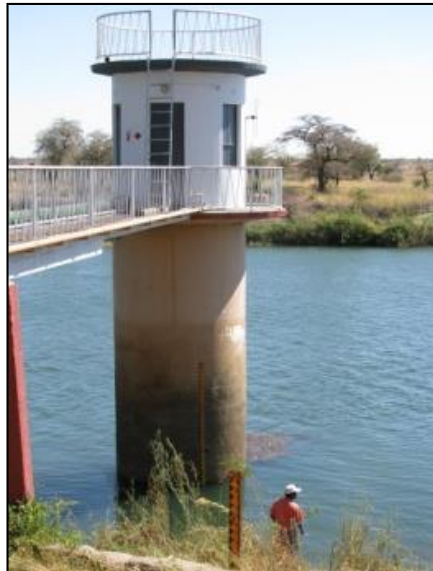


REPUBLIC OF NAMIBIA

MINISTRY OF AGRICULTURE, WATER AND FORESTRY

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**A PRE-FEASIBILITY STUDY INTO:
THE AUGMENTATION OF WATER SUPPLY TO THE CENTRAL
AREA OF NAMIBIA AND THE CUVELAI**



**PART I: CENTRAL AREA OF NAMIBIA
PART II: CUVELAI AREA OF NAMIBIA**

PROJECT UPDATE: ENGINEERING COMPONENT

16 SEPTEMBER 2015

SUBMITTED BY:



IN JOINT VENTURE WITH



WITH SUB-CONSULTANTS



AND OTHERS

PREFACE

This document which provides an update on the *Pre-Feasibility Study into the Augmentation of Water Supply to the Central Area of Namibia and the Cuvelai* is submitted in response to a request for an update on the Project dated 17 August 2015, by the Hon. Mutorwa, Minister of the Ministry of Agriculture, Water and Forestry.

The main objective of this Pre-Feasibility Study is to examine all the nominally feasible options for augmenting the water supply to the Central and the Cuvelai Areas of Namibia where existing sources might become inadequate in the near future. In terms of alleviating the supply shortfalls which are expected to occur in the future, additional water sources are to be examined on the basis of augmentation and back-up – i.e. whether the proposed source and / or scheme is to serve for augmentation and / or supply, is to be investigated.

This Pre-Feasibility Study will be undertaken in three main phases as follows:

1. Phase 1: Investigations and Water Demands,
 2. Phase 2: Modelling and Concept Schemes,
 3. Phase 3: Engineering and Environmental Evaluations.
- Phase 1 of the Project was concluded with the submission of the Interim Reports No. 1 for the Cuvelai and CAN areas on 25 July 2015.
 - Phase 2 is at an advanced stage, with the completion in July 2015 of the first round of public participation and stakeholder consultation meetings in Rundu, Oshakati and Windhoek and is scheduled for completion by the end of 2015.

This document aims to provide a concise update on the following:

1. The important milestones of the Project to date,
2. The water supply situation in the Cuvelai Area,
3. The water supply situation in the Central Area of Namibia (CAN).

EXECUTIVE SUMMARY

E1 INTRODUCTION

The main objective of this Study is to examine all the nominally feasible options for securing the long term, up to 2050, water supply to the Central Area of Namibia (**CAN**) and the Cuvelai area of Namibia where existing sources might become inadequate in the near future.

E2 PROJECT MILESTONES

Nine meetings of the Project Steering Committee (**PSC**) have been held. A number of reports and updated chapters have been submitted to the PSC; this is the 8th report / submission. A number of presentations to various audiences have been provided under the auspices of this Project.

During July 2015, the first round of public participation and stakeholder consultation meetings under Phase 2 of the Project were successfully concluded in Rundu (21 July), Oshakati (22 July) and Windhoek (24 July 2015).

E3 WATER SUPPLY SITUATION IN THE CUVELAI AREA

E3.1 Assessments in the Cuvelai Area

The current and potential water sources, historic water consumption, rates and trends, population growth rates, known and expected developments and the projected future water demands for the Cuvelai area have been assessed, and a yield assessment of the Kunene River system has been conducted.

E3.2 Water Supply Sufficiency for Abstraction from the Kunene River at Calueque

The Kunene River should have sufficient capacity to meet the future water demands of the Cuvelai Area, however, this is highly dependent:

1. On the rehabilitation of Calueque Dam and the optimised operation of the Gove and Calueque Dams,
2. The abstraction by Angola in the Upper and Lower Kunene River and at Calueque.

Irrespective of the actual water abstraction upstream by Angola, it is clear that the future availability of water to the Cuvelai area of Namibia is dependant on upstream activities in Angola, which remains a risk outside the control of Namibia.

E3.3 Potential Alternative Water Supply Sources to the Cuvelai Area

The following water supply sources and options are being considered further as potentially viable alternatives for supply to the Cuvelai Area:

1. Water reuse and recycling.
 - a. It is estimated that 0.757 Mm³/a of water can be available for non-potable reuse in Oshakati, Ongwediva and Ondangwa; approximately 20% of the current volume of potable water supplied by NamWater,
 - b. Assuming a 100% coverage of waterborne sanitation in these three urban areas in 2050, approximately 41% of the estimated future water demand could be available for non-potable reuse,
 - c. Non-potable reuse of water is considered to be the most likely possibility in the Cuvelai area therefore, given the potential for public reticence or reservation in this matter, especially as this would be the first time that water reuse would be carried out on a large scale in the Cuvelai Area,
 - d. Non-potable reuse for the irrigation of marketable crops, as being done on a small(er) scale at Outapi should, be considered first, in order to make reuse as economically viable as possible, and thereafter non-potable water use for road construction, landscaping and the irrigation of sports fields and green spaces,
2. Supply from the Ohangwena II Aquifer. Investigations into the long-term sustainable yield and recharge of the aquifer are still ongoing by others, and information thereon is unavailable and unconfirmed. Current (preliminary) estimates are that a yield of 6 Mm³/a is possible, which represents:
 - a. In 2013: 36% of the current potable demand, 47% of human only demand,
 - b. By 2050: 21% of the potable demand, 24% of the human only demand.
3. Pumping from the Kunene River at Ruacana, on Namibian soil, as was done in the past. This option, still under investigation, will have high capital and particularly energy and operational costs.

A combination of these options is considered the most feasible and is currently being formulated.

E4 WATER SUPPLY SITUATION IN THE CENTRAL AREA OF NAMIBIA

E4.1 Assessments in the Central Area of Namibia

The current and potential water sources available to the CAN, the historic water consumption, rates and trends for all the sub-systems of the CAN, the population growth rates, known and expected developments, projected future water demands up to 2050 for various areas and consumers have been assessed, and a cross-correlation assessment for the flows in the Okavango River and inflows into the three CAN dams has been conducted.

E4.2 Current Supply Situation in the Central Area of Namibia

In 2013 NamWater sold more water (32.85 Mm³/a) than the long-term sustainable capacity of the existing resources (31.45 Mm³/a). If treatment and transfer losses are factored into the sales, the required source abstraction (approximately 36.68 Mm³/a) exceeded the sustainable resources by over 5 Mm³/a. This means that since 2013 already, the CAN has been in a water deficit.

E4.3 Potential Water Sources to Supply the Central Area of Namibia

All groundwater and surface water sources in the interior of Namibia were investigated and it was determined that with the exception of the Windhoek Aquifer, none of these have sufficient capacity to supply the long-term water demands of the CAN.

Further development of the Windhoek Aquifer under the Windhoek Managed Aquifer Recharge Scheme (**WMARS**) is possible, with the completion of current projects and the extension of the water bank and upgrading of recharge (injection) / abstraction infrastructure. Estimated costs for the work remaining under this project, for completion before May 2018 and May 2022 are approximately N\$ 688 million.

Following upgrades to the Gammams Waste Water Treatment Plant (**GWWT**) by the City of Windhoek, it is estimated that the New Goreangab Water Reclamation Plant will be able to run at its full capacity of 21,000 m³/d, or 7.66 Mm³/a – an increase of 2.66 Mm³/a over the current capacity, as of April 2017.

Following the upgrade of the GWWT, the construction of an additional reclamation plant, to provide 4.2 Mm³/a via advanced membrane technology is recommended. Further into the future, this system could be doubled, to provide a total of 8.4 Mm³/a of additional water.

Only two sources with sufficient capacity to supply the long-term water demands of the CAN could be identified, namely the Okavango River and the desalination of sea water.

Investigations into the capacity of the Okavango River are underway. The supply of desalinated sea water from the coast is not included in the Terms of Reference for this Study.

E4.4 Potential Water Supply Sources to the Central Area of Namibia

Based on the work carried out under this *Water Augmentation* Study, it is clear that the CAN faces a major water supply problem. The Consultant's appointment is to examine the long-term water supply in the CAN. However, a dual strategy has been proposed for securing the water supply to the CAN; covering two periods; the first 8 years to 2023/24 and then until the end of the planning horizon in 2049/50, namely:

1. Medium-term strategy (up to 2023/24):
 - a. This includes known water supply sources and options which can be up-scaled / extended, with implementation within 2 to 5 years with regard to minimising supply shortfalls in the next 8 – 10 years, as follows:

- b. Scenario 2: Treatment of the Swakoppoort Dam water to ensure full utilisation thereof,
 - c. Scenario 3: VBWTP supernatant recycling to reduce the losses at the plant (mostly being implemented by NamWater already),
 - d. Scenario 4: An eventual 8 Mm³/a recharge and 21 Mm³/a abstraction capacity and 89 Mm³ water bank for the Windhoek Aquifer under the WMARS project, under different phases, for completion by May 2018 and 2022,
 - e. Scenario 6 Advanced reclamation be accepted as interim supply source for the first 8 years until 2023/24,
 - f. The estimated cost of these medium-term scenarios is N\$ 1.5 billion,
 - g. the proposed medium-term measures, including also other measures already in place, have been prioritised in terms of implementation which will provide the most water in the shortest space of time (refer to **Section 4**),
2. Long-term strategy:
- a. Water from outside the CAN, either from the Okavango River or desalinated water from the coast, needs to reach the CAN by May 2022 to prevent potentially catastrophic water shortages in future,
 - b. These options need to be analysed in further detail, selected, designed, constructed and implemented within the 8 – 10-year period to May 2022.

E5 REMAINING WORK UNDER THE WATER AUGMENTATION STUDY

E5.1 Phase 2 of the Project

The Environmental and Social assessments are currently being formulated following the 1st round of public participation meetings in July 2014. Following the receipt of these evaluations, the Engineering Consultant will formulate the project proposals as follows:

1. The Cuvelai Area of Namibia:
 - a. A combination of options for back-up supply to the Cuvelai area including a reduction in the non-revenue water, non-potable reuse in Oshakati, Ongwediva and Ondangwa, supply from the Ohangwena II Aquifer, and pumping from the Kunene River at Ruacana,
2. The Central Area of Namibia:
 - a. The medium-term options for Scenarios 2, 3, 4 and 6 as listed above,
 - b. Long-term supply from either the Okavango River or from desalinated sea water.

A proposal has been made to the PSC that the Terms of Reference of the Engineering Consultant be extended to include consideration of the supply of desalinated sea water to the CAN. A decision on this matter is required before Phase 2 of the Project can be finalised. Phase 2 will conclude with the submission of a report detailing the above.

E5.2 Phase 3 of the Project

Under Phase 3 of the Project, for both the Cuvelai and Central Areas of Namibia, the following are to be determined:

- The required new infrastructure for the water supply schemes / options proposed,
- The required upgrades / rehabilitation of existing infrastructure for the water supply schemes / options proposed,
- The proposed water supply schemes / options are to be evaluated in terms of costs, technical, financial and other feasibility, including operation, maintenance and other considerations,
- A 2nd round of public participation meetings is to be conducted in Rundu, Oshakati and Windhoek,
- A final project report detailing the above is to be submitted.

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1. INTRODUCTION

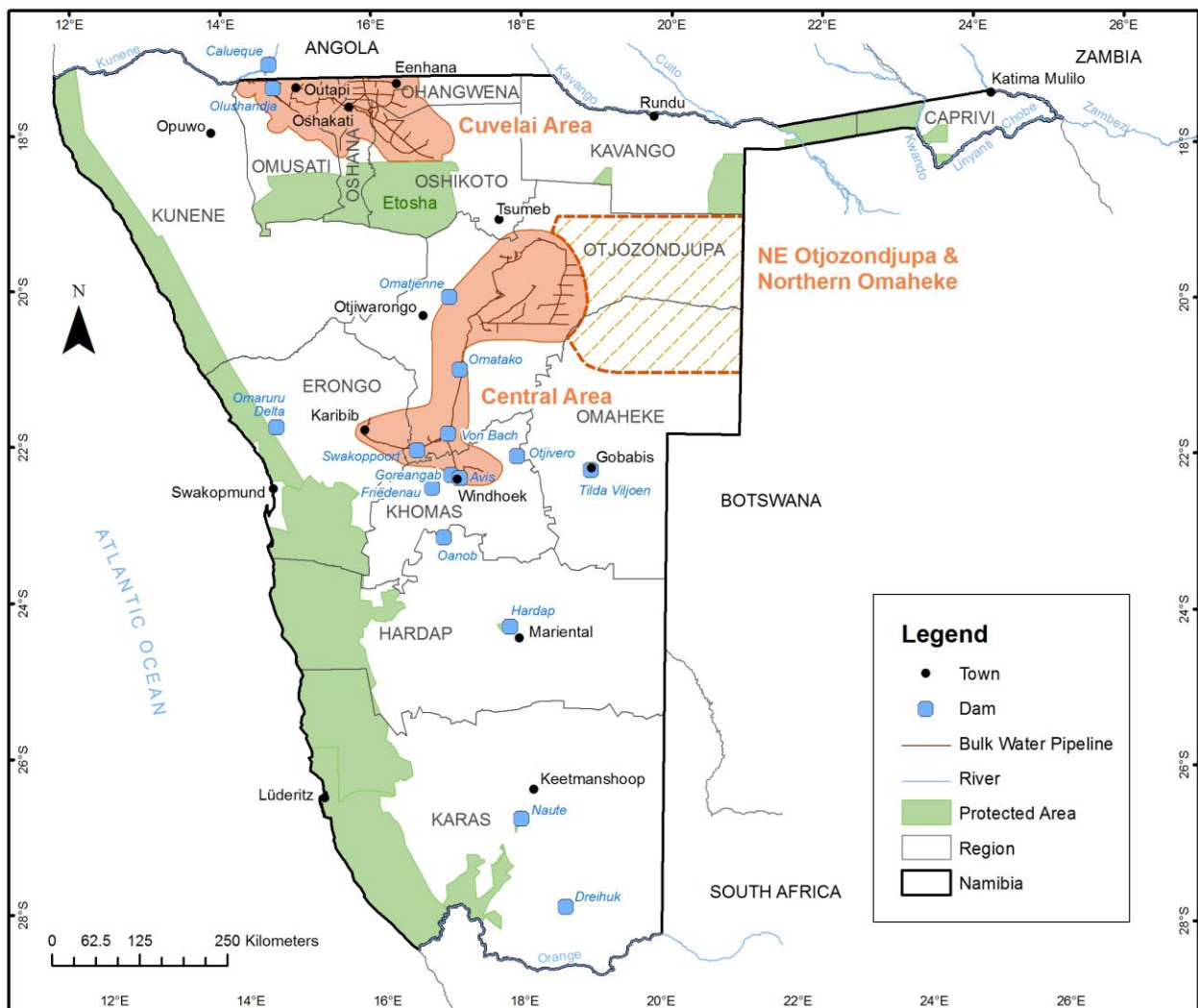
1.1 PROJECT OBJECTIVE

The main objective of this Study is to examine all the nominally feasible options for securing the long term, up to 2050, water supply to the Central Area of Namibia (**CAN**) and the Cuvelai area of Namibia where existing sources might become inadequate in the near future.

1.2 PROJECT AREA

The initial water supply area for the Study consisted of the Central Area of Namibia (**CAN**) and the Cuvelai area, which latter area corresponds with the largest portion of the four north central regions, being the Omusati, Oshana, Ohangwena and Oshikoto Regions.

Figure 1.1: Preliminary Extent of the Study Area



During the compilation of the ToR for this Study, it was decided that the area east of Okakarara as far as Gam, as well as Otjinene and the areas south to Rietfontein, including Okondjatu, Talismanis, Gam and Tsumkwe be included in the investigation, as well as the areas along the Okavango River upstream of Rundu and the areas along any proposed pipeline route from the Okavango River. It was furthermore agreed that other areas which experience water shortages from time to time such as Omaruru, Otjimbingwe; both urban and rural, including the resettlement farms included in the Otjimbingwe bulk supply, and Otjiwarongo, after local sources are fully developed, also be included in the Project Area.

1.3 OVERALL PROJECT APPROACH AND METHODOLOGY

1.3.1 Overall Project Methodology

The overall methodology followed with the execution of this Study was the following:

1. Analysis and confirmation of the Project Area, including which areas of the Central Area of Namibia (**CAN**) and the Cuvelai are to be served for back-up and / or for augmentation purposes,
2. Determination of the realistic water demands for the Project Area, being the following areas initially included in the Project Area (later confirmed):
 - a. The CAN,
 - b. The Cuvelai area,
 - c. The Eastern Otjozondjupa and Omaheke Regions,
 - d. Other areas which experience water shortages from time to time such as Omaruru, Otjimbingwe; both urban and rural, including the resettlement farms included in the Otjimbingwe bulk supply, Otjiwarongo, after local sources are fully developed, Otjinene, Okondjatu, Talismanis, Rietfontein, Gam and Tsumkwe,
3. Analysis of the potential savings or reductions in water demands which can be realised from intensified water demand measures (realistic water demands),
4. Updating and confirming the capacities of the various currently available water supply sources,
5. A comparison of the water demands to be met over the planning horizon with the capacities of existing water supply sources in order to determine the expected extent and timing of supply shortfalls,
6. Establishing as far as possible the expected or potential capacities of future and / or additional water supply sources,
7. A comparison of the expected shortfalls (using current supply sources) with the expected capacities of additional water supply sources in order to determine which additional or combination of additional water supply sources are suitable and will be required in the future,
8. Preparing concept configurations and cost estimates for supply schemes to develop the suitable future or additional water supply sources,
9. Preparing financial analyses for the most feasible future / additional supply schemes up to the level of Dynamic Prime Cost (**DPC**),

10. Providing the technical information to the environmental / social team in order for them to assess the likely environmental impacts and costs of the various options considered,
11. Considering the results of the financial analyses of the proposed future schemes, the environmental impacts and costs as well as other considerations, to select the overall optimum or best trade-off (most financially viable, economically beneficial and environmentally acceptable) future water supply schemes which are to be investigated in further detail in a following stage of this overall Project.

1.3.2 Underlying Approach to this Study

The underlying approach approved for this Pre-Feasibility Study, was that of a desk study which used the information which is available from whatever sources, in particular that from previous studies, updating this information where required, in order to arrive at an up to date and relevant pre-feasibility investigation. It was envisaged that major field work, associated components and more detailed investigations will only become necessary in a later, detailed feasibility or design phase, should the decision be made to proceed with the Project.

1.3.3 Planning Horizon

A planning horizon is the time frame for planning strategic activities and for accomplishing strategic goals, which means that establishing a planning horizon is a strategic decision for an organisation or agency.

NamWater assumed a 15 year planning period for the compilation of their Bulk Water Infrastructure Development and Capital Replacement Master Plans, under which water demand projections were prepared and supply sufficiencies analysed up to 2029/30. For rural water supply projects planned and implemented by the MAWF, a 15-year planning horizon is also usually applied.

This Study however examines options which are of a strategic nature, with the aim of securing water supplies to the CAN and the Cuvelai for the medium to long term. Such projects typically have a long implementation period (up to 10 years) which should also be taken into account. The recent Master Plan for the Central Water Supply Area (the CAN) completed for NamWater determined that a new water source for the CAN is expected to become a necessity by 2020.

This is therefore the proposed implementation / commission date of the recommended project infrastructure, following which a sufficiency period of 30 years (for the supply of water and the minimum lifespan of infrastructure) should be used for the Study.

Water demands will therefore be prepared up to 2050 and all water supply options will be examined for supply sufficiency up to this date.

2. MAJOR PROJECT MILESTONES AND DELIVERABLES

The official Project Launch by the Hon. Minister Mutorwa took place on 13 February 2015 in the board room on the 4th floor of the MAWF Building, Government Office Park, with members of the media present.

Other project milestones (elaborated on separately below) include:

1. Meetings of the Project Steering Committee,
2. Report submissions,
3. Presentations,
4. Cabinet submissions,
5. Public participation meetings.

2.1 PROJECT STEERING COMMITTEE MEETINGS

Meeting Nos. 1 to 4 took place during the initial stage of the Project when the Terms of Reference were being compiled for the MAWF. Meetings under the Pre-Feasibility Study Phase therefore resumed from No. 05 onwards.

Table 2.1: Meetings of the Project Steering Committee

Meeting No.	Date	Important Topics
5	01 October 2013	Project administration, data acquisition, website, press release
6	05 November 2013	Project administration, data acquisition, notifications to OKACOM, PJTC
7	11 February 2014	Data acquisition, progress, website, press release, invitations to Project Launch, Project notifications
8	01 April 2014	Submission of Draft Reports, report presentations formation of the Water Demands Sub-Committee
9	20 May 2014	Presentations, finalisation of Draft Reports for Phase 1, data acquisition, WEAP modelling, formation of the Modelling Sub-Committee, Project notifications
10	05 August 2014	Finalisation of Draft Reports for Phase 1, WEAP modelling, Modelling Sub-Committee, Project notifications
11	04 November 2014	Data acquisition, Modelling sub-committee, CAN modelling workshop, preliminary results of the CAN modelling, notification to OKACOM, public participation
12	03 March 2015	Finalisation of Interim Reports, data acquisition, Presentation of the CAN Modelling analyses included in Interim Report No. 02 , notification to Cabinet of the water supply situation in the CAN, protection of the Windhoek Groundwater Zone.
13	18 May 2015	Finalisation of Interim Reports, data acquisition, project summary, desalination option, OKACOM matters, public participation, media release, notification to Cabinet of the water supply situation in the CAN
14	11 September 2015	Project update, feedback from / report on the 1 st round of public participation and stakeholder consultation. Desalination supply option

2.2 REPORT SUBMISSIONS

Milestones regarding the submission of the various Reports submitted under the Project thus far are provided in **Table 2.2**.

2.3 PROJECT PRESENTATIONS

Milestones regarding the various presentations delivered under the Project thus far are provided in **Table 2.3**.

2.4 CABINET SUBMISSIONS

The Engineering Consultant was requested to assist with drafting Cabinet Memoranda and Inter-Ministerial Memoranda on the basis of the results of and information available under the Project. Details of these are provided in **Table 2.4**. These constitute additional services, not included in the ToR, which have been provided at no additional charge to the MAWF.

2.5 PUBLIC PARTICIPATION MEETINGS

During July 2015, the first round of public participation and stakeholder consultation meetings under Phase 2 of the Project were successfully concluded in Rundu (21 July), Oshakati (22 July) and Windhoek (24 July 2015).

Table 2.2: Submission of Project Reports

Report Name	First Submission (Draft)	Submission to	Subsequent Submission	Submission of Final	Re-Submission	Current Status and Comments
Interim Report No. 1: Water Demands and Water Resources for Part I: The Central Area of Namibia	31 March 2014 Draft	PSC	11 April 2014	25 July 2014 Final: Incorporating comments received from the PSC	20 May 2015	Hardcopy report lost at MAWF. Report not yet signed.
Interim Report No. 1: Water Demands and Water Resources for Part II: The Cuvelai Area of Namibia	31 March 2014 Draft	PSC		25 July 2014 Final: Incorporating comments received from the PSC	20 May 2015	Hardcopy report lost at MAWF. Report not yet signed.
Summary Document on Water Demands and Water Demand Projects for the Central Area of Namibia	07 April 2014	PSC and Water Demands Sub-Committee		N/A		Information document to the Water Demands Sub-Committee. No comments received.
Information Document on the Hydrological and Supply / Demand Modelling for the Central Area of Namibia	14 October 2014	PSC and Modelling Sub-Committee and participants of the Modelling Workshop		N/A		Information document to the Modelling Sub-Committee and participants of the Modelling Workshop. No comments received.
Draft specialist report into the Water Resources Yield Assessment of the Kunene River and Drought Analyses	27 November 2014 Draft	PSC		No comments received on Draft Report by deadline. Report deemed approved by PSC.	20 May 2015	No comments received. Report not yet signed.
Interim Report No. 2: Hydrological and Supply / Demand Modelling for the Central Area of Namibia (Part I: The Central Area of Namibia)	16 February 2015 Draft	PSC		No comments received on Draft Report by deadline. Report deemed approved by PSC.	20 May 2015	No comments received. Report not yet signed.
Part I: The Central Area of Namibia: Updated Chapters 4, 12 and 13 towards further Interim Report	17 April 2014	PSC				No comments received.
Parts I and II: Project Update: Engineering Component	21 August 2015	PSC		16 September 2015		Additional update report requested by the Minister.

Table 2.3: Project Presentations

Date	Presentation Topic	Present	Comments
15 April 2014	Water demands methodology and factors which influence water demands	Water Demands Sub-Committee	
19 May 2014	Interim Report No. 1: Water Demands and Water Resources for Part II: The Cuvelai Area of Namibia	PSC and NamWater invitees	Only Ms. Sibanda present from the MAWF
20 May 2014	Interim Report No. 1: Water Demands and Water Resources for Part I: The Central Area of Namibia	PSC and NamWater invitees	Only Ms. Sibanda present from the MAWF
10 June 2014	Presentation of Interim Reports	MAWF Management	Additional presentation requested by the MAWF. Postponed on the day
17 June 2014	Presentation of Interim Reports	MAWF Management	
18 June 2014	Update on the Project and the water supply situation in the CAN	Presentation to the annual NamWater Central Areas Workshop. Presentation at the request of NamWater	
22 July 2014	Presentation of Interim Reports	MAWF Management	Additional presentation requested by the MAWF. Postponed on the day
20 October 2014	Background on the Central Area of Namibia	Modelling Sub-Committee and participants of the CAN Modelling Workshop	Introduction to CAN Modelling Workshop
	Background on the CAN Modelling		Draft / Preliminary results of the CAN Modelling and feedback on the setup of the WEAP Model
24 October 2014	Modelling of the CAN: Preliminary Feedback		
23 February 2015	Water supply situation in the Central Area of Namibia	Invitees of the City of Windhoek, incl. Hon. Mutorwa and His Worship the Mayor, officials from the CoW and MAWF	Presentation at the request of the CoW
03 March 2015	Interim Report No. 2: Hydrological and Supply / Demand Modelling for and the water supply situation in the Central Area of Namibia	Project Steering Committee	
23 April 2015	Update on the Project and the water supply situation in the CAN	Presentation to the annual NamWater Central Areas Workshop. Presentation at the request of NamWater	
12 May 2015	Water supply situation in the Cuvelai and Central Areas of Namibia	Sustainable Development Advisory Council	Presentation provided following a request to the Project
21 July 2015	Water supply situation in the Cuvelai and Central Areas of Namibia	Rundu Public Participation Meeting	
22 July 2015		Oshakati Public Participation Meeting	
24 July 2015		Windhoek Public Participation Meeting	
10 September 2015	Medium and long-term water supply options to the Central Areas of Namibia	Economic Association of Namibia	Presentation provided following a request to the Project

Table 2.4: Cabinet Submissions Prepared under the Auspices of the Project

Date	Subject	Purpose	Comments
March 2014	Moratorium on permitting the establishment of water-using (water intensive) industries in the Central Area of Namibia and on permitting the establishment of polluting industries in the Upper Swakop River Basin	To request cabinet approval for the prohibition of water-using industries in the Central Area of Namibia and the prohibition of polluting industries in the Upper Swakop River Basin	Cabinet Memorandum prepared on the request of the MAWF (Mr. Koch) during March 2014. Submission of the document to the MAWF on 27 March 2014.
December 2014	Action plan to prevent critical water shortages in the Central Area of Namibia in the short term (until 2024) and in the long term (until 2050)	To alert cabinet about the pending critical water supply shortage in the Central Area of Namibia and the predicted impact thereof in the near future. To request Cabinet Approval for: (1) A moratorium on permitting the establishment of water intensive industries in the CAN and (2) For the necessary funding to address the water supply in the CAN	Cabinet Memorandum prepared on the request of the MAWF (Mr. Nehemia) during November – December 2014. Submission of the document to the MAWF on 09 December 2014.
February – March 2015	Critical water shortages in the Central Area of Namibia	At the request of the MAWF (Mr. Nehemia), the Cabinet Memorandum of December 2014 was changed to an Inter-ministerial Memorandum from the MAWF to the MoF. Cost estimates, budget provisions and funding deficits were provided for the 6 proposed projects for the period 2015/16 to 2018/19. Submission of the document to the MAWF on 02 March 2015.	
May 2015	Summary of project implementation to prevent major shortfalls to the Central Area of Namibia	Assistance was provided to the MAWF in drawing up a schedule to prioritise 7 projects identified to alleviate the shortfalls in the CAN, including budget provisions and programme for 2015/16 to 2018/19. Submission of the document to the MAWF on 19 May 2015.	

3. WATER SUPPLY SITUATION IN THE CUVELAI

3.1 ASSESSMENTS IN THE CUVELAI AREA

The following have been assessed for the Cuvelai Area:

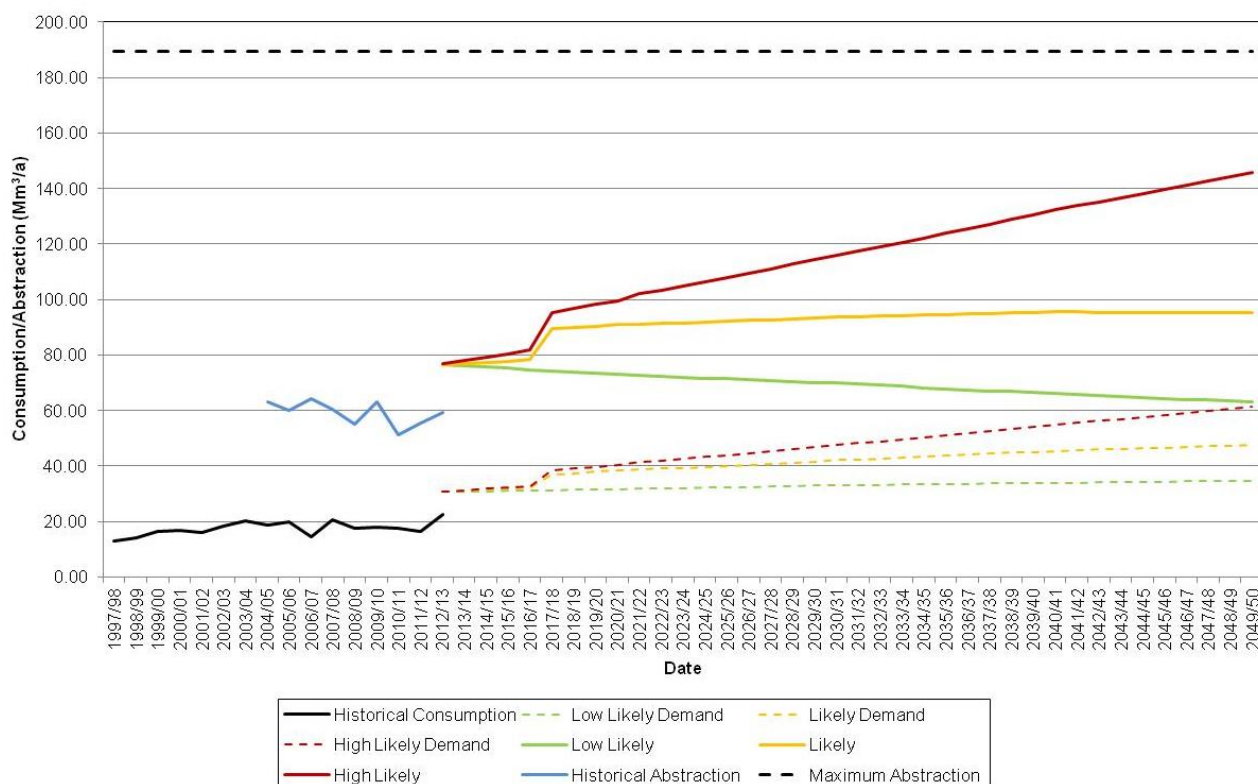
1. The current and potential water sources, including:
 - a. The Cuvelai system,
 - b. The Kunene River,
 - c. Groundwater in the Cuvelai area, including the Ohangwena II Aquifer,
2. Historic water consumption, rates and trends,
3. Population growth rates, known and expected developments,
4. Projected future water demands up to 2050:
 - a. Assuming different population growth rates for urban and rural areas,
 - b. Incorporating all known future developments,
 - c. For Urban areas,
 - d. For Rural areas,
 - e. For Irrigation water use,
 - f. Combined water demands and abstraction requirements at Calueque.
5. A yield assessment for the Kunene River system.

3.2 WATER DEMAND PROJECTIONS

As noted above, the water demands for different areas and categories of use have been estimated to 2050. With the incorporation of non-revenue water, the abstraction requirements at Calueque have been determined. These are shown in **Figure 3.1**.

For all water demand scenarios, the projected abstraction volume is below the maximum allowable abstraction limit (6 m³/s to Namibia) from the Kunene River, although this does not necessarily imply that the flow rate in the river will in future allow this abstraction rate.

Figure 3.1: Historic and Estimated Abstraction Requirements for the Cuvelai Area



3.3 ABSTRACTION FROM THE KUNENE RIVER AT CALUEQUE

The yield analysis for the Kunene River has shown the following:

1. The maximum yield at Ruacana occurs following the rehabilitation of Calueque Dam and with optimised spills and minimised releases from Gove Dam upstream. This would require improved cooperation between Namibia and Angola, via the PJTC, regarding operation of the Gove and Calueque Dams, and subsequent streamflow regulation. This is also the only scenario modelled which complies with the minimum requirement of 50 m³/s streamflow downstream of Ruacana.
2. The yield at Ruacana reduces significantly with increased abstraction from Calueque Dam (as being planned for irrigation purposes by Angola). Increased abstraction in the Upper and Lower Kunene River further lowers the expected yields at Ruacana. These scenarios clearly illustrate the impact of increased abstraction and water use by Angola upstream of Calueque / Ruacana.

It has been reported that Angola is planning major irrigation schemes and other developments along the Kunene River at and upstream of Calueque. In this context, in order to guarantee flows downstream of Ruacana for the downstream aquatic environment and hydropower generation, upstream abstraction may need to be limited or capped. Conversely, with unlimited upstream abstraction, there may be insufficient flow downstream of Ruacana for the downstream aquatic environment and hydropower generation.

It can therefore be concluded, that whilst the Kunene River should have sufficient capacity to meet the future water demands of the Cuvelai Area, this is highly dependent:

3. On the rehabilitation of Calueque Dam and the optimised operation of the Gove and Calueque Dams,
4. The abstraction by Angola in the Upper and Lower Kunene River and at Calueque.

Irrespective of the actual water abstraction upstream by Angola, it is therefore clear that the future availability of water to Namibia is dependant on upstream activities in Angola, which remains a risk outside the control of Namibia.

3.4 WATER SUPPLY OPTIONS CONSIDERED FOR THE CUVELAI AREA

A number of water supply options have been considered for either augmentation or back-up supply to the Cuvelai Area.

3.4.1 Water Supply Sources with Insufficient Capacity

The following water supply sources and options are not considered viable alternatives for supply to the Cuvelai Area:

1. Development of the ground water sources to the east (Nipele Sub-basin) and west (Olushandja Sub-basin) of the central pipeline network. This included investigating linking up the existing individual borehole installations for supply to the central Cuvelai area or developing new well fields for this purpose. Neither of these groundwater sub-basins have sufficient capacity to provide water to the central Cuvelai Area. Supplying the central Cuvelai Area is also undesirable since communities in these areas are entirely dependent on groundwater supply.
2. The desalination of saline ground water in the central portions in remote parts of the Cuvelai area for human and animal consumption is not considered feasible given the limited capacity and available information on the groundwater in the central, Iishana Sub-basin.
3. The harnessing of surface flow in the *iishana*, and the construction of dams, for example at Lake Oponono. The surface water in the Cuvelai, when available, constitutes a valuable natural resource, which can be used informally for livestock watering and fish harvesting. The construction of small earth dams has the potential to enhance the utilisation of surface water for livestock watering by allowing water to be impounded for longer periods, although problems were experienced with similar schemes in the past. However, due to the variability of surface flow in the *iishana* and very high evaporation losses in the area, the large-scale use of surface water is not recommended for either back-up or augmentation for the Cuvelai Area.
4. Abstraction from the Okavango River. In the context of possible supply to the CAN and possibly other areas of Namibia, it is unlikely that the Okavango River, particularly upstream of the confluence with the Cuito River, will have sufficient capacity for supply to the Cuvelai Area as well.

3.4.2 Potential Water Supply Sources to the Cuvelai Area

The following water supply sources and options are being considered further as potentially viable alternatives for supply to the Cuvelai Area:

1. Water reuse and recycling.
 - a. It is estimated that 0.757 Mm³/a of water can be available for non-potable reuse in Oshakati, Ongwediva and Ondangwa; approximately 20% of the current volume of potable water supplied by NamWater,
 - b. Assuming a 100% coverage of waterborne sanitation in these three urban areas in 2050, approximately 41% of the estimated future water demand could be available for non-potable reuse,
 - c. Non-potable reuse of water is considered to be the most likely possibility in the Cuvelai area therefore, given the potential for public reticence or reservation in this matter, especially as this would be the first time that water reuse would be carried out on a large scale in the Cuvelai Area,
 - d. Non-potable reuse for the irrigation of marketable crops, as being done on a small(er) scale at Outapi, be considered first, in order to make reuse as economically viable as possible, and thereafter for road construction, landscaping and the irrigation of sports fields and green spaces,
2. Supply from the Ohangwena II Aquifer. Investigations into the long-term sustainable yield and recharge of the aquifer are still ongoing by others, and information thereon is unavailable and unconfirmed. Current (preliminary) estimates are that a yield of 6 Mm³/a is possible, which represents:
 - a. In 2013: 36% of the current potable demand, 47% of human only demand,
 - b. By 2050: 21% of the potable demand, 24% of the human only demand.
3. Pumping from the Kunene River at Ruacana, on Namibian soil, as was done in the past. This option, still under investigation, will have high capital and particularly energy and operational costs.

3.4.2 Conclusions and Remaining Work

A combination of these options is considered the most feasible and is currently being formulated for inclusion into the Interim Report whose submission will conclude Phase 2 of the Project for Part II: the Cuvelai Area.

4. WATER SUPPLY SITUATION IN THE CENTRAL AREA OF NAMIBIA

4.1 ASSESSMENTS IN THE CENTRAL AREA

The following have been assessed for the Central Area of Namibia (CAN):

1. The current and potential water sources, including:
 - a. Surface water resources (dams), between Omatako Dam and Hardap Dam,
 - b. Groundwater resources between Tsumeb / Grootfontein and Rehoboth,
 - c. Reclaimed and recycled water,
 - d. The Okavango River,
2. Historic water consumption, rates and trends for all the sub-systems of the CAN:
 - a. The Waterberg Water Supply Area,
 - b. The Eastern National Water Carrier system,
 - c. The Swakoppoort supply system (Karibib, Navachab Mine, Otjimbingwe and other users),
 - d. The Swakoppoort – Von Bach system,
 - e. The Von Bach system which includes Windhoek and other industries, Von Bach – Windhoek, Brakwater, Elisenheim, Otjihase Mine and the Hosea Kutako (Windhoek International) Airport, including to the surrounding developments such as Finkenstein, Herbothsblick, Kapp's Farm, Sungate Mixed Use Development and Sonnleiten Nature Estate, Okahandja, Resorts and Others, which includes the Gross Barmen and Von Bach Dam Resorts and the Von Bach – Gross Barmen and Gross Barmen – Rüdenu Nord pipeline schemes,
3. Population growth rates, known and expected developments,
4. Projected future water demands up to 2050 for:
 - a. Existing consumers as per the above systems,
 - b. Supply augmentation to Otjiwarongo (2040), Omaruru (2021) and Otjinene (2041), where local resources will become inadequate in the near future,
 - c. Smaller areas in the Otjozondjupa Region which are supplied from groundwater,
 - d. Currently undeveloped areas in the north-eastern Otjozondjupa and northern Omaheke Regions.
5. A cross-correlation assessment for the flows in the Okavango River and inflows into the three CAN dams.

4.2 CURRENT SUPPLY SITUATION IN THE CENTRAL AREA OF NAMIBIA

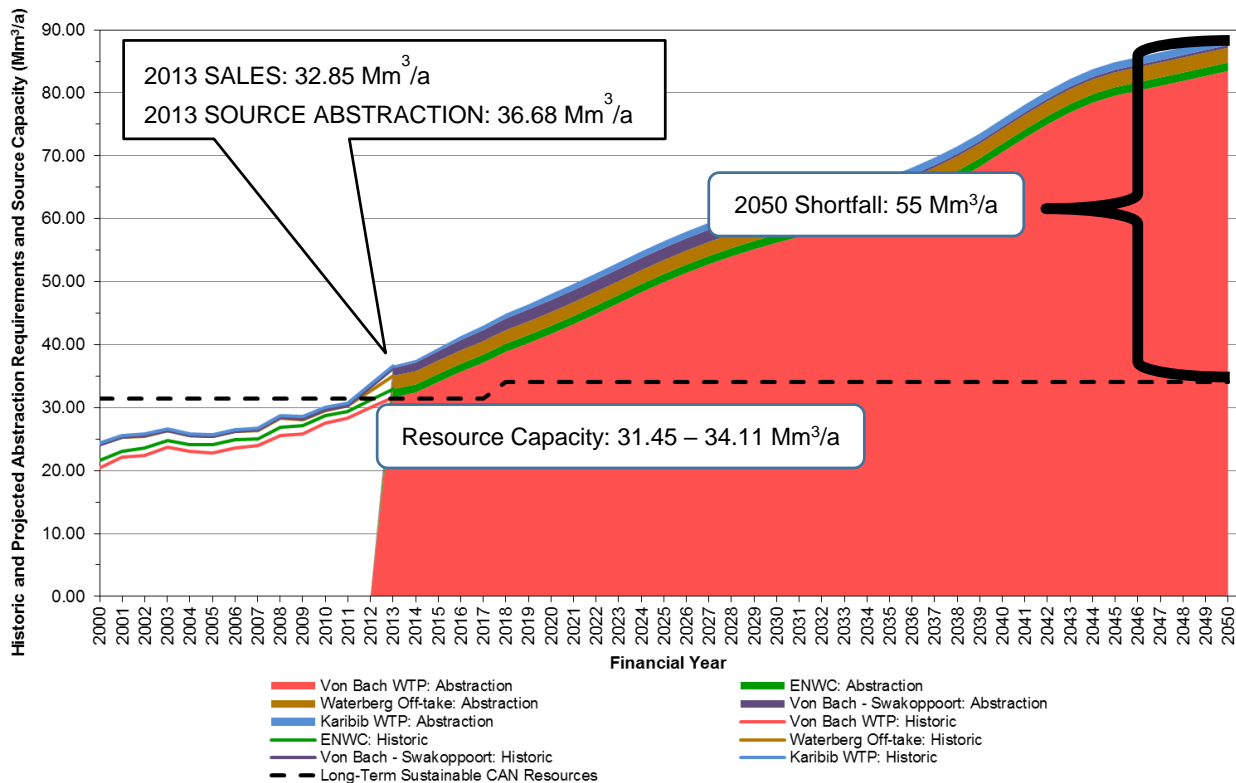
In 2013 NamWater sold more water (32.85 Mm³/a) than the long-term sustainable capacity of the existing resources (31.45 Mm³/a). If treatment and transfer losses are factored into the sales, the required source abstraction (approximately 36.68 Mm³/a) exceeded the sustainable resources by over 5 Mm³/a. This means that in 2013 already, the CAN has been in a water deficit.

4.3 SIMPLIFIED FUTURE WATER SUPPLY SITUATION

4.3.1 Existing Supply Areas and Consumers

A simplified comparison of the projected future water demands of existing consumers and the supply capacity of existing sources is shown in **Figure 4.1**. The direct comparison between the abstraction requirements for the Central Area of Namibia and the resource capacity represents a simplified comparison in that no climatic or hydrological variation is taken into account, the storage capacity available in the three CAN dams and the stored groundwater resources are also not taken into account and no prioritisation of source abstraction is catered for.

Figure 4.1: Abstraction Requirements for the Current Extent of the Central Area of Namibia versus Current Resource Capacity



Likely scenario water demands. Simplified hydrological comparison.

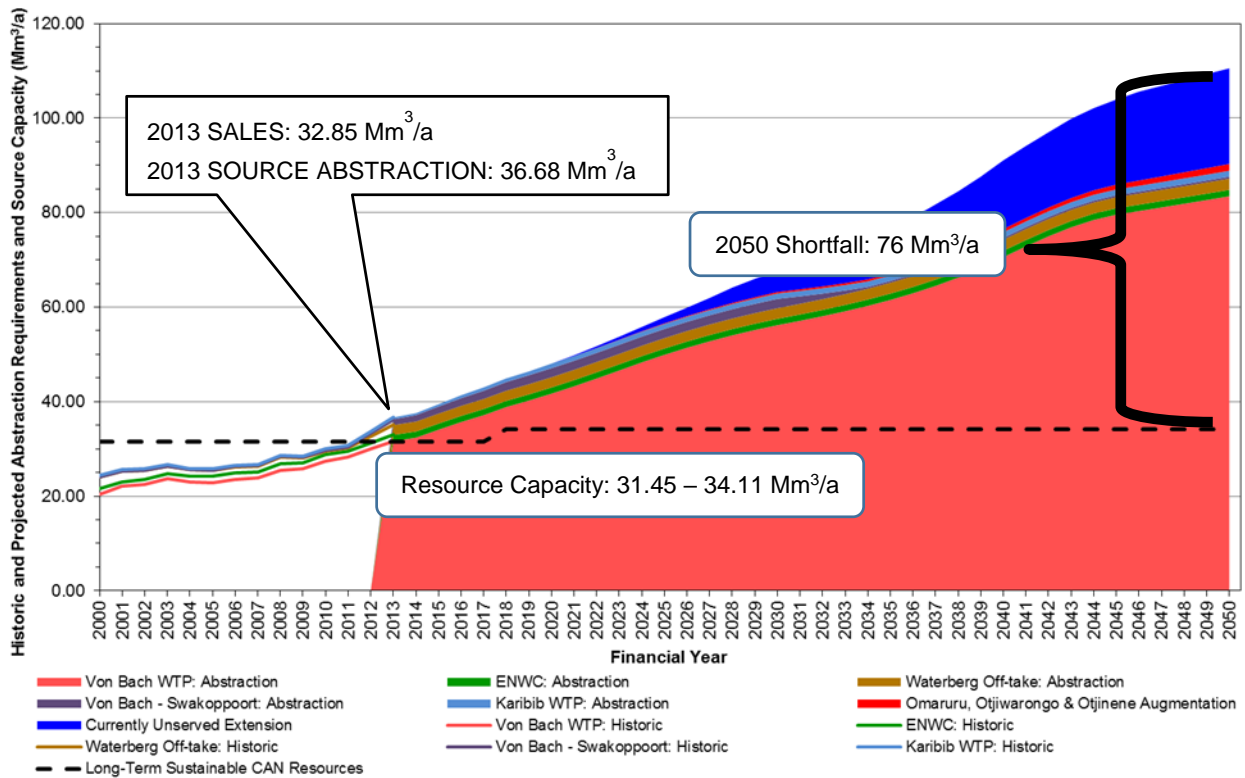
Based on this, simplified comparison, the 2050 shortfall is estimated to be about 55 Mm³/a. In volumetric terms, this is larger than Von Bach Dam, and in terms of the yield of the dam, means that the equivalent of 8.5 Von Bach Dams would be required to meet this shortfall.

4.3.1 Possible Extended Central Area of Namibia

A simplified comparison of the projected future water demands of existing and potential consumers and the supply capacity of existing sources is shown in **Figure 4.2**. Supply augmentation to Ojtiwarongo, Omaruru and Otjinene is shown in red, whilst the supply to the currently undeveloped areas in the north-eastern Otjozondjupa and northern Omaheke Regions is shown in blue – additional demands to those of existing consumers.

The direct comparison between the abstraction requirements for the Central Area of Namibia and the resource capacity represents a simplified comparison in that no climatic or hydrological variation is taken into account, the storage capacity available in the three CAN dams and the stored groundwater resources are also not taken into account and no prioritisation of source abstraction is catered for.

Figure 4.2: Abstraction Requirements for the Current Extent of the Central Area of Namibia versus Current Resource Capacity



Likely scenario water demands. Simplified hydrological comparison.

By 2050, this simplified analysis shows a shortfall of 76 Mm³/a, the equivalent of 11 Von Bach Dams in terms of yield.

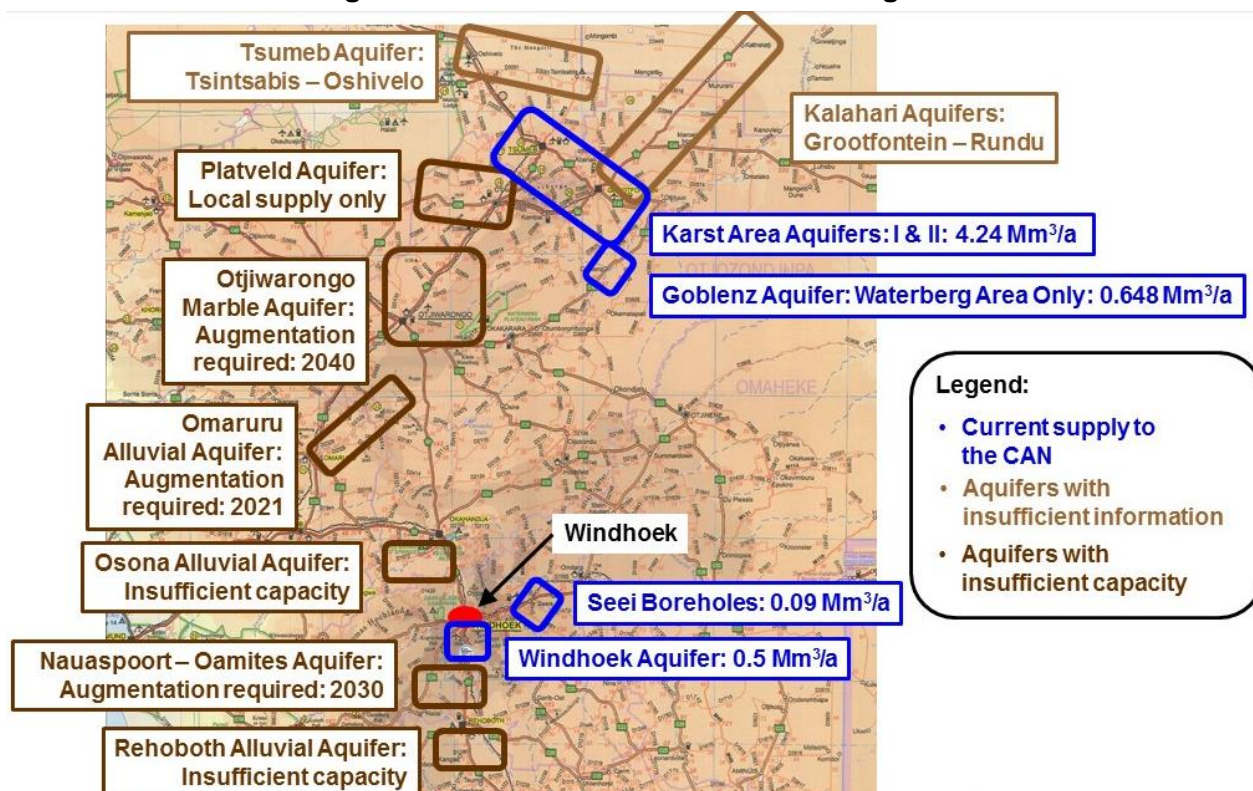
4.4 POTENTIAL WATER SOURCES

All realistic potential water sources which could be developed to supply water to the CAN were investigated.

4.4.1 Groundwater Sources

All groundwater sources within Namibia between the Karst area and Rehoboth were investigated with regard to their potential supply capacity for the CAN.

Figure 4.3: Groundwater Sources Investigated



Apart from the Windhoek Aquifer, which has the potential to be further developed under the Windhoek Managed Aquifer Recharge Scheme (WMARS), no other groundwater sources between the Karst area and Rehoboth have sufficient capacity to supply water to the CAN.

The capacity of the Windhoek Aquifer, under the Windhoek Managed Aquifer Recharge Scheme (**WMARS**) has been analysed on the following basis:

1. Baseline Scenario (current situation and current planning):
 - a. The Windhoek boreholes provide a base supply of 0.5 Mm³/a and a limited-use emergency supply rate 5.5 Mm³/a until 30 September 2015 and 9.15 Mm³/a as from 01 October 2015 (implemented on 1 May 2015 for modelling),
 - b. Phase 1 and part of Phase 2 of the artificial recharge to the Windhoek Aquifer is already implemented with an operational installed recharge capacity of 1 Mm³/a until 30 September 2015 (implemented on 01 May 2015 for modelling) and

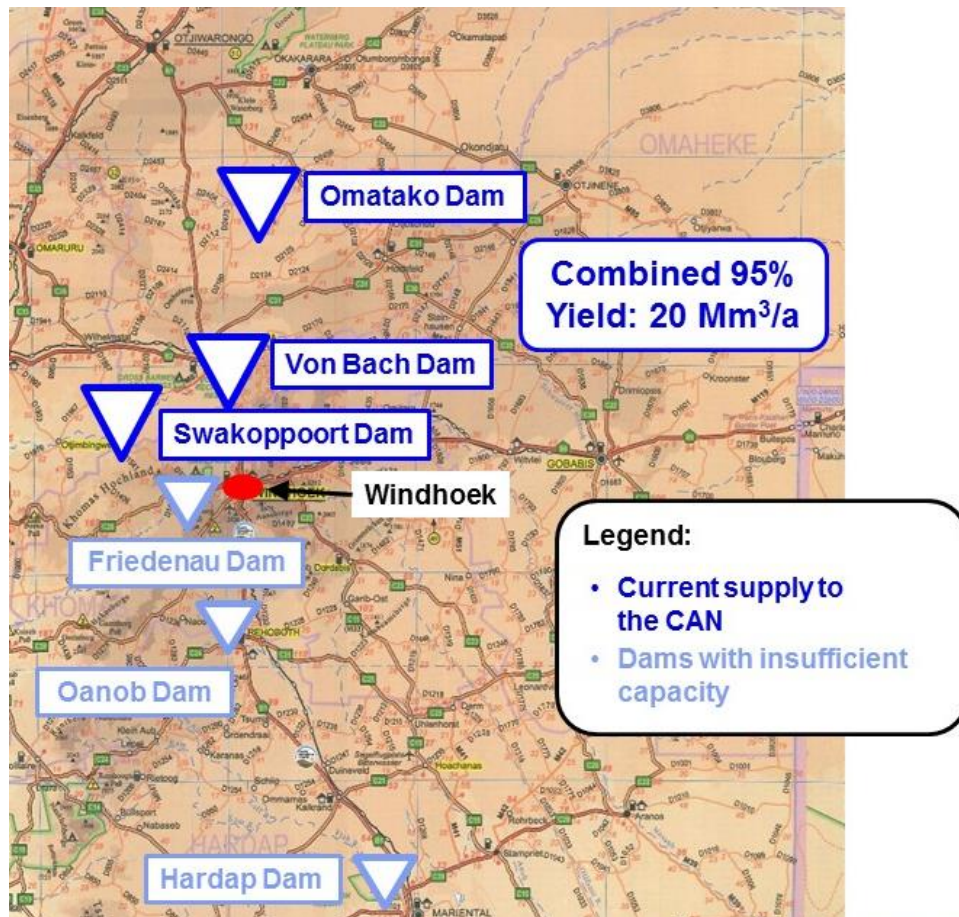
2.44 Mm³/a into the Auas Mountain Quartzites for the remainder of the simulation period.

2. Further development of the WMARS project (Scenario 4 below):
 - a. Increased recharge to 8 Mm³/a as from May 2018,
 - b. Emergency abstraction of 19 Mm³/a from May 2018,
 - c. Storage capacity of the existing water bank: 61 Mm³ after completion of boreholes and infrastructure,
 - d. Increased size of the water bank, from 61 Mm³ to 89 Mm³ and an increased emergency abstraction rate of 21 Mm³/a from 01 May 2020 onwards.

4.4.2 Surface Water Sources

All groundwater sources within Namibia between the Karst area and Rehoboth were investigated with regard to their potential supply capacity for the CAN.

Figure 4.4: Surface Water Sources Investigated



None of the Hardap, Oanob or Friedenau Dams have sufficient capacity to supply water to the CAN, and may themselves be oversubscribed in future.

4.4.3 Reclaimed and Recycled Water

4.4.3.1 Reclaimed Water in Windhoek

The City of Windhoek (CoW) is currently planning the upgrade of the Gammams Waste Water Treatment Plant (GWWTP), which will allow the treatment of larger volumes of waste water to a better quality. This will allow the New Goreangab Water Reclamation Plant to run at its full capacity of 21,000 m³/d, or 7.66 Mm³/a – an increase of 2.66 Mm³/a over the current capacity, which is estimated will be available from April 2017.

Following the upgrade of the GWWTP, the construction of an additional reclamation plant, to provide 4.2 Mm³/a via advanced membrane technology is recommended. Further into the future, this system could be doubled, to provide a total of 8.4 Mm³/a of additional water.

4.4.3.2 Recycled Water in Okahandja

Water reclamation may not be practical in towns with a water consumption of less than 1 Mm³/a in the CAN since the cost and operation of reclamation plants is expensive in comparison with conventional treatment and the necessary expertise may not be available in smaller towns. The only town with potential for reclamation is therefore Okahandja. The estimated current effluent volume for Okahandja is approximately 35% of the potable water supply, based on NamWater's sales data and production of the Okahandja Boreholes (together 1,577,924 m³), provided that the various premises are linked to a sewer system as assumed. Based on the expected water demand for 2049/2050 (3.952 Mm³/a) the available volume of reusable effluent for non-potable use will be 1.362 Mm³/a (34%), provided that the relative portions of future water use in Okahandja remain the same as currently.

4.4.3.3 Dual Pipe Systems

To improve water use efficiency in the CAN, it may be advisable to enforce the installation of dual pipe systems at least for parks (landscaping), sport fields and cemeteries in all new developments. The potential savings in potable water will vary from town to town but may be in the order of 7 to 15%.

4.4.4 Other Supply Options

Other supply options investigated previously and only updated under this Study include:

1. Covering of the Eastern National Water Carrier Canal: For savings estimated at between 0.8 and 1.1 Mm³/a of a cost of MN\$ 210 excluding VAT in 2004, this is not a viable supply option to the CAN,
2. Abstraction from the Kunene River: The Kunene River should be reserved for supply to the Cuvelai Area (the only supply source to the area) and hydropower generation. There is a risk that with increased abstraction upstream in Angola, capacity for supply to Namibia may be reduced,

3. Abstraction from the Orange River:

- a. Since the Orange River is further from Windhoek than the Okavango River is from Grootfontein, with greater pumping requirements, this option will remain more expensive than abstraction from the Okavango River, and is made more so with the requirement of another water treatment plant near Windhoek.
- b. With flow in the Orange River already highly regulated, and likely to become more so in the future, Namibia is very dependant on abstractions from and flow management of the upstream systems. With the projected future water demand of current users (mostly irrigation, but including supply to Noordoewer, Oranjemund, Rosh Pinah and Skorpion Zinc Mine) likely to be a multiple of the currently agreed share available to Namibia, it is uncertain whether additional water can be abstracted for supply to the CAN by Namibia.
- c. This option will therefore remain much more expensive and therefore less attractive than abstraction from the Okavango River and consequently does not constitute a viable water supply augmentation option for the CAN

4.4.5 Viable Long-Term Water Sources

Only two sources with sufficient capacity to supply the long-term water demands of the CAN could be identified, namely the Okavango River and the desalination of sea water.

Investigations into the capacity of the Okavango River are underway, from which the following preliminary conclusions can be made:

1. Advantages:

- a. Flows in the Okavango River appear not to be correlated with the inflows into the 3 CAN dams (i.e. droughts in the CAN do not coincide with droughts in the Okavango River), which means that this is a source independent of the hydrological conditions in the CAN,
- b. Likely to be a less expensive supply option than desalination, both in terms of capital and energy costs,
- c. Will be a less energy intensive supply option than desalination,
- d. The Okavango River currently has good quality water, though it is aggressive towards concrete,

2. Disadvantages:

- a. Competing water demands in the Kavango Regions and particularly with the irrigation demand of the Green Schemes (estimated to be 235 Mm³/a vs 64 Mm³/a required for the current extent of the CAN) may create a conflict w.r.t a possible abstraction limit / allocation to Namibia,
- b. As with the Kunene River, flow in the Okavango River is highly dependent on abstraction upstream in Angola. This is expected to increase significantly in future, with the development of irrigation schemes and even a possible transboundary scheme transferring water from the Cubango River to the Cuvelai area of southern Angola,

- c. Climate change effects may result in reduced or more erratic rainfall and hence runoff and flows in the Okavango River,
- d. The Okavango River is a Ramsar site and now a World Heritage Site and any potential threat to this system will attract international attention,
- e. Abstraction is currently only planned to 2050. Beyond this, the future demands are uncertain. If further into the future, demands have increased substantially, it is unlikely that the Okavango River will have sufficient supply capacity, given that other abstractions are likely to have increased as well (particularly upstream in Angola).

The supply of desalinated sea water from the coast is not included in the Terms of Reference for this Study. However, from a high level assessment, the following preliminary conclusions can be drawn:

- 1. Advantages:
 - a. The source capacity is essentially unlimited, which means that all future demands could be supplied,
 - b. The source is independent of the hydrological conditions in the CAN,
 - c. The capacity of the source will not be impacted by upstream use and abstraction in another country,
 - d. The source will most likely not be effected by climate changes,
- 2. Disadvantages:
 - a. Likely to be a more expensive supply option than the Okavango River, both in terms of capital and energy costs,
 - b. Will be a much more energy intensive supply option than the Okavango River and Namibia is currently a net importer of power, dependent on power generation in neighbouring countries.

4.5 FURTHER ANALYSIS OF WATER SUPPLY TO THE CAN

4.5.1 Supply / Demand Computer Modelling

NamWater uses the Central Area Model (**CA-Model**), which is a computer model which simulates the hydrological water balance of the Central Area of Namibia using a monthly time scale to analyse the water security on the CAN. Since the regional hydrology of the CAN is dictated by highly variable rainfall events with low annual yields and very high annual evaporation rates, the CA-Model performs a repeated water balance using a randomised pattern of historic statistical analyses to quantify the security of water supply in terms of statistical probabilities. The CA-Model can also be used to predict the earliest run-dry date given current water storages and no future inflows (worst case scenario). Over the past 16 years, the CA-Model has become an invaluable tool in NamWater's annual water management planning, as well as for long-term planning of regional capital infrastructure investment.

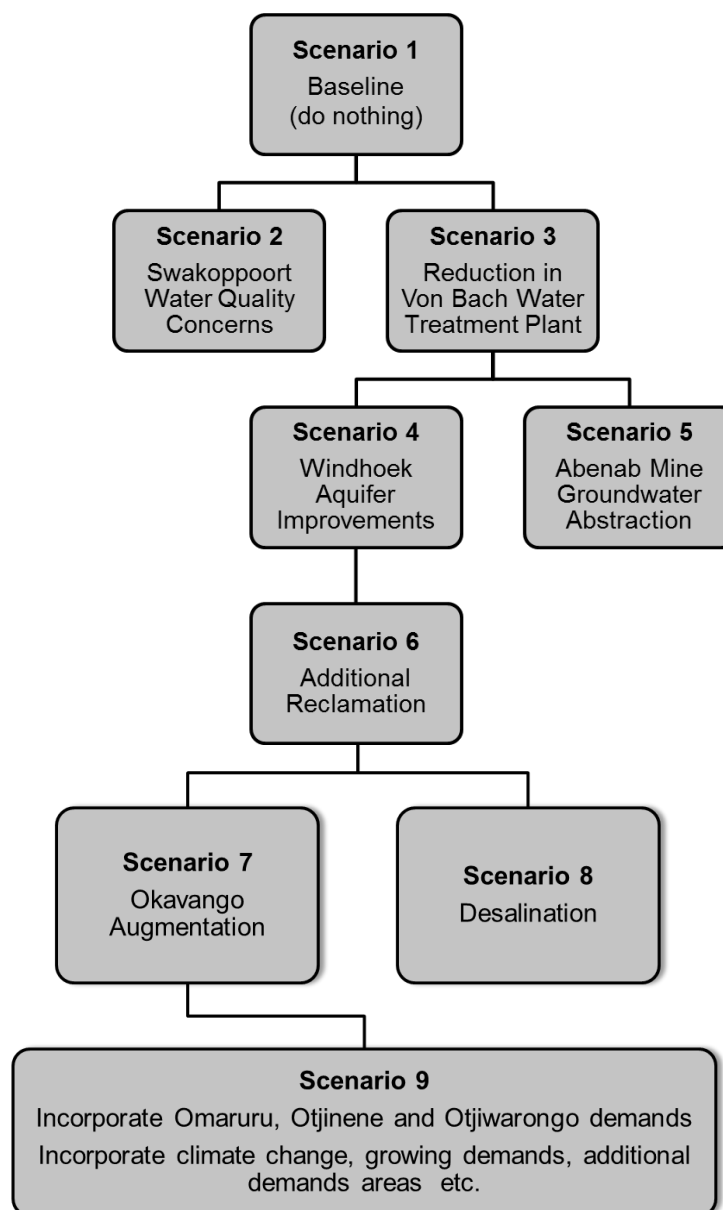
4.5.2 Supply Scenarios

The Consultant has used the CA-Model, as used by NamWater, to conduct hydrological and supply / demand modelling to analyse the long-term water supply situation in the CAN. A number of scenarios were investigated, which are summarised briefly as:

1. Scenario 1: Baseline, “do nothing” or “business as usual”,
2. Scenario 2:
 - a. Scenario 2a: No transfer from Swakoppoort Dam to Von Bach Dam due to water quality concerns (mostly applicable during recharge periods and mainly as a result of high DOC values),
 - b. Transfer from Swakoppoort Dam to Von Bach Dam only for 8 months of the year, due to water quality concerns (no transfer in August, September October and November as result of extremely high algal counts),
3. Scenario 3: Reduction of losses to 1% at the Von Bach Water Treatment Plant through the recycling of supernatant to the Von Bach Dam as from May 2016,
4. Scenario 4: Completion of the Windhoek Managed Aquifer Recharge Scheme (WMARS):
 - a. Increased recharge to 8 Mm³/a as from May 2018,
 - b. Emergency abstraction of 19 Mm³/a from May 2018,
 - c. Storage capacity of the existing water bank: 61 Mm³ after completion of boreholes and infrastructure,
 - d. Increased size of the water bank, from 61 Mm³ to 89 Mm³ and an increased emergency abstraction rate of 21 Mm³/a from 01 May 2020 onwards,
5. Scenario 5: As an alternative to the WMARS, supply from the Abenab Area for an emergency abstraction rate of 12 Mm³/a for 3 years only, implemented in May 2018,
6. Scenario 6: WMARS development of Scenario 4 plus additional reclamation of 4.2 Mm³/a in Windhoek as from May 2019,
7. Scenario 7: Abstraction from the Okavango River,
8. Scenario 8: Supply of desalinated sea water from the coast,
9. Scenario 9: Supply to additional areas and increased water demands:
 - a. Scenario 9a: Augmentation to Omaruru, Otjinene, and Otjiwarongo,
 - b. Scenario 9b: Scenario 9a plus an additional 10% demand in Windhoek,
 - c. Scenario 9c: Scenario 9b plus an additional 10% (21% in total) demand in Windhoek,
 - d. Scenario 9d: Scenario 9c plus supply to the currently unserved and undeveloped areas in the North-Eastern Otjozondjupa and Northern Omaheke Regions.

An overview of the supply scenarios and their hierarchy is provided in **Figure 4.5**.

Figure 4.5: Supply Scenarios



4.5.3 Design / Modelling Goal

With the erratic rainfall and inflow into the three dam system it is important to control the magnitude of the maximum shortfall in supply. The proposed design or supply goal is based on a 99% likelihood that annual shortfall magnitudes will be no greater than 15% of the annual demand for each year of the 36-year planning horizon. This design goal for the CAN was developed under the 2004 Water Augmentation Study and has been used since.

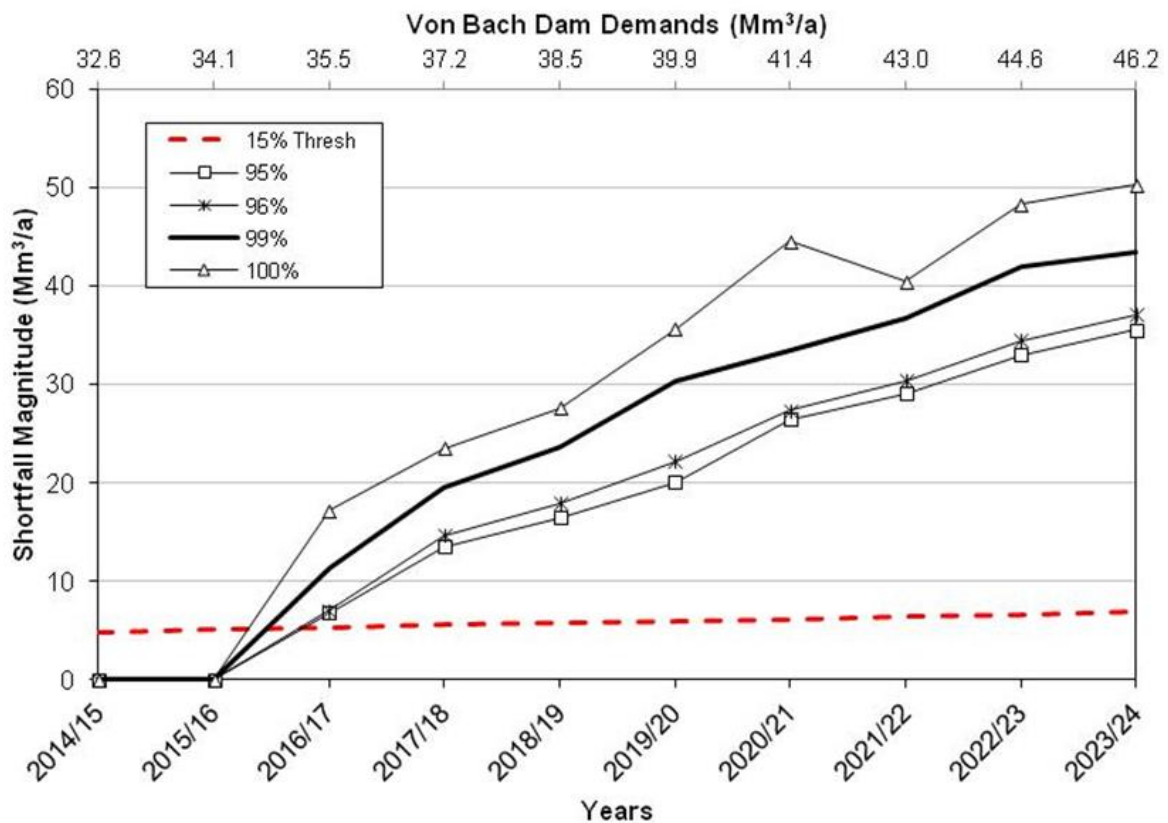
An acceptable shortfall in supply of 15% is based on the Failure of Supply estimate as determined under the 2001 CASU study, where it was found that a reduction in demand of between 12% and 15% would constitute an acceptable level of savings for Windhoek where no economic losses would occur during periods of shortfall.

This design goal implies that we are willing to accept a 1% annual or 1 in 100 year-to-year risk that shortfall magnitudes might exceed the 15% threshold, but we are not willing to accept a risk higher than that. This approach to system design provides an easy and direct method of interpreting modelling results and assessing during which year new infrastructure development is required in order to reduce future shortfall magnitudes to acceptable levels. The 15% shortfall threshold is shown as a red dotted line in the graphs below, which provide the results of the modelling.

4.5.4 Results of the Baseline Scenario

The shortfall magnitudes for the Baseline Scenario (Scenario 1) are depicted in **Figure 4.6**, which shows that shortfalls in excess of 11 Mm³/a may occur as from April 2016 onwards, with a maximum shortfall of 43.5 Mm³/a by April 2024, based on the design goal (99% security of supply). With the shortage of water, the production of the Windhoek boreholes reduces to the annual recharge whilst almost no water is available for reclamation, which causes a water supply system collapse.

Figure 4.6: Baseline Shortfall Magnitudes



No shortfalls are expected up to 2015/16, due to the water available in the 3 CAN dams and the various aquifers (based on the initial conditions). Once these resources have been drawn down, shortfalls are expected from 2015/16 onwards.

Analysing the results of the modelling shows that CAN has a very high probability of shortfalls in water supply to all users supplied from the Von Bach Dam for the period from April 2016 onwards, based on a 99% security of supply over the 10 year period. The probabilities of failure (shortfalls greater than 15%) based on the current status of bulk water supply are:

1. 50% probability that shortfalls up to 16 Mm³/a may occur in any year,
2. 35% probability that shortfalls up to 22 Mm³/a may occur in any year,
3. 10% probability that shortfalls up to 34 Mm³/a may occur in any year, and
4. 5% probability that shortfalls up to 39 Mm³/a may occur in any year.

4.5.5 Results of Scenario 2 (No or Limited Water from Swakoppoort Dam)

The results of Scenario 2 relative to the Baseline Scenario show that restricting the pumping from Swakoppoort Dam to Von Bach Dam is not an option, as the shortfalls are significantly higher than for the Baseline Scenario (Scenario 1). The shortfalls under Scenario 2a (no transfer at all from Swakoppoort Dam) also commence immediately, as opposed to the one-year delay under the Baseline Scenario.

It is therefore imperative that a scheme to solve the water quality concerns caused by high algae growth at Swakoppoort Dam through advanced treatment or treatment in the dam be implemented.

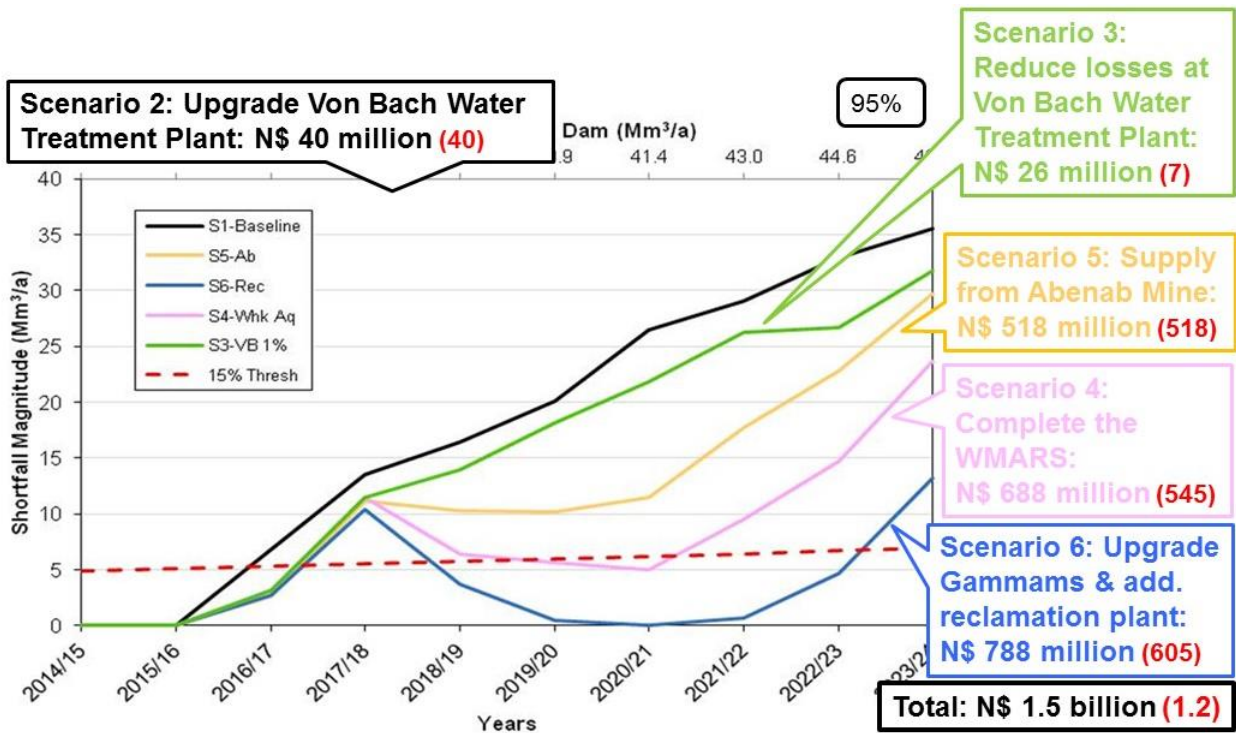
4.5.6 Results of Medium Term Scenarios

4.5.6.1 Results of Medium Term Scenarios

In developing Scenarios 3 to 6 the goal was to try and establish a period of 10 years of relatively safe supply to provide some time to investigate and implement other major supply augmentation schemes such as the link to the Okavango River or the desalination of sea water. Many of the proposals will be difficult and expensive to implement, with a major effect on the unit cost of water downstream of the VBWTP, if costs are to be recovered from water tariffs. Most of the options, such as increasing the size of the Windhoek water bank or increased reclamation in Windhoek, can be phased in as required, depending on the levels of the dams. Additional deep boreholes can be drilled and tested while infrastructure can be phased in, if and when required. Similarly, advanced reclamation (membrane systems) is modular and can be implemented in stages of 100 m³/h say.

The expected shortfalls for Scenarios 3 to 6 are depicted in **Figure 4.7**, which shows that in order to reduce the expected shortfalls to the lowest possible volumes up to 2023/24, Scenarios 2, 3, 4 and 6 **ALL** need to be implemented, at an estimated cost of N\$ 1.5 billion.

Figure 4.7: Results of the Medium Term Scenarios



Notes:

1. 95% Security of Supply results shown because the design goal of 99% Security of Supply cannot be met,
2. Estimated costs of each scenario shown.
3. NamWater and the CoW have budgeted some money for some of the scenarios investigated. The budget shortfalls are shown in red.

Figure 4.8: Results of the Medium Term Scenarios: Decreasing the Probability of Failure

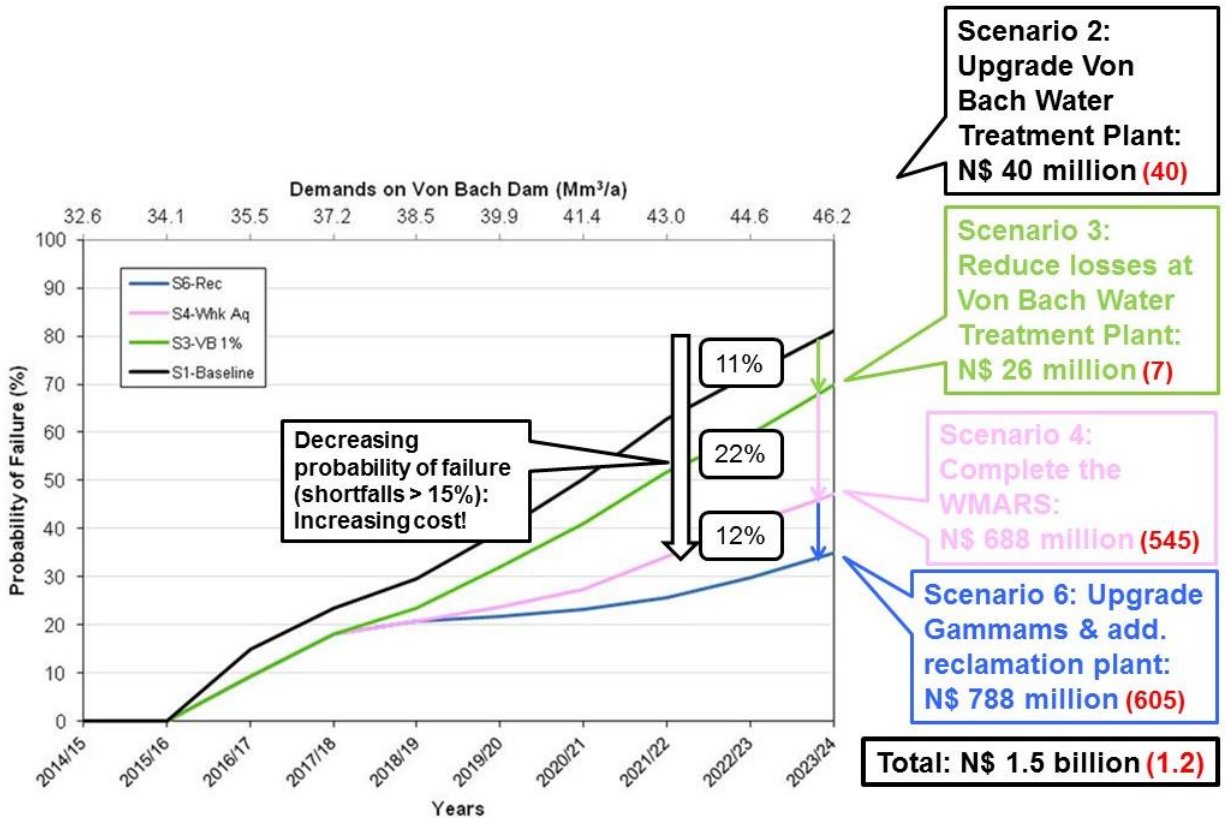


Figure 4.8 provides the same results shown differently – here in the context of reducing the probability of failure, which is defined as shortfalls exceeding 15% of the water demand. It is clear that systematically reducing the probability of failure results in systematically increasing costs.

4.5.6.1 Prioritisation of the Medium Term Scenarios

Given the critical nature of the current and short-term water supply in the CAN, the proposed medium term measures, including also other measures already in place, have been prioritised in terms of implementation which will provide the most water in the shortest space of time. This is shown in **Table 4.1**.

Table 4.1: Implementation of Medium-Term Measures to Reduce the Shortfalls in the Central Area of Namibia

Project Priority	Project	Cost Estimates for Implementation Per Financial Year (N\$ millions)					Remarks
		2015/16	2016/17	2017/18	2018/19	Total Cost	
1	Extending the Windhoek Aquifer area and increasing the abstraction and recharge capacities (ongoing)	60	162	162	139	523	Will increase abstraction from 5.5 Mm ³ /a to maximum of 19 Mm ³ /a over 4 to 5 years. Phase 1 (2015/16) to increase capacity first to 7 and then to 9 Mm ³ /a critical for completion as soon as possible to prevent shortfalls by the end of 2015.
1	De-water Kombat Mine.	22	23			45	Up to potential of 7.3 Mm ³ /a can be abstracted by dewatering Kombat Mine
1	Upgrading of the Gammams Waste Water Treatment Plant (ongoing)	205	150	10	10	375	Required to provide reclaimable water to New Goreangab Water Reclamation Plant (NGWRP). Capacity 7.66 Mm ³ /a. If not completed, NGWRP may stop production.
2	Treatment and recycling of the wash water from the Von Bach Water Treatment Plant		7			7	Water recycled as part of the drought scenario. Required for improved water quality.
2	Upgrading of the Von Bach Water Treatment Plant for the treatment of Swakoppoort Dam water		20	20		40	Subject to feasibility study to determine the best option. Water Quality requires improvement.
2	Construction of an additional water reclamation plant in Windhoek	5		125	100	230	First year research and development for implementation if and when required. Low salinity water required for aquifer recharge to refill the water bank after major abstraction. (Annual Capacity 4.2 Mm ³ /a)
2	Develop Abenab & Karst Area III groundwater sources and connect to ENWC		200	250	68	518	Emergency abstraction rate of 13.4 Mm ³ /a comprising of 12 Mm ³ /a and 1.4 Mm ³ /a from the Abenab and Karst III respectively obtained for a period of 3 consecutive years followed by a recovery period of 12 years.
Total annual budget		292	562	567	317	1,738	

Notes:

- All costs are based on 2015 estimates excluding VAT. Annual allocations require adjustments for price adjustments each financial year. Financial years in accordance with Government Financial Years.
- The de-watering of Kombat Mine is included at the request of NamWater as an existing supply source and option. As such it is not included in the cost estimates earlier provided for Scenarios 2 to 6. The development of the Abenab & Karst Area III groundwater sources is also not included in the earlier cost estimates; this is why the values differ.
- The above shortfalls are based on CAN modelling results. The annual water demand in the Central Area of Namibia (CAN) is much higher than the safe yield of the available water resources. The projects in the above table are prioritised to bridge expected short-falls until 2021 to provide time for implementation of the next major supply scheme. Most of the above schemes require more than one year for construction and requires funding for implementation.

4.5.7 Scenario 7: Abstraction from the Okavango River

To prevent system capacity constraints influencing the results, all system transfer bottlenecks were adjusted upwards (refer to earlier footnotes). Transfer capacities of the various infrastructure components will be assessed separately, taking normal and peak transfers into account, for example with pipelines such as the Von Bach – Windhoek Pipeline.

The supply augmentation from the Okavango River was modelled as an emergency resource with no permanent transfers. This transfer is only activated if a shortfall may occur within the next 12 months. The modelling further assumed that the NGWRP would operate at full capacity while higher production from the Windhoek Aquifer is activated when a potential shortfall may occur in the next 12 months. The volume of supply from the Okavango River was increased over time in steps as summarised in **Table 4.2**. These steps are introduced to ensure full utilisation of all local resources in the modelling exercise before additional water is to be abstracted from the Okavango River.

Table 4.2: Modelled Abstraction Capacity from the Okavango River

Year		Emergency Capacity
Absolute	Relative	Mm ³ /a
2022/23	9	25
2028/29	15	32
2032/33	19	45
2039/40	26	60
2044/45	31	65

Note: These are the “capacity” values modelled in terms of abstraction. The actual volumes of water required / to be abstracted are shown in **Table 4.3**.

It is further important to note that the modelling of Scenario 7 was conducted in an iterative manner, both increasing abstraction from the Okavango River in a step-wise manner and bringing forward the date of implementation in order to meet the design or modelling goal / criteria. This implies that water abstracted from the Okavango River is to reach the CAN in 2022/23, which is 9 years after the start of modelling – this is shown in **Figure 4.9**.

The abstraction volumes from the Okavango River are illustrated in **Figure 4.10**, which also shows the commencement of the scheme in 2022/23. As expected, the abstraction from the Okavango River increases with time at almost at the same rate as the increase in the water demand. This is because the safe yields from the local resources in the CAN become relatively small in comparison with the expected water demand on the system. The median abstraction in 2049/50 is 40.5 Mm³/a whilst the 95% abstraction is 60.6 Mm³/a and the maximum abstraction is 61.1 Mm³/a. These rates are equivalent to continuous abstraction rates (20 hours a day) of 1.28, 2.30 and 2.32 m³/s respectively. There is a statistical anomaly produced by the model for the last two years. It is suggested that the figure for 99% abstraction be adjusted from 60.64 Mm³/a to 64 Mm³/a.

Figure 4.9: Comparative Shortfalls on Von Bach Dam for Scenario 7 (99 Percentile)

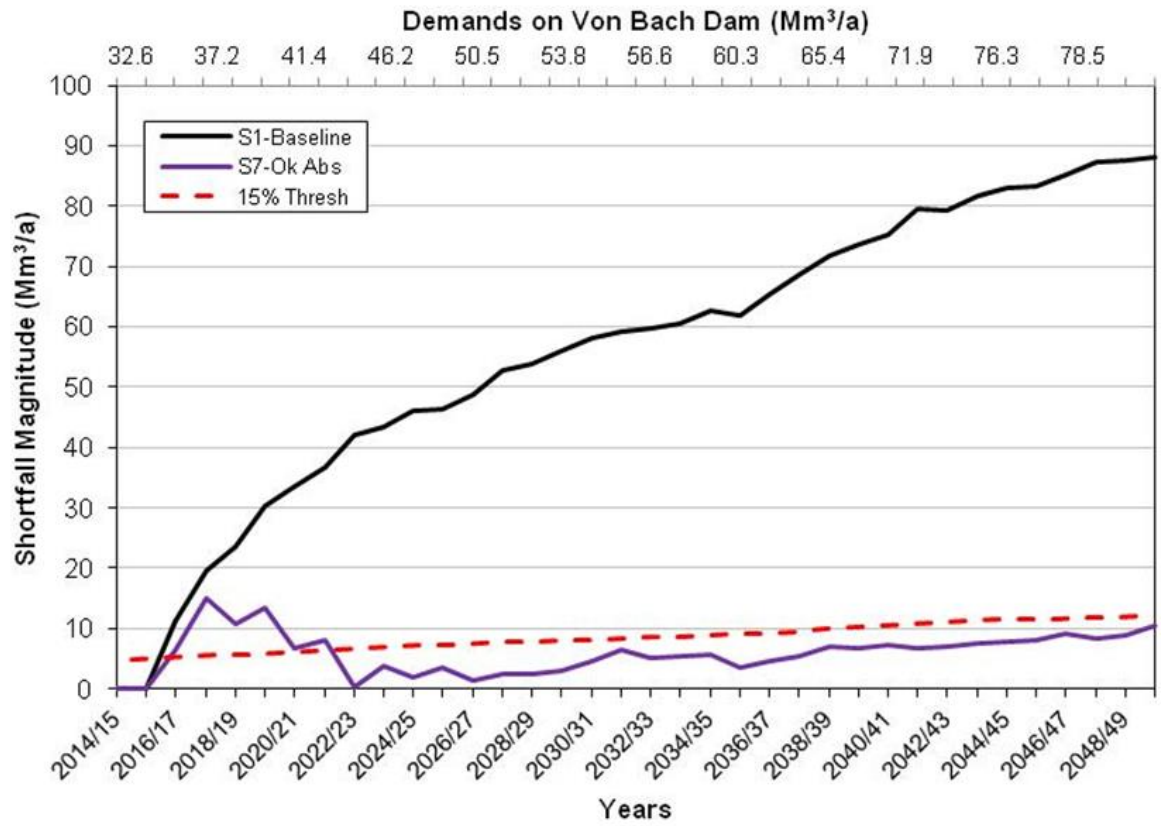
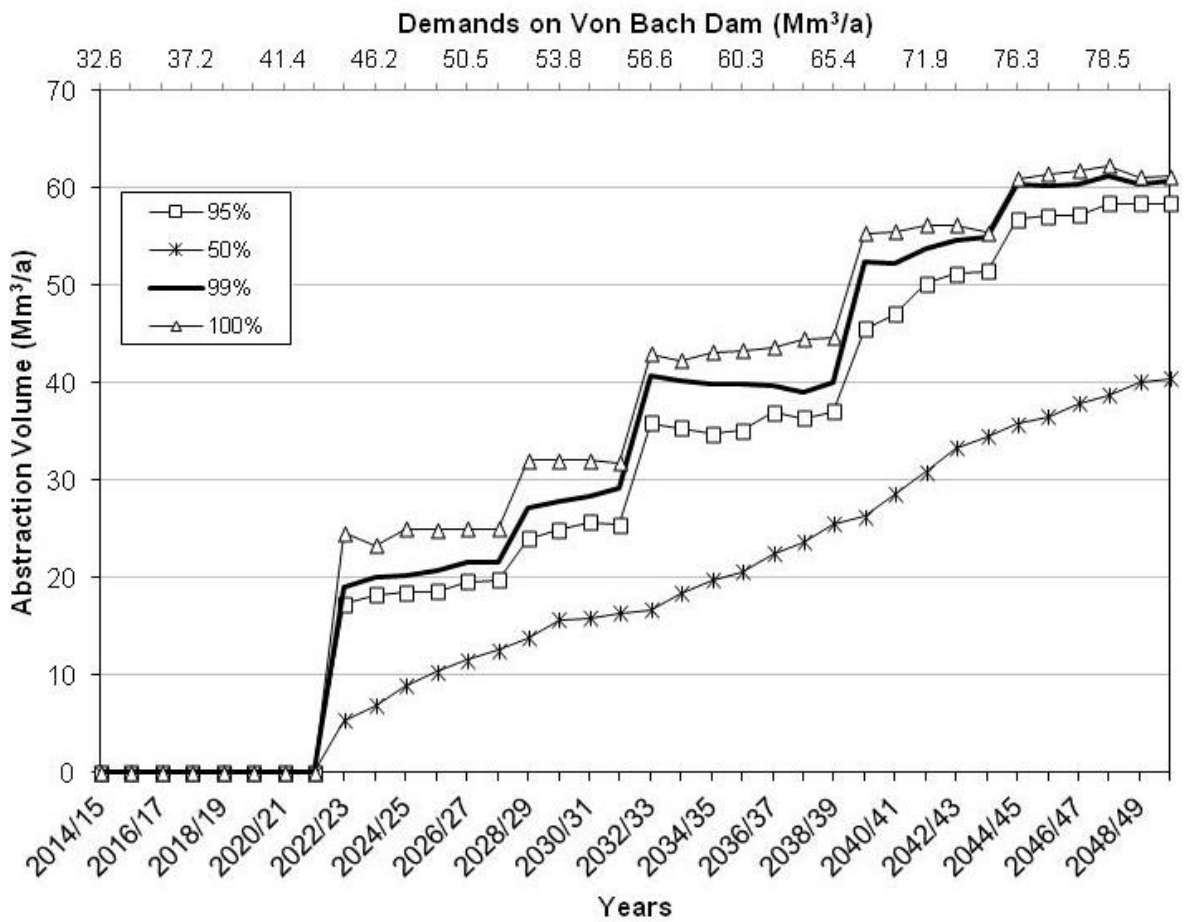
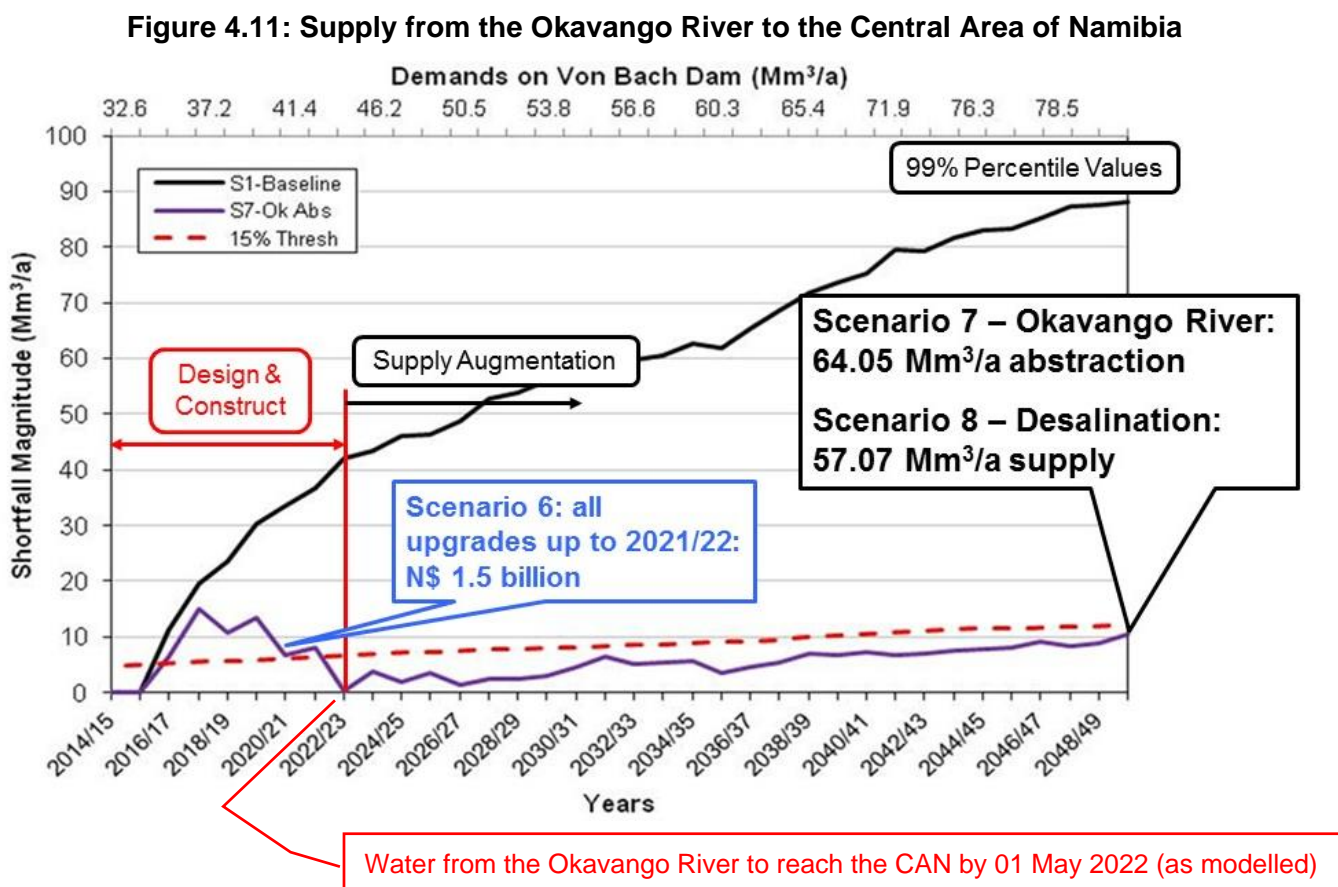


Figure 4.10: Abstraction Volumes from the Okavango River



The proposed implementation of abstraction from the Okavango River, with water to reach the CAN by May 2022, is shown in **Figure 4.11**.



4.5.8 Scenario 8: Desalinated Sea Water from the Coast

The option is exactly the same as Scenario 7 which examines the importation of water from the Okavango River. The only difference is the lower losses through the pipeline system with Supply under Scenario 8 directly to Von Bach or Windhoek in comparison with the losses in the ENWC Canal and some evaporation losses under Scenario 7. The volumes of desalinated sea water from the coast required under Scenario 8 were calculated based on those required from the Okavango River under Scenario 7, adjusting for the lower system losses, because the CA-Model does not have the capability to adequately analyse this as a separate supply source.

A comparison of the volumes required from the Okavango River (Scenario 7) and those of desalinated sea water (Scenario 8) are provided in **Table 4.3** – for supply to existing systems and consumers in the CAN only. As a result of the lower transfer losses to Von Bach Dam, lower volumes of water are required for Scenario 8 (desalination) than for Scenario 7 (Okavango River supply).

Table 4.3: Required Abstraction from the Okavango River (Scenario 7) and Desalination (Scenario 8)

Date	Scenario 7: Okavango Supply			Scenario 8: Desalination		
	50% ¹ (Mm ³ /a)	99% (Mm ³ /a)	100% (Mm ³ /a)	50% (Mm ³ /a)	99% (Mm ³ /a)	100% (Mm ³ /a)
2022/23	5.36	18.95	24.56	4.56	17.32	22.50
2024/25	8.89	20.25	25.00	8.05	18.27	21.99
2029/30	15.68	27.81	32.00	14.52	26.08	26.11
2034/35	19.77	39.80	43.10	18.43	36.59	36.75
2039/40	26.27	52.37	55.33	24.96	46.83	48.85
2044/45	35.72	60.34	60.95	33.46	55.98	55.72
2049/50	40.35	64.05 ²	67.14 ²	37.66	57.07 ²	59.95 ²

Note:

1. % denotes percentile values.
2. Figures for 2049/50 adjusted slightly to compensate for a statistical anomaly.

4.5.9 Scenario 9: Additional Supply Options

Different options for increased supply to the CAN were investigated under Scenario 9 as follows:

- Scenario 9a: Augmentation to Omaruru, Otjinene, and Otjiwarongo,
- Scenario 9b: Scenario 9a plus an additional 10% demand in Windhoek,
- Scenario 9c: Scenario 9b plus an additional 10% (21% in total) demand in Windhoek,
- Scenario 9d: Supply to the currently unserved and undeveloped areas in the North-Eastern Otjozondjupa and Northern Omaheke Regions.

The results of these scenarios, in terms of supply from the Okavango River, as shown in **Table 4.4**.

Table 4.4: Summary of Abstraction from the Okavango River for Scenario 9

Date	99% Security of Supply: Abstraction Volumes (Mm ³ /a)				
	Scenario 7: Current Consumers	Scenario 9a: Including Augmentation to Omaruru, Otjiwarongo and Otjinene	Scenario 9b: Windhoek Demand +10%	Scenario 9c: Windhoek Demand +21%	Scenario 9d: Scenario 9c + Supply to NE Areas
2024/25	20.25	20.38	26.05	27.58	30.10
2029/30	27.81	28.52	37.77	40.06	45.87
2034/35	39.80	40.26	49.13	55.41	66.01
2039/40	52.37	52.98	58.45	66.39	82.03
2044/45	60.34	61.53	69.92	76.69	95.76
2049/50	64.05	65.00	72.98	81.18	102.46

Note:

1. % denotes percentile values.
2. Figures for 2049/50 adjusted slightly to compensate for a statistical anomaly.

The possible abstraction rates from the Okavango River for the different demand scenarios, assuming a 20-hour pumping day by NamWater, are shown in **Table 4.5**. It can be seen that abstraction from the Okavango River forms a small percentage of the high flows and even of the overall volume in the river. However, abstraction forms a much higher percentage of the low flows in the river; over a third of the lowest flow on record at Rundu for Scenario 9d. Abstraction during low flow periods in the river constitutes the most sensitive ecological impact of this option, which will require evaluation by the Environmental and Social Consultant.

Table 4.5: Possible Abstraction Rates from the Okavango River

Source Supply (99%) and Scenario	Okavango River Supply					Scenario 8: Desalination "Normal" Demands as per Scenario 7
	Scenario 7: Current Consumers	Scenario 9a: Including Augmentation to Omaruru, Otjiwarongo and Otjinene	Scenario 9b: Windhoek Demand +10%	Scenario 9c: Windhoek Demand +21	Scenario 9d: Scenario 9c + Supply to NE Areas	
Volume: 2049/50 (Mm³/a)	64.05	65.00	72.98	81.18	102.46	57.07
Rundu (MAR: 5,464 Mm ³ /a)	1.2%	1.2%	1.3%	1.5%	1.9%	---
Mukwe (MAR: 9,773 Mm ³ /a)	0.70%	0.7%	0.7%	0.8%	1.1%	---
Flow Rate: 2049/50 (m³/s) {20 hrs}	2.44	2.47	2.78	3.09	3.90	2.17
Rundu (Median: 109.76 m ³ /s)	2.2%	2.3%	2.5%	2.8%	3.6%	---
Mukwe (Median: 248.49 m ³ /s)	1.0%	1.0%	1.1%	1.2%	1.6%	---
Rundu (Min: 11.12 m ³ /s)	21.0%	22.2%	25.0%	27.8%	35.1%	---
Mukwe (Min: 74.73 m ³ /s)	3.3%	3.3%	3.7%	4.1%	5.2%	---

Notes:

1. MAR = Mean Annual Runoff.
2. Supply to "NE Areas" is the supply to the currently unserved and undeveloped areas in the North-Eastern Otjozondjupa and Northern Omaheke Regions.
3. Not including supply to the areas and schemes currently supplied with water from the Okavango River, for example Rundu and the Green Scheme irrigation projects.

4.6 CONCLUSIONS, RECOMMENDATIONS AND REMAINING WORK

4.6.1 Conclusions

Based on the foregoing, the CAN faces a major water supply problem. The Consultant's appointment is to examine the long-term water supply in the CAN. However, a dual strategy has been proposed for securing the water supply to the CAN; covering two periods; the first 8 years to 2023/24 and then until the end of the planning horizon in 2049/50, namely:

1. That all the water supply options which are known about and which can be implemented within 2 to 5 years be analysed with regard to minimising supply shortfalls in the next 8 – 10 years (Scenarios 2 to 6), and then
2. That alternatives which will minimise supply shortfalls up to the end of the planning horizon in 2050 be analysed and the timing of the implementation of these alternatives be optimised as far as possible (Scenarios 7 to 9). The chosen alternative(s) will need to be implemented within the 8 – 10-year period initially analysed.

4.6.2 Recommendations

The inability to use Swakoppoort Dam water (Scenario 2) impacts very severely on the water supply security of the CAN, with higher and more immediate shortfalls to be expected. It is therefore imperative that the poor water quality in Swakoppoort Dam be addressed as a matter of urgency.

It is recommended that the following Scenarios be accepted for an analysis of the possible environmental impacts and following that more detailed cost estimation under the remaining components of Phase 2 of this Project:

1. Scenario 3: VBWTP supernatant recycling to reduce the losses at the plant,
2. Scenario 4: 8 Mm³/a recharge and 21 Mm³/a abstraction capacity and 89 Mm³ water bank for the Windhoek Aquifer under the WMARS project,
3. Scenario 6 Advanced reclamation be accepted as interim supply source for the first 8 years until 2023/24,
4. Scenario 7 (Okavango River supply) and Scenario 8 (Desalination) be investigated up to preliminary design and costing, including the water supply to the currently unserved and undeveloped areas in the North-Eastern Otjozondjupa and Northern Omaheke Regions (Scenario 9d).

It should however be noted that investigation of the "desalination option" is not included in the Terms of Reference for this Study. The Consultant has provided preliminary results of the supply / demand modelling for this scenario on the basis that apart from the Okavango River, it is the only other alternative long-term, secure water source with sufficient capacity to supply the future water demands of the CAN. However, further work will be required to analyse this option / scenario in more detail and it is recommended that the MAWF extend the Engineering Consultant's appointment to facilitate this.

4.6.3 Remaining Work (Phase 2)

Pending the outcome of the environmental assessments, the following is recommended:

1. That the cost sensitivity be tested for both Scenarios 9a (water augmentation to Otjiwarongo, Otjinene and Omaruru) and 9b (Scenario 9a plus an additional 10% water demand in Windhoek),
2. That capacity constraints related to the bulk supply options be identified on the existing bulk water supply infrastructure.

A proposal has been made to the PSC that the Terms of Reference of the Engineering Consultant be extended to include consideration of the supply of desalinated sea water to the CAN. A decision on this matter is required before Phase 2 of the Project can be finalised.

Following the finalisation of the preliminary environmental assessments under Phase 2 this Project, the Engineering Consultant will formulate the abovementioned proposals / schemes and Phase 2 will conclude with the submission of a report detailing the above.

4.6.4 Remaining Work (Phase 3)

Under Phase 3 of the Project, for both the Cuvelai and Central Areas of Namibia, the following are to be determined:

- The required new infrastructure for the water supply schemes / options proposed,
- The required upgrades / rehabilitation of existing infrastructure for the water supply schemes / options proposed,
- The proposed water supply schemes / options are to be evaluated in terms of costs, technical, financial and other feasibility, including operation, maintenance and other considerations,
- A 2nd round of public participation meetings is to be conducted in Rundu, Oshakati and Windhoek,
- A final project report detailing the above is to be submitted.

5. APPROVAL OF REPORT AND RECOMMENDATIONS

This report has been read and approved for submission to the Director: Infrastructure Development of the Department of Water Affairs and Forestry for concurrence. I support the recommendations set out in the report and submit it to the Deputy Permanent Secretary of the Department of Water Affairs and Forestry for endorsement.


DEPUTY DIRECTOR: INFRASTRUCTURE DEVELOPMENT

04/03/2016
DATE

I endorse the recommendations set out in the report and submit it to the Permanent Secretary of the Ministry of Agriculture, Water and Forestry for approval.


DEPUTY PERMANENT SECRETARY: DWAF

07/03/2016
DATE

The recommendations in this report have been decided upon as follows:


PERMANENT SECRETARY

07/03/2016
DATE