Unlike manufacturing mineral water from groundwater, for example, the price of potable water should consider a long life span for cost recovery. Water infrastructure is good over a long period, probably up to 50 years with proper maintenance. The forward-looking approach allows the unit cost of water to be lower as the length of time increases.

- **Revenue Adequacy**

  The revenue component has to be addressed and established in a regulated service environment. This is to ensure efficient and effective services to the consumers. Setting a maximum limit to revenue will provide a basis for most approaches in establishing water rates.

- **Sustainable Investment**

  For sustainable investment where services are to be maintained into the future, investors must be given the opportunity to recoup an appropriate return on investment. Water pricing must consider this as a cost factor and allows the investors to receive a reasonable profit margin to enable them to inject part of the returns for future development.

(9) **Regulatory Efficiency and the Stakeholders**

Pricing method minimizing regulatory intrusion and compliance should be adopted. However, sometimes the rates are being separately charged by more than one authority. For example, some countries have imposed a conservation surcharge, sale tax and resource tax involving more than two parties. For the developed nations, these separate charges may not create any issues on the part of the users, but could be a problem in Malaysia where payments have to be made to more than one authority and on different locations. The use of a one-stop-centre to collect all of the water payments may reduce the problems.

Regulatory intervention in deciding water pricing does not occur without some risks of regulatory failure. Where regulatory intervention is required, additional objectives may have to be followed such as low regulatory compliance costs; accountability and transparency of the process to promote consistency, allow for ready verification of compliance; and involvement of stakeholders to ensure comprehensiveness and transparency.

(10) **Public Interest**

Public interest is important in water pricing considerations as they must be aware of and are able to see the benefits of paying a bit more to enjoy good quality water.

(11) **Full Cost Recovery (FCR)**

FCR is very difficult to achieve. However, the followings are a list of recommended elements to move the FCR forward:

- Public awareness and participation;
- Full cost recovery must include environmental costs;
- Metering and pricing schemes for all sectors;
- Increasing block schedules, in which prices increase with larger volumes of water consumed;
- Seasonal variations;
- Earmarking of water charges;
- Minimizing fixed and minimum charges;
- Providing information to water users;
- Providing an understandable bill;
- Transparency, and
- A gradual transition to new pricing schemes.

SECTION 4

ENVIRONMENTAL STUDIES

Section 4 ENVIRONMENTAL STUDIES

4.0 WATER RESOURCES AND THE ENVIRONMENT

4.1 INTRODUCTION

(1) Water and the environment are symbiotically linked and interdependent on one another. Factors that threaten the integrity of the environment will also make water vulnerable to its overall availability and quality. Thus, the governance of water resources in Malaysia has become very complex. Any water crisis ranging from a case of having too little, too much or the water being too polluted is now considered a crisis of governance, not only for water but also the environment.

(2) To ensure security and sustainability of water resources, which are highly dependent on rainfall and the environment, the Federal Government is now moving towards greater involvement in the conservation of water source areas, integrated management of river basins from source to the sea, tighter control on water pollution through strict enforcement and monitoring actions, and preserving biological diversity and the environment. It is also looking at alternative sources of water and water recycling, and encouraging the application of new technologies that can improve water quality, reduce water demand, whilst subscribing to the need for water savings and preparing the country to better cope with the perceptible negative effects of climate change.

(3) The above views have been reflected in the 5-year development plans, the most recent being the Tenth Malaysia Plan 2011 – 2015, which treats natural resources and water as Malaysia's natural endowments. With regards to the environment, the Tenth Malaysia Plan states that "*the Government will ensure that Malaysia's environmental assets and ecological resources are managed sustainably, so that present developmental needs are met without compromising the future*". To achieve this, progressive policies have been introduced in the Tenth Malaysia Plan, guided by the framework for Awareness, Faculty, Finance, Infrastructure, Research and Marketing (AFFIRM), which outlines the creation of a comprehensive ecosystem approach to environmental and water resources sustainability.

(4) The Study has taken the approach to present an overview of the nation's environmental and water resources assets focussing on the environmental requirements and the limiting factors that reduce water quantity and quality, and ways to sustain the environment in order to sustain water resources.

(5) The JICA Study (1982) and the NWRS (2000-2050) were reviewed, with this Final Report providing the updated environmental and water resources profiles, with important information on the survival of sensitive ecosystems and habitats, for example, wetlands and forests, that if lost or degraded, could severely affect the river water regimes and water source areas that provide water for beneficial uses. This

updated information is also invaluable for the States in their allocation of water resources for a variety of beneficial uses on a secure and sustainable basis.

(6) For comparative purposes for the country as a whole, the Study has identified a number of water resources and environmental diagnostic indicators for individual States, which collectively provide the status of water resources in the country. The integration is presented in the form of a National Water Resources Vulnerability Index (NWRVI). The NWRVI is useful to provide the States and the country with a standardised method for characterising their water resources vulnerability in relation to the environment (e.g. degraded environment causing water stress or flooding) for targeted actions to ameliorate the problems in the immediate, medium and long-term periods.

4.2 PRIORITY NEEDS OF THE ENVIRONMENT

Ecosystems and the environment are often prioritized lowly in the economic planning and decision-making process for water resources development and allocations, when compared with potable water supply and irrigation needs, which take precedence. From an environmental perspective and consequent to the physical, cultural and historical backgrounds of each State, the requirements by the environment and the ecosystems should be recognised equally alongside domestic, industrial and agricultural demands on water resources, as they serve and provide many essential functions, including:

(i) Regulation (moderate micro-climatic conditions, provide water resources for supply, flood protection, erosion control, water purification, natural pest control);

(ii) Habitat (refuge for wildlife and migratory species, reproduction habitat for harvestable species);

(iii) Production (food, fisheries, raw materials, fertilisers, medicinal resources, ornamental resources such as aquarium fish); and

(iv) Aesthetics/recreation (valued scenery, tourism, cultural and historical value, scientific and educational support).

4.3 SOCIO-CULTURAL AND LANDUSE PROFILES

(1) The landuse by States is divided into four categories of usage, namely, water body, forest, agriculture and built-up areas as illustrated in **Figure 4.1.** Forests form the largest overall landuse in the States of Kelantan, Sabah, Sarawak, Pahang, Terengganu and Perak. These are the spatially larger States in the country and therefore they are also the water-rich States, where they possess extensive "water source areas".

(2) This NWRS has shown that the future landuse will be closely associated with urbanisation and industrial development within the States and in relation to the five

proposed development corridors, the details of which are provided in Volume 4 and the State reports.

(3) River basins within the States are cultural heritage areas as most of the socio-cultural aspects of population and settlements have their beginnings along rivers where there is freshwater. Thus, for example, the Sg Merbok-Muda basin complex (in Kedah) is arguably the richest archaeological site associated with the Bujang Valley. Upstream of Sg Perak is where the "Perak Man" (Paleolithic period, Perak) was found, which is the oldest site of human occupation in the country, and the stretch of river from Bota to Batu Gajah, Parit, Pasir Bogak and Kuala Kangsar, is often referred to as the "Valleys of the Kings" due to its rich historical association with the State's royal settlement. Descriptions of the socio-cultural, archaeological, heritage and historical areas that are flood-prone, and areas dependent on freshwater for their continual survival, are provided in Volume 4 and the State reports.

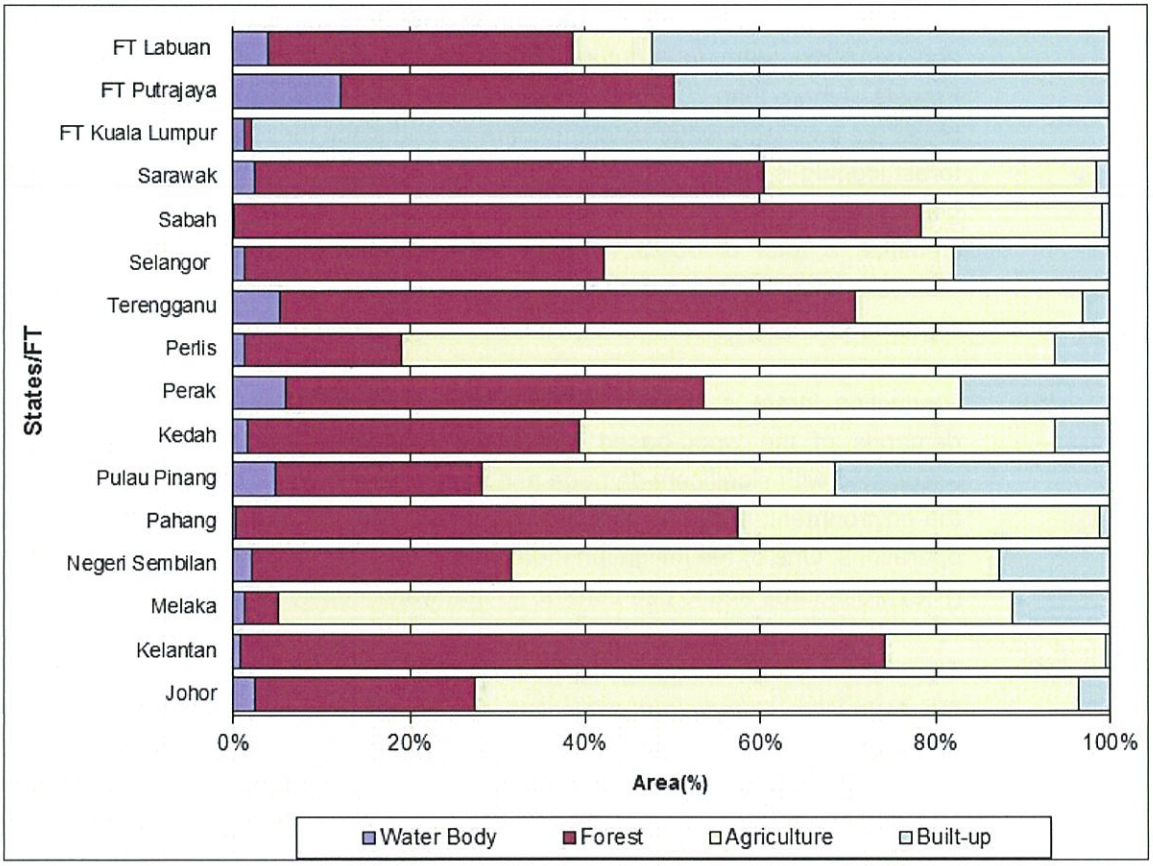


Figure 4.1 - Current Landuse of States in Malaysia

4.4 FOREST ECOSYSTEMS

(1) In terms of the environment, forest forms the largest single ecosystem in the country. But it is under threat of being degraded and fragmented through logging and encroachment by development. In some States such as Melaka, Johor, Pulau Pinang, Perlis and the FT Kuala Lumpur, forests have already been cleared for other forms of landuse, mainly for agriculture as in the case of Johor and Melaka. Built-up

areas cover most of the spatial areas in FT Kuala Lumpur and to a certain extent Pulau Pinang, which saw agriculture and forest sharing equal areas of the landuse.

(2) In total, forests cover 19.52 million ha or 59.5% of the total land area in Malaysia, consisting of 5.88 million ha in Peninsular Malaysia, 4.40 million ha in Sabah and 9.24 million ha in Sarawak (**Table 4.1**).

(3) Malaysia's commitment to managing its' forests in a sustainable manner is not just for economic reasons but more importantly, for maintaining environmental integrity, ecological balance and to achieve its' social obligations. It carries this out through the gazettal of forests under the Permanent Reserved Forest (PRF) programs, national and State parks or other legally protected forests in an effort to conserve the various types of forests for future generations (**Table 4.2**).

(4) In terms of sustaining the water resources and maintaining the environment, State authorities are required to gazette and delineate forest catchment areas to protect and conserve them from future developmental activities including forest logging. Forests of more than 1000 meters above mean sea level are now protected, as these areas are invariably water catchment areas, and since these are also sensitive areas, forest logging is not permitted to sustain the important function of continual supply of good water quality for beneficial uses. So far the National Forestry Council has identified a total of 839,357 ha of these forests within the PRF in Peninsular Malaysia, 231,150 ha in Sabah and 4,079,535 ha in Sarawak, to be gazetted as water catchment areas.

(5) Production forest is allowed for harvesting to generate revenue and to meet the demands of the wood-based industries. However, forest harvesting is normally associated with significant damage and impairment to water quality and quantity, and the environment, and thus requires effective abatement measures during harvesting operations. One of the mitigation measures is to adopt the "*Reduced Impact Logging*" (RIL) procedures and to use buffers, so that water quality can recover after logging.

(6) The importance of managing forests for water resources is significantly highlighted in the *Malaysian Criteria and Indicators for Forest Management Certification* or the MC&I (2002), the standard used for assessing forest management practices at the Forest Management Unit (FMU) level. For the purpose of certification, nine Principles and 47 Criteria of sustainability are used, of which Principles Number 5 and 6, explicitly address practices to protect hydrological parameters and water resources.

Table 4.1 - Distribution, Area and Types of Forests in Malaysia in 2008 (million ha)

Region	Land Area	Natural Forest			Plantation Forest	Total Forested Land	% of Total Land Area
		Dry Inland	Swamp Forest	Mangrove Forest			
Peninsular Malaysia	13.16	5.40	0.30	0.10	0.08	5.88	44.7
Sabah	7.37	3.83	0.12	0.34	0.11	4.40	59.7
Sarawak	12.30	7.92	1.12	0.14	0.06	9.24	75.1
Total (Malaysia)	**32.83**	**17.15**	**1.54**	**0.58**	**0.25**	**19.52**	**59.5**

Source: Food and Agriculture Organisation (FAO), 2010

Table 4.2 - Permanent Reserved Forest (PRF) in Malaysia 2008 (million ha)

Region	Protection forest	Production forest	Total Area under PRF	% of Total Land Area
Peninsular Malaysia	2.00	2.80	4.81	36.6
Sabah	0.59	3.00	3.59	48.7
Sarawak	1.10	5.00	6.10	49.6
Total (Malaysia)	**3.69**	**10.81**	**14.50**	**44.2**

Source: FAO, 2010

4.5 LAKE AND WETLAND ECOSYSTEMS

(1) Lakes and wetlands are special ecosystems in that the water table is very high, often fluctuating depending on the rainfall, and they are very location-specific where they develop their own unique system of water-related habitats adapted to the water conditions. A major constraint in terms of water resources in these areas is the quality of the water in the lakes and wetlands. The Carlson's numerical Trophic State Index (TSI) (1977) shows that as many as 62% of the 90 registered lakes in the country are eutropic, meaning that they are polluted. The details and an inventory of the lakes are provided in Volume 4.

(2) The main threats to wetlands are reclamation, logging and conversion to agriculture and urban development. Some of the wetlands are located within forest reserves categorised as "Production Forest" such as the Beriah Swamp, which has seen critical losses in endemic flora and fauna species and habitats when it was converted for oil palm cultivation. As wetlands are depository sites for valuable biodiversity and genetic materials not found in other ecosystems, it is clear that there is a need to protect them for such a purpose. Wetlands will also need protection for their other functions such as ecological and water purification, shoreline and riverbank protection against storm surges, recreational potential, water regulation, food gathering and cultural significance.

4.6 AQUATIC ECOLOGY

(1) Besides the wetlands, rivers are also special ecosystems and being fluvial, they have flowing water within the river system all the time. Depending on the river morphology, fluvial conditions and the water quality, the aquatic life will adapt to the flowing water environment. However, some fish will migrate upstream against the flow to breed

such as the *Kelah* and *Terubok*, and therefore there is a need for a minimum flow to sustain the migration of these fishes upstream to complete their life cycle.

(2) The State reports have provided information on some important fish species including their status and natural habitats to highlight the threats of on-going development to their survival. Current conservation efforts include providing an optimal environmental flow that causes least disruptions to the food chain and more protection for their spawning areas, amongst other measures.

4.7 INLAND FISHERIES AND AQUACULTURE

(1) Inland fisheries and aquaculture are two components that affect the water resources as they require water of sufficient quality for their breeding and living habitats. Their washing and return flows after harvest are often highly polluted with chemicals.

(2) Rivers that provide freshwater and drain from them have an impact further downstream on the operations of brackish (saline) water ponds for shrimp farming, shellfish beds, hatcheries and seaweed culture, and to a lesser extent, oyster culture in estuarine and coastal areas. The use of polluted water in aquaculture may incur losses to the cultivators, causing high mortality rates especially in hatcheries and contamination of consignments. Clean water in aquaculture is therefore essential to provide and maintain an optimal environment for growth and to ensure quality of harvest.

(3) In 2008, there were approximately 46,082 freshwater ponds distributed over about 4,916 ha in the top five States of the country: Sarawak, Sabah, Perak, Kedah and Negeri Sembilan. There were also about 13,041 brackish water ponds distributed over about 7,137 ha in the top five States: Sabah, Sarawak, Perak, Selangor and Johor.

(4) In future, when clean freshwater becomes scarce due to higher pollution loads in rivers and growing demands for portable water, greater effort is needed to optimally manage and conserve the water resources, both surface and groundwater. To promote efficient use of water in aquaculture production, the Water-Use Index, can be adopted as a measuring tool. Recommendations to enhance aquaculture productivity and improve water quality are found in methods such as using seaweed bio-remediation, integrated aquaculture farming, recycling of effluent and adhering to sound and accepted best practices in aquaculture, as described in Volume 4. Aquaculture can be sustainable provided all interested parties and stakeholders – government, related authorities and farmers are willing to co-operate.

4.8 RECREATION AND TOURISM

(1) Tourism and recreational activities impinge upon water resources in two main areas; direct consumption of water by tourists and secondly, clean raw water is necessary for tourism sites to sustain their attraction. Direct consumption of water by tourists is supplied through hotels, restaurants, eating shops and public conveniences. All

water-related tourism and recreational sites will also require adequate, free-flowing, clean water for sustaining their attraction and for operational efficiency. These sites include all the idyllic and pristine islands, waterfalls, lakes and rivers which attract water-sport recreation and activities such as white-water rafting and boarding, and all the golf courses. The quality and quantity of water in these places are necessary to provide the "draw factor" in the tourism industry.

(2) Factors that determine the potential of sites for water-related tourism are landuse composition, population density, and water resource quantity and quality. Sarawak, Sabah, Pahang, Terengganu, Kelantan and Perak appear to have great potentials for water-related tourism to grow and expand due to the rich natural endowment of water resources and relatively low population density. However, Pulau Pinang and Melaka are highly urbanised and densely populated, but they are important tourist destinations too because of their rich history, even though they are not richly endowed with water resources. They have reached saturation in water-related tourism and recreation attraction and may even decline if water resources management in these two States is not carried out prudently.

4.9 WATER QUALITY AND SOURCES OF POLLUTION

(1) All land clearing, urban, industrial and agricultural activities will affect water quality in rivers, lakes and wetlands. Polluted rivers will result in a loss of water resources causing habitat decline and even collapse, increasing the cost of treating potable water, impacting on the health of the rivers and the water users, and eventually increasing conflicts among stakeholders as they fight over diminishing water resources. If water pollution persists, it can be foreseen that there will be inadequate water to meet all the demands in the country be it for industry, agriculture, potable water supply or environmental needs.

(2) Among the main agencies that are monitoring water quality are:

(i) The Department of Environment (DOE), which in 2008 reported that it monitored water quality at 1,063 stations within 143 river basins throughout Malaysia. It also monitors point sources from industries discharging effluent of more than $60m^3$/day, maintains a pollution point source inventory and records of sewage treatment plants, agro-based and manufacturing industries and animal farms.

(ii) The Department of Irrigation and Drainage (DID) maintains 28 water quality stations in the Peninsula together with corresponding flow data of the main rivers in the country.

(iii) The Natural Resources and Environment Board of Sarawak maintains 164 water quality monitoring stations in Sarawak.

(iv) The Ministry of Health (MOH) monitors raw water quality at every potable water intake. It also administers the National Drinking Water Quality

Surveillance Programme (NDWQSP) to ensure safety and acceptability of drinking water for consumers by reducing the incidence of water-borne communicable diseases or intoxication of water supplies through long-term surveillance.

(3) The ambient waters in the rivers have been classified by DOE into general categories of clean, slightly polluted and polluted according to the Water Quality Index (WQI), which is a composite index based on six parameters: Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), pH, Ammoniacal Nitrogen (AN) and Total Suspended Solids (TSS). **Table 4.3** summarises the number of rivers categorised as Classes I - V by States.

(4) The results showed that 58% of the rivers monitored in 2008 were classified as clean while 38% were considered slightly polluted. Only 4% were considered polluted and these were mainly rivers, which flowed through densely urbanised and industrial areas. The detailed results and assessments of water quality by States are provided in the State reports along with indications of possible causes of deterioration in river basins.

Table 4.3 - WQI for Rivers in Malaysia 2008

State	Perlis	Kedah	Kelantan	Perak	Selangor	Melaka	Johor	N. Sembilan	Pahang	Pulau Pinang	Terengganu	Sabah	Sarawak	Total
Class I	1	5	1	5	-	1	1	-	4	1	-	5	-	24
Class II	4	14	25	30	19	8	67	10	67	7	26	57	42	376
Class III	3	7	4	16	18	9	38	5	7	22	7	7	14	157
Class IV	-	-	-	-	3	1	8	-	1	6	1	-	-	20
Class V	-	-	-	-	-	-	1	-	-	-	-	-	-	1

Source: Department of Environment, 2009

(5) Water pollution originates from many sources that can be grouped into point and non-point sources as shown in **Table 4.4** together with their potential impacts on the environment.

Table 4.4 - Water Pollution Sources and Potential Environmental Impacts

Source	Types of Pollution	Potential Environmental Impact
Land Development	• Surface runoff • Erosion and sedimentation from land clearing • Oil, grease and hydraulic fluid spills	• Loss of existing landuse/ terrestrial habitat • Loss of vegetation and changes in landscape • Smother benthic fauna and aquatic plants and reduce photosynthesis • Increase in surface water turbidity • Loss of soil resources and landslides • Accumulation of sediment may increase the risk of flooding • Water pollution problems in water bodies • Increasing runoff and increasing peak flow resulting in flash floods and localised flooding
Industry	• Scheduled waste generation • Hazardous solvents • Acidic and alkaline materials • Industrial effluents, heavy metals, solid and scheduled wastes • Oil, grease and hydraulic fluid spills • Spills of raw materials and chemicals due to leakages	• Oil and grease from equipment may get into water bodies causing hydrocarbon contamination and affect aquatic lifeforms • Benzene and poly-aromatic hydrocarbons, which are soluble constituents of fuel are recognised carcinogens • Heated liquid discharges can have an impact on marine and aquatic life • Inhibit biological processes • Increase physical distress in aquatic lifeforms • Cumulative effect in food chains through heavy metal bio-accumulation • Some PCBs maybe mutagenic or carcinogenic causing health problems to aquatic life and humans handling the substances • Increasing pollution load into water bodies (BOD, COD, AN, TSS)
Residential	• Sewage effluent • Sullage • Solid wastes • Storm-water	• Organic pollution (AN, *E. coli*, BOD and COD) in receiving waters resulting in euthrophication • Relative temperature differences or excess nutrients will affect aquatic ecology • Fish kills through accidental spillage of toxic chemicals (e.g. chlorine) • Solids in discharges may block fish gills and smother benthic life • Anoxic conditions in low water level conditions • Sludge layer formation
Commercial	• Commercial wastewater • Commercial wastes	• Water quality deterioration or contamination due to high concentrations of *E. coli*, BOD, COD and AN
Agriculture	• Irrigation discharge • Nutrient loads (nitrogen, phosphates) • Pesticides, herbicides and fungicides • Sedimentation from land clearing and cultivation	• Affect ecosystem balances • Reduce dissolved oxygen levels • Taint water and unpleasant aesthetic quality • Genetic alteration of forage fish fauna • Excessive phosphates cause undesirable algal blooms and excessive growth of aquatic plants • Insecticides will cause carcinogenic,

Source	Types of Pollution	Potential Environmental Impact
		mutagenic, fetotoxin, hormonal effects • Herbicides will reduce population of crustaceans and amphibians, immunotoxin • Fungicides will cause carcinogen, mutagen, teratogen, transformation product
Aquaculture	• Aquaculture pond discharge • Clearing of wetlands for pond construction • Salinity increase	• Concentrations of suspended solids, organic matter, total phosphorus and total nitrogen
Livestock	• Animal wastes • Nutrient loads	• Give rise to serious organic pollution (AN, *E. coli,* BOD, and COD) in receiving waters
Recreation	• Sullage	• Sodium salts can cause some clay soils to change their structures and become unsuitable for absorption • Hair, lint and other suspended particles
Hydropower	• Lower environmental flow downstream • Sedimentation and silt discharge	• Altered surface hydrology affecting aquatic life • Reduced water quality due to silt and other debris • Over abstraction affecting downstream users
Water Transportation	• Oil and grease from maintenance of crafts	• Oil and grease may get into the water bodies causing hydrocarbon contamination and affect aquatic life-forms
Mining	• Mine tailing • Heavy metal pollution • Waste rocks and sedimentation	• Prospecting for mineral resources often requires drilling and/ or strip mining resulting in massive land clearing • Oil drilling releases oil and grease • Heavy metals, cyanide and residual chemicals from mineral processing released as mine tailings and contaminating the water
Sand mining	• Sedimentation from sand dredging	• Accelerated riverbank erosion causing the riverbed to become shallower • Alteration of river morphology and flow regime
Waste Disposal	• Landfill leachate • Solid wastes	• Surface and groundwater contamination • Eutrophication through enriched water discharge • Disease vector proliferation in stagnant pools • Odours from emissions • Public health and sanitary problems from improper disposal
Forest logging	• Sedimentation from land clearing	• Loss of habitat and ultimately obliterate the wildlife • Increase surface exposure and erosion rates • Disturbed forest water balance resulting in higher erosion rate and possibility of flooding
Groundwater abstraction	• Saline intrusion	• Increasing abstraction, particularly in low water table areas, may result in increasing intrusion of saline waters resulting in soil contamination

Source: Compiled for this NWRS

4.10 POLLUTION FROM SEWAGE

(1) Sewage in large quantities, untreated or partially treated, will contribute to water pollution in rivers, and is an important limiting factor in water resource use. Due to the highly populated and urbanised nature of FT Kuala Lumpur and Selangor, their rivers have BOD loads which are highest in comparison with other States.

(2) Apart from sewage from the human population, animal husbandry also produces an appreciable volume of untreated animal waste that often ends up in water courses. Unfortunately, impacts from such activities causing water pollution have not been given due attention except perhaps for hog farming. Generally, the Department of Veterinary Services of Malaysia (DVS) has stated that all discharges from hog farms in the country should comply with Standard B BOD level, which is 50mg/L. Pollution from animal husbandry is one area that needs further studies in terms of pollution control in the rivers in the country.

4.11 POLLUTION FROM SOLID WASTE

(1) Solid waste is another source of water pollution. It poses a problem when it is dumped into river systems causing water pollution, blockage to the flow of river water and localised flooding.

(2) Malaysia currently produces approximately 8 million tonnes per year of municipal solid waste, which are dumped within landfills with the majority of wastes consisting of food wastes (45%) and plastics (24%) (Jabatan Pengurusan Sisa Pepejal Negara, 2009).

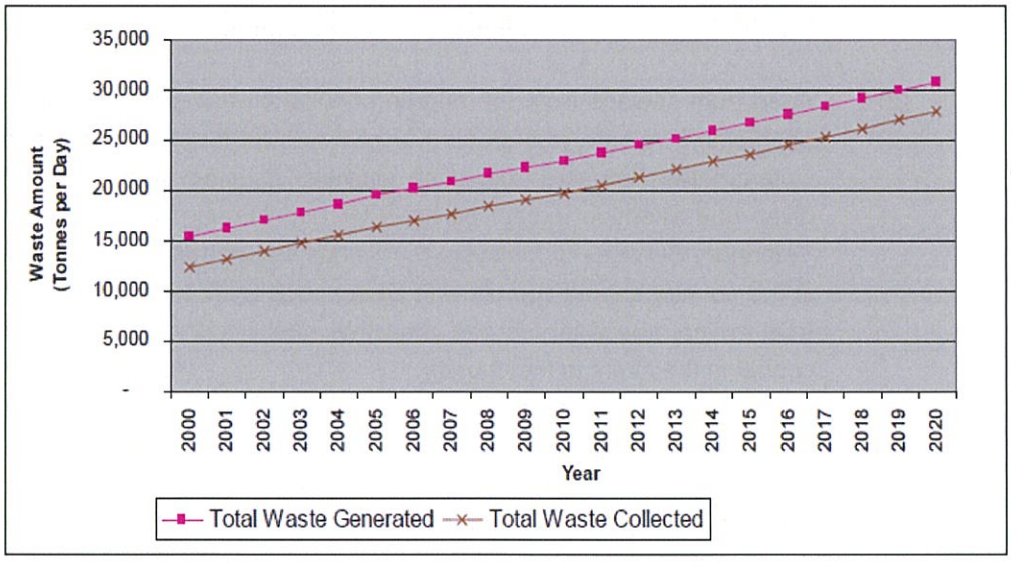
(3) There are 290 landfills listed in the country (Jabatan Pengurusan Sisa Pepejal Negara, 2009) with nearly 94.3% of the operating landfills being non-sanitary landfills (Level I and II).

(4) The main impact from solid waste is the leachate that it produces that will affect surface and groundwater quality. Most of the landfills in the country are unsanitary ones with no ground linings, and therefore the principal concern is focused on the pollution potential due to migration of leachates generated from these landfill sites, which seep into and contaminate groundwater supply sources.

(5) Surface and groundwater pollution by leachates (heavy metals, toxic organic compounds, acidity) has several adverse effects on human health reflected in the form of carcinogenic symptoms, skin disorders, neurotoxicity, kidney damage, suppressed immunity, digestive disorders, as well as adverse effects on flora and fauna. The constituents of the leachates may also contain high levels of ammoniacal nitrogen and organic acids that will affect aquatic life in rivers.

(6) In the event that the leachate escapes into the watercourse, the oxygen content will slowly deteriorate, resulting in the establishment of anaerobic conditions, which threaten aquatic life in the rivers. Although a degree of dilution of these contaminants

is possible in rivers, the impact on water treatment plants downstream is a concern due to the difficulty in treating water tainted with ammonia and heavy metal constituents to produce potable water. As seen in **Figure 4.2**, the problem will only escalate in future when the tonnage of waste increases.



Note: Waste Generation and Waste Collection Amount derived from
(a) current population in Population and Housing Census of Malaysia, 2000 and population projection by Draft National Spatial Plan, 2001; and
(b) waste assumptions of study team (see **Appendix 6G of Volume 3**).

Figure 4.2 - Waste Projection for Peninsular Malaysia, 2010-2020

4.12 ENVIRONMENTAL FLOW

(1) The health of river systems and ecosystems is sustained by adequate amounts of water passing through them. There are several models for determining the amount of water required for a particular river system, often referred to as the environmental flow. The approach in this NWRS report on environmental flows includes the following:

(i) A review of the NWRS (2000-2050) with respect to environmental flow issues;

(ii) Developing a framework for assessing the ecological and environmental functions of rivers, which require special protection and provision of environmental flow;

(iii) Providing a sequential methodological approach in best management practices to achieve optimal environmental flow management. This includes providing examples of rivers in each State demonstrating the application of the approaches, which maybe used to assess and estimate environmental flow requirements for different types of water resource areas and different data availability; and

(iv) Recommending strategies for maintaining river environmental flow.

(2) Most studies use the term "environmental flow" to apply to the minimum amount of water left in a water system and often, for a single purpose, such as:

(i) Streamflow requirements or in-flow requirement (IFR);
(ii) Flows for fish only;
(iii) Maintenance of IFR;
(iv) Drought IFR;
(v) Ten percent of Mean Annual Flow, or other percentiles;
(vi) The flow regime required to maintain all river ecosystem functions, and to provide sufficient access to water to allow plants and animals to reproduce in most years; and
(vii) Minimum flow or 7-day low flow.

(3) Based on a review of environmental flow approaches, it is proposed that an estimation of the environmental flow of Malaysian rivers be carried out using the Smakhtin and Eriyagama (2008) approach with the subsequent "Adaptive Refinement of Flow Prescription" method to achieve the environmental objectives for each river.

(4) Two main factors are considered for environmental flow: first, the most likely ecological condition and second, the management perspective. The "most likely ecological condition" is expressed in terms of physical, chemical and biological aspects. The "management perspective" is expressed in terms of landuse activities and management policies or plans for the river catchment, including the level of development and the likely stress faced in managing the aquatic system.

(5) Six Smakhtin and Eriyagama classes have been compared with the three DOE river water quality classification of polluted, slightly polluted and clean, from the Water Quality Index, to work out the environmental flows. Examples have been given of the range of flows in rivers that need to be considered to maintain beneficial uses, to the aquatic organisms and to the associated communities they support. These communities are not only the flora and fauna along the rivers and riverbanks, but also include human communities who are dependent on the aquatic environment for irrigation and fisheries, among other uses.

4.13 NATIONAL WATER RESOURCES VULNERABILITY INDEX (NWRVI)

(1) Based on the environmental requirements and the limiting factors on water resources, the availability and quality of water are highly vulnerable to changes caused by the amount and uneven distribution of rainfall and the environmental conditions that sustain them. Pollution caused by anthropogenic activities is another diagnostic factor showing the limits of water quantity and quality for beneficial use. Thus, a degraded environment for example could lead to a threatened or vulnerable condition in the availability and quality of water resources.

(2) The complex relationship between the environment and water resources is integrated by using the NWRVI. The NWRVI is an approach to provide an overall indication of the status of the environment vis-à-vis the water resources. Vulnerability is defined here as the degree to which a system (such as, water resources or the environment) is likely to experience harm as a result of exposure to perturbations or stress. The NWRVI is useful to provide the States and collectively for the country as a whole, with a means to benchmark water resources vulnerability in relation to the integrity of the environment so that targeted actions can be taken to avert degradation of the environment to protect the water resources within a specific time-frame such as, in the immediate, medium and long-term periods.

(3) The NWRVI is based on four objective categories and 11 component indicators for estimating the vulnerability of water resources in relation to the environment by States. The four objective categories refer to the principle objectives of IWRM, which are: water for food, for people, for nature and for industrial and other uses that form the basis for the NWRVI (see **Table 4.5).** The details of the methodology and approach including the assessments by States are provided in Volume 4.

Table 4.5 - Categories and Indicators for NWRVI

IWRM Principle Objectives	Main Sectoral Category	Component Indicators
Water for industry and other uses	Water	1. Water Quality
Water for nature	Biodiversity/ Ecology	2. Ecology 3. Lakes 4. Wetlands 5. Forestry
Water for people	People	6. Population Density 7. Heritage and Culture 8. Fisheries 9. Tourism and Recreation
Water for food	Land	10. Environmentally Sensitive Areas (ESAs) 11. Land Capability

(4) The NWRVI is shown in **Figure 4.3.** Basically, the lower the score, the more vulnerable the water resource is with regards to water quality and quantity as the integrity of the environment is being degraded. **Table 4.6** provides the broad strategies that can be developed into action plans as a follow-up from this Study.

(5) The findings showed that most of the States in Peninsular Malaysia fall under the 'moderately vulnerable' category. However, the exercise also identified some States that are vulnerable in terms of quantity and quality of water resources. These States are Pulau Pinang, Selangor and FT Kuala Lumpur, and Melaka. This is not surprising because they correlate well with large urban population, low acreage under forests, poor water quality and often experiencing water stress. These States will have to target their strategies with strict enforcement in landuse change and carry out risk management (especially for periods of drought and floods) as part of the measures to ensure water resources security and sustainability in the State.

(6) The only States that have scored 'low vulnerability' are Sabah and Sarawak. This is also not surprising due to their large forested areas that are still intact with abundance of pristine biodiversity, and relatively low population. These States, however, could easily become vulnerable once their pristine areas are logged or degraded.

Table 4.6 - Proposed Strategy According to Vulnerability

Percentage (%)	Vulnerability	Description	Proposed Strategy
1 – 25	1 (high)	High vulnerability. State has limited water resources and is water-stressed with degraded and depleted forest areas. Many rivers are highly polluted.	Conservation and restrict development
26 – 50	2	Vulnerable. Immediate measures are required to ensure sustainability of water resources. Some of the rivers are polluted.	Strict enforcement and risk management
51 – 75	3	Moderately vulnerable. Water resources available but would require prudent management for long-term sustainable use. The rivers are slightly polluted.	Risk minimization and sustainable development
76 – 100	4 (low)	Low vulnerability. Water resources are adequate to meet present needs, but specific vulnerable areas will require protection and preservation. Pristine conditions and not too polluted.	Sustainable management of all development.

(7) The findings from the NWRVI were then compared with the outcomes of the Water Demand Study where water-stressed States were identified in Volume 3. The comparisons shown in **Table 4.7** indicate that the vulnerable areas identified through this NWRVI correlate very well with the water-stressed areas in Volume 3. Although FT Labuan was not evaluated on its own in this Study, the overall compatibility was established.

Table 4.7 - Comparisons of NWRVI Findings with the Water-Stressed States

Vulnerability 2 in the NWRVI	Water-Stressed States (in Volume 3)
• Pulau Pinang • Melaka • Selangor / FT Kuala Lumpur / FT Putrajaya	• Pulau Pinang • Melaka • Selangor • Perlis • FT Labuan

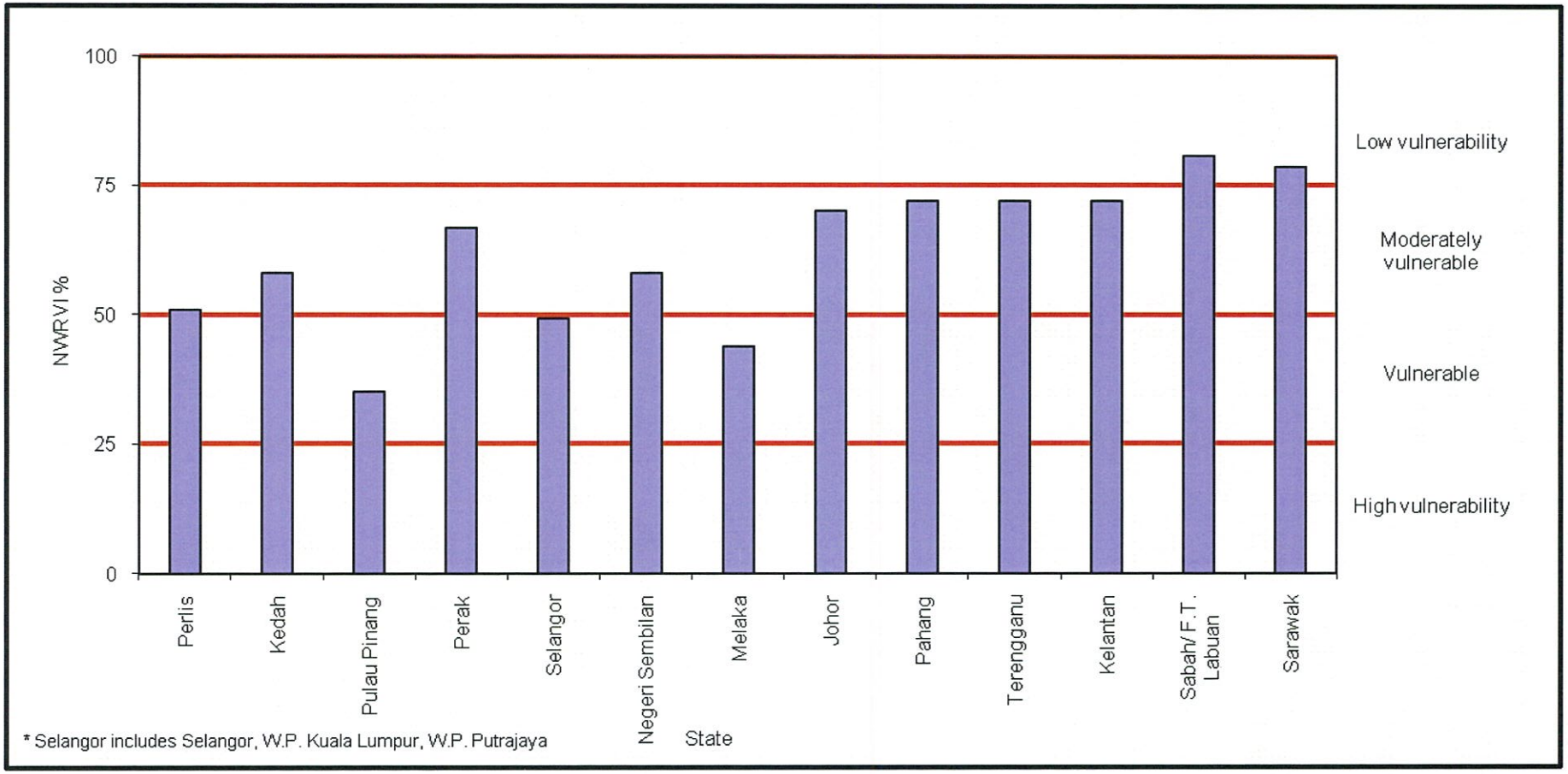


Figure 4.3 – National Water Resources Vulnerability Index (NWRVI) by States

4.14 ENVIRONMENTAL CONSERVATION AND CAPACITY BUILDING

(1) Environmental conservation is a management objective necessary to protect the environment from the negative effects of physical development and use. This section is individually provided in the State reports (Volumes 7 to 20) where the protocols in the form of recommendations and guidelines for future detailed studies have been included. The recommendations are essentially based on a review of the environmental profiles and current status of water resources by States and the need to sustain water resources in the environment for all beneficial uses in the long-term.

(2) Capacity building and human development are important aspects in water resources and environmental management and development. Volume 4 has devoted a section on capacity building initiatives through the creation of awareness, advocacy and training with the aim to ensure that all the recommendations in this Study will have the manpower and appropriate institutions to carry out the tasks ahead.

4.15 ENVIRONMENTAL EVALUATION OF IDENTIFIED IMMEDIATE WORKS PROJECTS

(1) Various priority water resources schemes have been proposed for some of the States in the country where environmental issues and impacts may arise that require mitigation measures in the State Reports.

(2) Under the Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order, 1987, Section 34A of the Environmental Quality Act 1974 (Act 127), 19 categories of activities are listed as prescribed activities for which an Environmental Impact Assessment (EIA) report is required to be submitted to the Director-General of DOE for approval. Among the proposed water resources projects that are likely to fall under the prescribed activities are the following with their respective schedules:

(i) Schedule 19(a). Water Supply: Construction of dams or impoundment of reservoirs with a surface area of 200 ha of more.

(ii) Schedule 13(b). Dams and hydro-electric power schemes with either or both of the following: (i) dams over 15 meters high and ancillary structures covering a total area in excess of 40 ha; (ii) reservoirs with a surface area in excess of 400 ha.

(iii) Schedule 3(a). Drainage and Irrigation: Construction of dams and man-made lakes and artificial enlargement of lakes with surface area of 200 ha or more.

(3) For large dam projects, a detailed EIA may also be required. In order to provide an indication of the magnitude of the impacts due to the project, the Rapid Impact Assessment Matrix (RIAM) method has been used in this Study for screening environmental impacts of the projects so that it can form part of the baseline for future environmental assessments when more information and detailed layouts are

ready. The RIAM ranks and scores the impacts based on physical/chemical, socio-economic and biological/ecological components.

(4) Guidelines in formulating mitigation measures for dam and water projects are provided by the DOE Guidelines such as the '*Environmental Impact Assessment Guidelines for Dams and/or Reservoirs Projects*", and many other water and land related guidelines published by DOE.

(5) An Environmental Management Plan (EMP) is a follow-up report after approval of the EIA or detailed EIA. It contains the details of mitigation measures that must be adhered to by the contractors and defines the roles and responsibilities of those responsible for the project.

SECTION 5

NATIONAL WATER RESOURCE MANAGEMENT DECISION SUPPORT SYSTEM FRAMEWORK

Section 5 NATIONAL WATER RESOURCE MANAGEMENT DECISION SUPPORT SYSTEM FRAMEWORK

5.0 NATIONAL WATER RESOURCES MANAGEMENT DECISION SUPPORT SYSTEM FRAMEWORK

5.1 OBJECTIVES AND STUDY BOUNDARY

(1) Presently, although there are many stand-alone or even web-based applications, there is no centralized inter-agency Information Technology (IT)-based management system specifically designed for the National Water Resources Management.

(2) The main objectives of this document are to outline the requirements and to chart the direction towards the development of a Decision Support System (DSS) framework so that a full-fledged DSS for the management of water resources in the country can be carried out in future.

(3) The DSS framework is a blueprint presented in the form of a Master Plan for the development of a Water Resource Management DSS. As a system development Master Plan, this document outlines the DSS functionalities, the model, system structural design, system interfacing, and methods for actual implementation of such a DSS in future. The document also describes the concept for inter-agency interfacing and data sharing.

(4) In addition to the DSS framework, this document also describes the database management framework to support the intended DSS. The Database Management System Framework refers to the technical design of a suitable and practical database management system to support the DSS. The detailed structure, format, and other technical design aspects of the database along with the hardware, ICT infrastructures, supporting info-structures, and human capital are also presented in this system development Master Plan.

(5) In documenting the Database Management Framework, a suitable data storage structure has been developed to store key data sets compiled by the project team members during the course of this Study. Once the actual DSS system is developed in future, these data sets will need to be transferred to the actual database.

5.2 NATIONAL WATER RESOURCE MANAGEMENT DECISION SUPPORT SYSTEM (NWRM-DSS)

(1) As part of the User Requirement Study (URS) for the development of NWRS-DSS, a series of discussions were held with JPS officers including dialogues conducted at the three Stakeholders Workshops, to determine the needs and requirements for the development of the NWRM-DSS.

(2) Among the outcomes of these dialogues and discussions were:

(i) The needs and requirements for NWRM-DSS.
(ii) Data and information sharing and management among the various stakeholders.
(iii) Role and responsibility of the proposed Federal and State Water Resource Department.
(iv) Role and responsibility of stakeholders.
(v) System functionalities and design concept.
(vi) The scope and the extent of the current work.

5.3 OBJECTIVES OF THE NWRM - DSS

(1) The objectives of the NWRM-DSS can generally be stated as:

"*To develop an integrated water resources management decision support system with a centralized databank for Federal level management, with a synchronized distributed application for State level water supply and demand assessment, with the capacity of producing regular updated data on water availability and demand, water catchment areas (existing and future), water resources development programs, activities affecting water resources such as oil palm plantations, logging, agricultural development, and other relevant information on water resources planning and management.*"

(2) Based on the respondents' feedback, some important criteria for the intended NWRM-DSS system have been identified and these have been incorporated into the development of the framework. These include:

(i) The DSS is intended to support management and/or policy decisions at the macro-level management, notably for overall water resources management and planning functions at the Federal level, and a more detailed management support at the State level (on river basin basis in line with the Integrated River Basin Management (IRBM) practice).

(ii) The focus of DSS will be on water resources, supply and water demand aspects.

(iii) The DSS must have the capability to support scenario analysis or to measure the effectiveness of alternative decisions related to water resources, water supply and/or water consumption.

(iv) The intended DSS should be a user-friendly system, easy to use, and not overly technical so that it can be used by water managers, planners, and administrators.

(v) The system should be able to make use of the various data sets, which can either be directly or physically obtainable or virtually linked to the various sources (or custodians, public and private agencies).

(vi) The system is intended to be a web-based system so that it can be shared, easily accessible, and shall work in real-time basis.

(vii) The system access should be controlled only to permissible users.

(3) The DSS, in addition to focusing on the engineering specifics or for describing the movement of water, based on detailed physical processes at the micro-level, shall also be a generalist tool to support basin-wide water management, planning, and policy assessment for ease of decision-making.

5.4 THE DESIRED NWRM-DSS

(1) The desired NWRM-DSS is a large system, requiring infrastructural and info-structural integration, involving not only Federal and State Water Resource Departments but also other relevant stakeholders at Federal and State Government levels, NGOs, and private agencies.

(2) The actual system would take a long time to develop and refine. The current stage focuses on the development of a framework for the NWRM-DSS and the output is more of a Master Plan or blueprint for the development of a full fledge NWRM-DSS in future. A small mockup was developed primarily as a basis for discussion and demo during User Requirement Study and Workshops. This was primarily to give a general idea and/or impression of the actual system.

5.5 NWRM-DSS – SYSTEM DESIGN PRINCIPLES

(1) The NWRM-DSS is a computer-based tool that multiplies the Decision-Makers (DMs) capacity of analysis and evaluation, stimulating the adoption of a wider and more integrated perspective in the planning process, as well as fostering the multi-actors dialogue, proposing a methodology for the integration of environmental and socio-economic aspects in the water resources planning exercise.

(2) The outcome of this project, as specified in the TOR, is more focused towards the design of a user-friendly DSS framework for the data, information and processes required to ensure that timely and well-informed public policy decisions can be made concerning the use and management of water resources.

(3) The NWRM-DSS framework is consistent with the IWRM principles, which are:

- Water is treated as an economic, social and environmental good;
- Water policies are focused on both the management of water (demand) and the provision of water (supply);

- Government regulatory frameworks are critical in fostering the sustainable development of water resources;

- Water resources are managed at the lowest appropriate level (i.e., in communities and villages); and

- Women are recognized and supported in the central role they play in the provision, management and safeguarding of water.

(4) The NWRM-DSS would function as a one-stop centre for water resources information management. The system is best developed in the form of a *distributed system* in which each State's system is synchronised with a Federal system. Structurally, the NWRM-DSS is envisaged as shown in **Figure 5.1**.

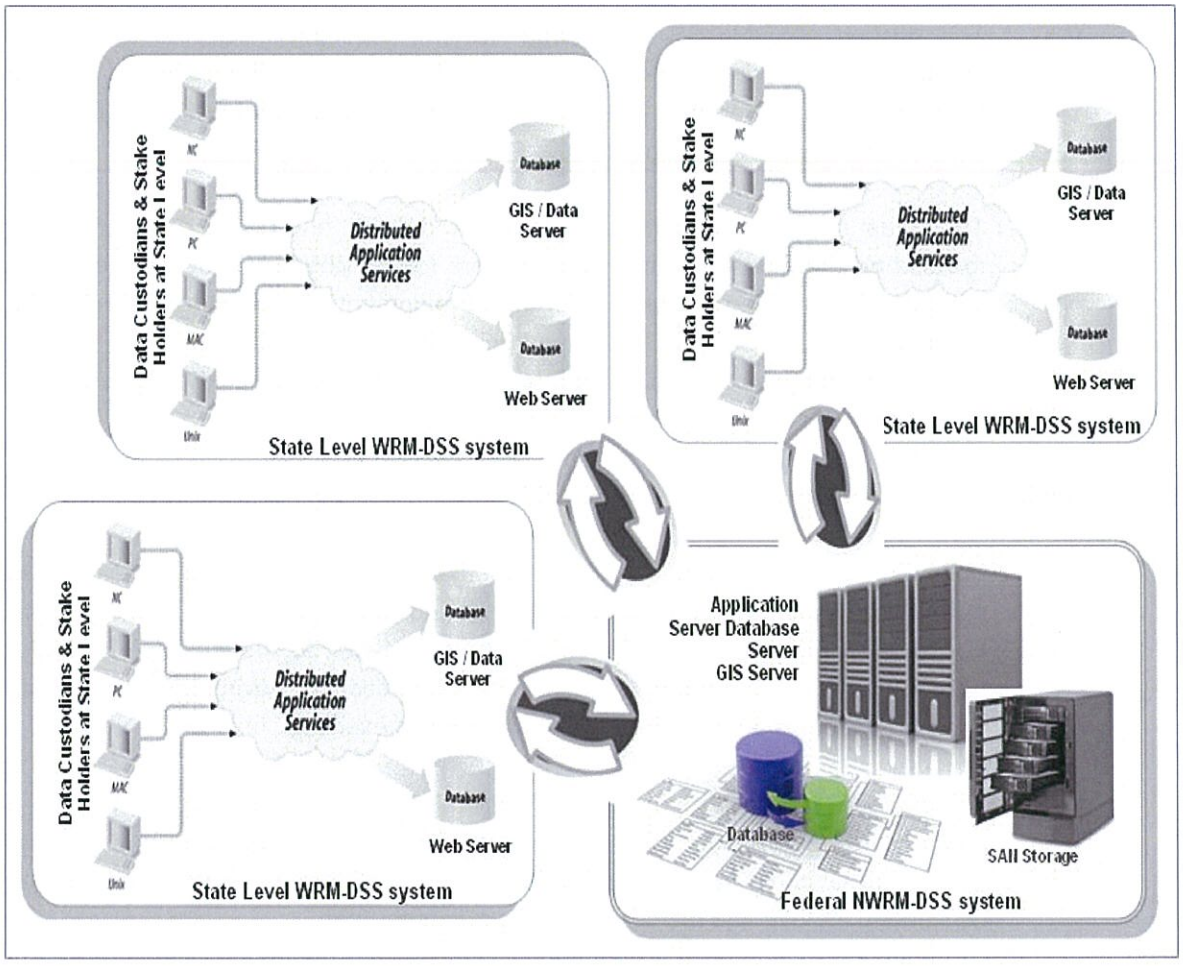


Figure 5.1 – General Architecture of NWRM-DSS and Interconnectivity between State and Federal Water Resources Agency

(5) The NWRM-DSS is intended to be a fully integrated ***Web-Based GIS system*** serving as a centralized water resource information management center or a centralized water resource information repository system. **Figure 5.1** emphasizes the role of State Water Resources Agency (SWRA) as the key user and their interconnectivity to a centralised Federal NWRM-DSS. Each State shall have its own WRM-DSS system. Each State WRM-DSS shall have its own servers to "communicate" with the various State Departments and relevant agencies systems (or servers). Each State's WRM-DSS is also connected and synchronized with the Federal NWRM-DSS. As such, State level information will also be accessible at the Federal NWRM-DSS.

(6) Some key stakeholders who would also serve as certain data custodians and/or data providers are as shown by **Figure 5.2**. Data custodians will remain responsible for the maintenance and updating of their data within their domain, subject to standards and guidelines as prescribed by MaCGDI (Malaysian Center for Geographic Data Infrastructure).

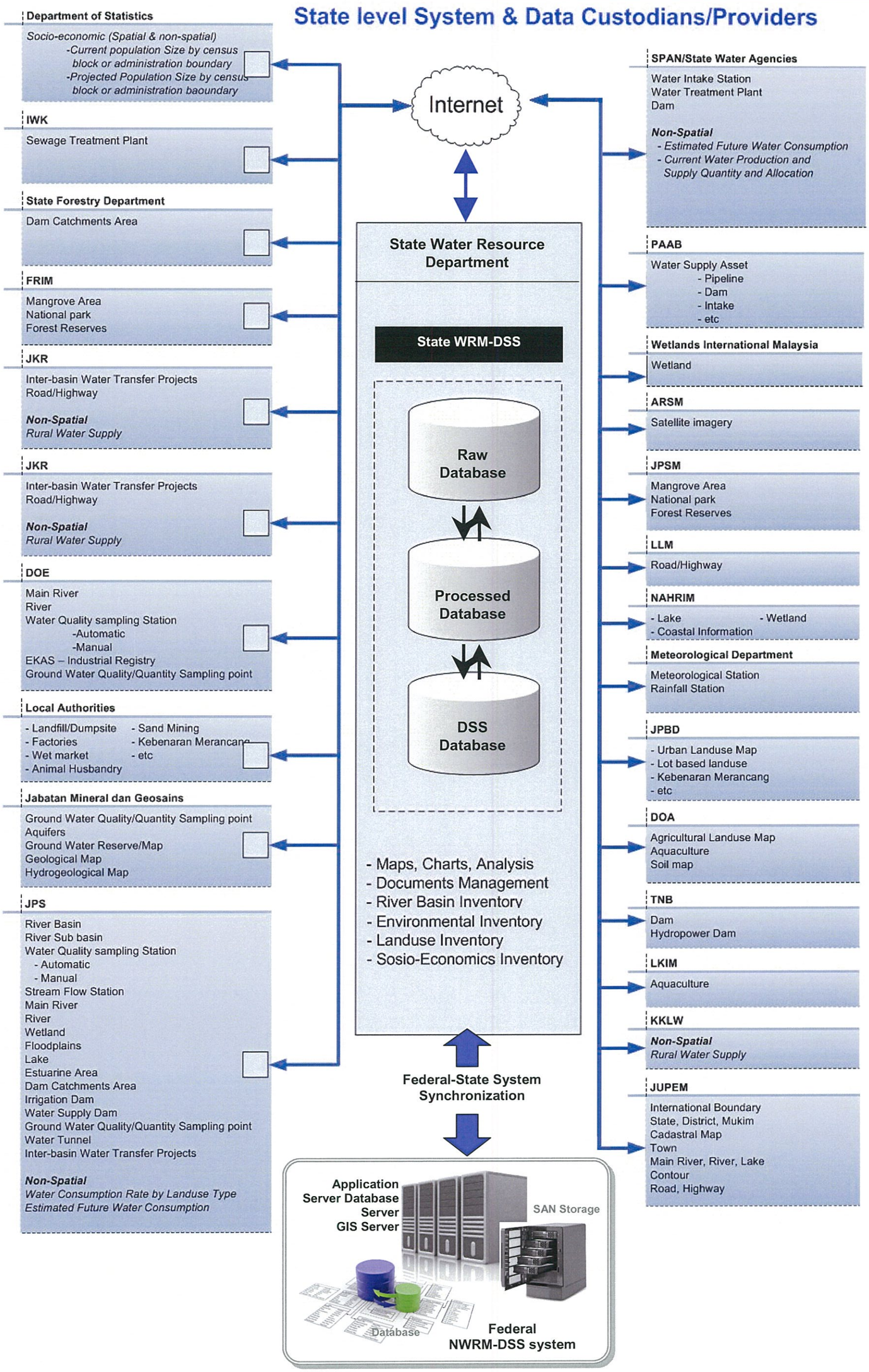


Figure 5.2 – Selected Data Custodians and/or Data Providers at State Level

5.6 DECISION SUPPORT COMPONENT

In addition to a centralized database management system, the NWRM-DSS should also contain decision-support tools, in particular to support management of supply and demand of the water resources. Due to the wide-ranging users, a less technical model known as *water accounting* model has been proposed as an essential tool for the evaluation of water resources availability, supply and water demand in the States and country. The United Nations have endorsed the Water Accounting Method as the international standard for water statistics and currently it is widely used in Australia, Germany, and many other countries. Water Accounting is related to a water balance model but presented in a less technical manner, and less data demanding.

5.7 HARDWARE AND DATA REQUIREMENTS

Hardware and data requirements are described in this Study. In addition to the sources of the data, the structure, content, and data management responsibilities, there are key aspects that need to be addressed during full system implementation. Data standards are governed by MaCGDI Guidelines but data sharing policies as well as data updating and respective departments' system upkeep are within the purview of the respective departments' IT policies. All these issues need to be addressed and resolved during the actual system implementation.

5.8 PHASING OF NWRM-DSS DEVELOPMENT

The actual development of NWRM-DSS is best divided into three phases as shown by **Figure 5.3.**

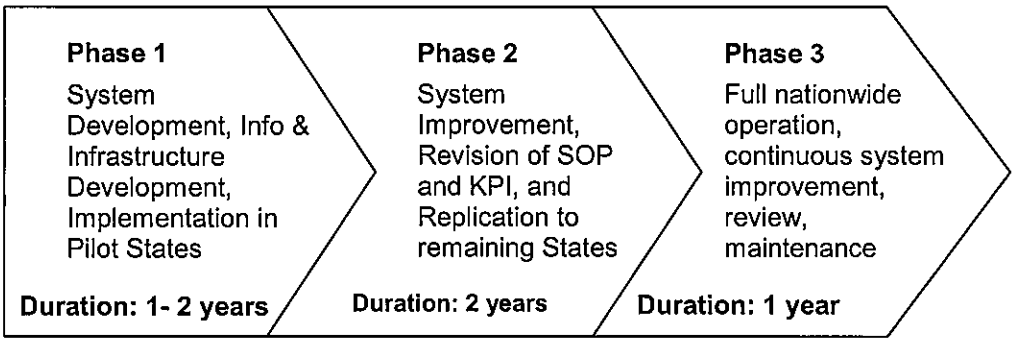


Figure 5.3 - Proposed Phasing for the Development of NWRM-DSS

Development of a massive system such as NWRM-DSS is best approached in phases.

Phase 1: Phase 1 development is geared more towards initial system development and implementation in selected Pilot States. The selected State(s) must not be too large to complicate the development process, but must be large enough that it contains typical issues faced by other States.

We recommend Negeri Sembilan, Johor, or Kedah as candidates as pilot States because they have some typical issues related to water resources management.

A detailed user requirement study, development of standard operation procedures, determination of Key Performance Indices (KPI), provision and set-up of hardware and software, and system integration works are some of the major works during this phase.

Phase 2: Phase 2 development is primarily aimed at improving and upgrading of the NWRM-DSS systems and revision of modules, review of DSS applications, and replication to other remaining States. System replication to the remaining States will involve the following work:

- Acquisition and set-up of hardware, software and network communications to all participating agencies (State NWRD, data custodians and stakeholders) of the remaining States.
- Data compilation, editing, standardization, and integration of the remaining States.
- Replication of system to the remaining States.
- Adoption of SOP, KPI, and related procedures to the remaining States.
- Training of users and system administrator in the respective States.

Phase 3: Phase 3 development is to continuously review the NWRM-DSS systems and to seek recommendations for further improvements and upgrades of the NWRM-DSS modules. Continuous development of NWRM-DSS shall include the following work:

- Full monitoring of nationwide operation of NWRM-DSS.
- Continuous data updating.
- Continuous review of system usage, recommendations for further improvement and system maintenance.
- Continuous revision and improvement of the Standard Operating Procedures (SOP) for all aspects of work including data editing and standardisation, data streaming and communication, system work flow, system maintenance, system integration and system upkeep.
- Continuous revision and improvement of the Key Performance Indices (KPI) for the management and maintenance of NWRM-DSS at both the Federal and State levels.
- Upgrade of the Decision Support module.
- System maintenance and continuous upkeep.

NWRM-DSS should be a continuous work. Each State and Federal WRD must have its own unit to manage and maintain the system, with continuous support by all stakeholders.