VEOLIA

Windhoek Direct Potable Water Reuse
-
Past, present and future

Yvan Poussade, Veolia

Windhoek: more than 50 Years of Direct Potable Reuse

50th

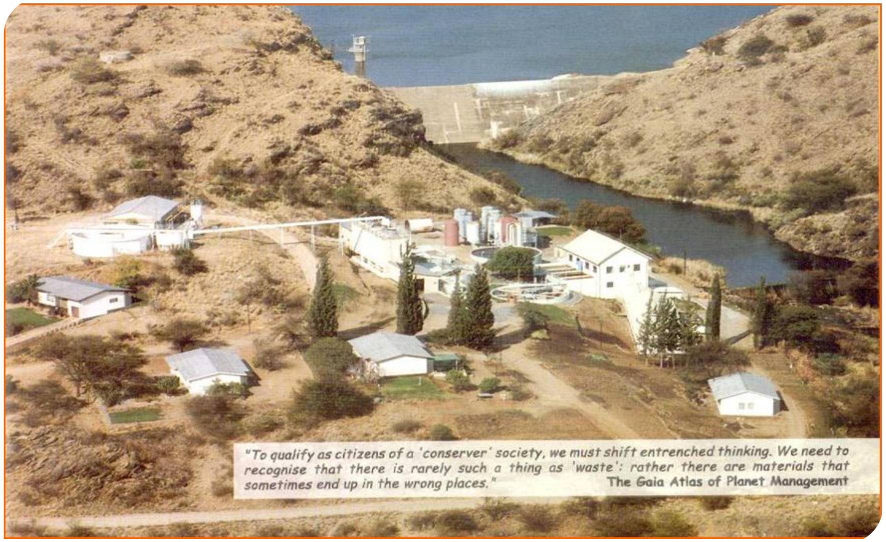
GOREANGAB RECLAMATION

ANNIVERSARY

DIRECT POTABLE RECLAMATION WITH A CLEAN BILL

Old and New Goreangab Water Reclamation Plant

Historic Landmark in Sustainable Water Management



First DPR plant - 1968

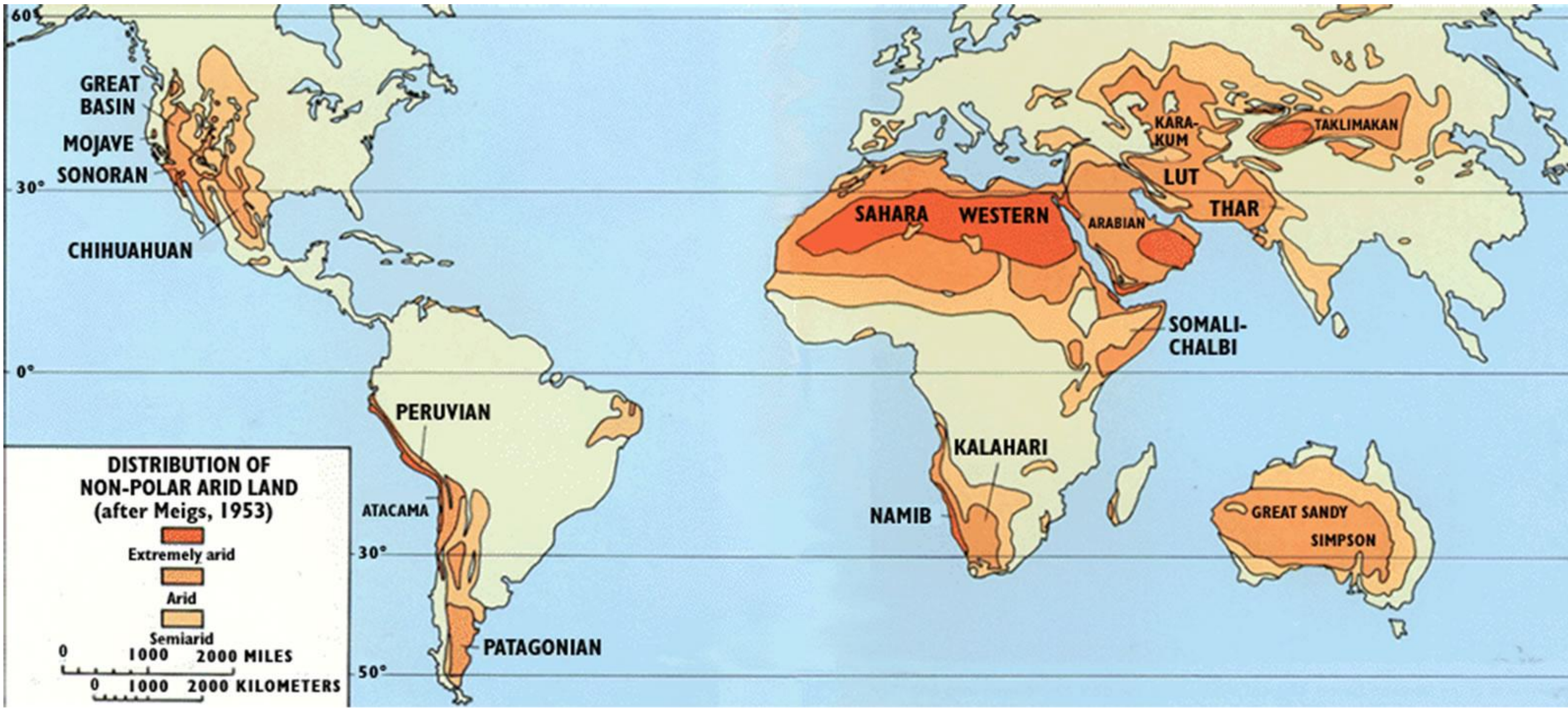
New DPR plant - 2002

Content

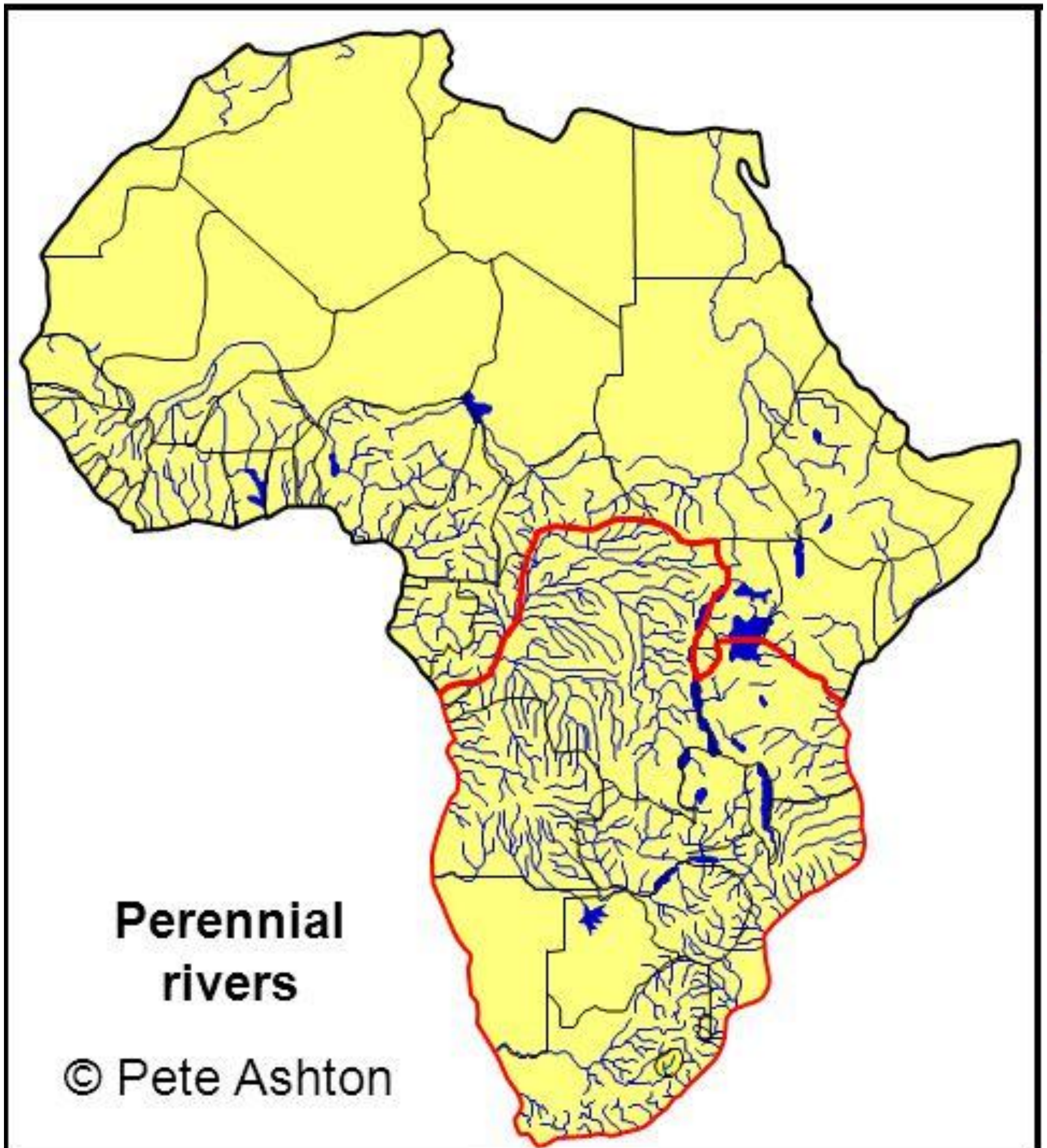
1. Why was Direct Potable Reuse implemented
2. How was it implemented
3. Public acceptance
4. Continuous impact
5. Current status & future supply of potable water to Windhoek

DPR to Augment the Potable Water Supply of Windhoek

Namibia – Country of 2 Deserts



DPR to Augment the Potable Water Supply of Windhoek



DPR to Augment the Potable Water Supply of Windhoek

Windhoek's Water Supply History

- **1800's** — Early settlement – hot natural springs. Names: /Ai//gams ("Fire water" - Nama) Otjomuise ("Place of steam" - Herero)
- **1911** — Development of well field
- **1933** — Avis Dam – 2.4 Mm^3
- **1957** — Water Crisis - Well field over abstracted by more than 50%
- **1959** — Goreangab Dam – 3.6 Mm^3
- **1960** — **Wellfield over abstracted by 100%**

DPR to Augment the Potable Water Supply of Windhoek

1960: Safe Yield 2.6 Mm^3/a versus 3.8 Mm^3/a demand with high growth.

Avis Dam (2.4 Mm^3)

- Average abstraction attained over initial lifespan (1934 to 1959) – 0.375 Mm^3/a
- Empty 4 out of 10 years on average (current status)
- "For all practical purposes therefore, Avis Dam can at 95% probability of a certain yield, provide nothing."

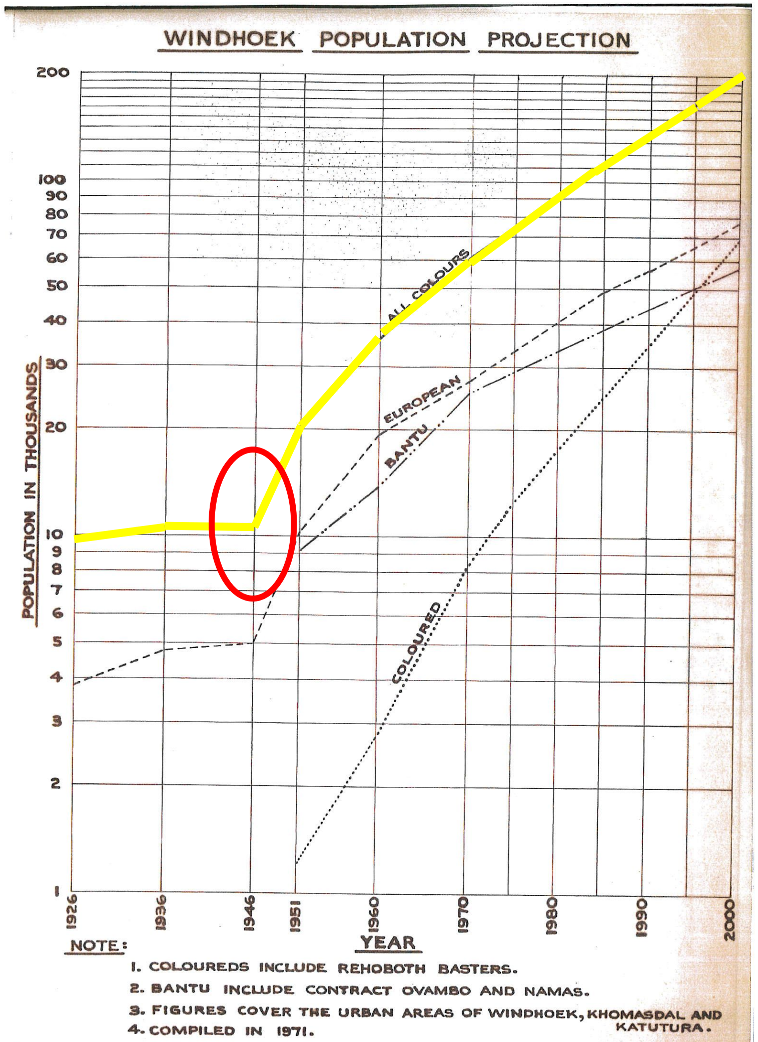
Goreangab Dam (3.6 Mm^3)

- New (1959) – Expected yield of 0.6 Mm^3/a at 95% reliability
- Considered together with Avis dam to be able to provide 0.8 - 1.0 Mm^3/a at 75% reliability
- Dam constructed downstream of the city (15km away) – prone to pollution (today not used for potable)

Windhoek Aquifer

- Safe Yield established at 1.6 Mm^3/a (3.1 Mm^3/a)
- Draw-off in 1960 – 3.22 Mm^3
- Continued over-abstraction of the aquifer a serious concern (Executive Commission Report, 1958)

DPR to Augment the Potable Water Supply of Windhoek



[redacted]

Period	Pop. Inc. (%)
1939 - 1945	3.6 %
1945 - 1951	8.8 %
1951 – 1957	10.5 %

[redacted]

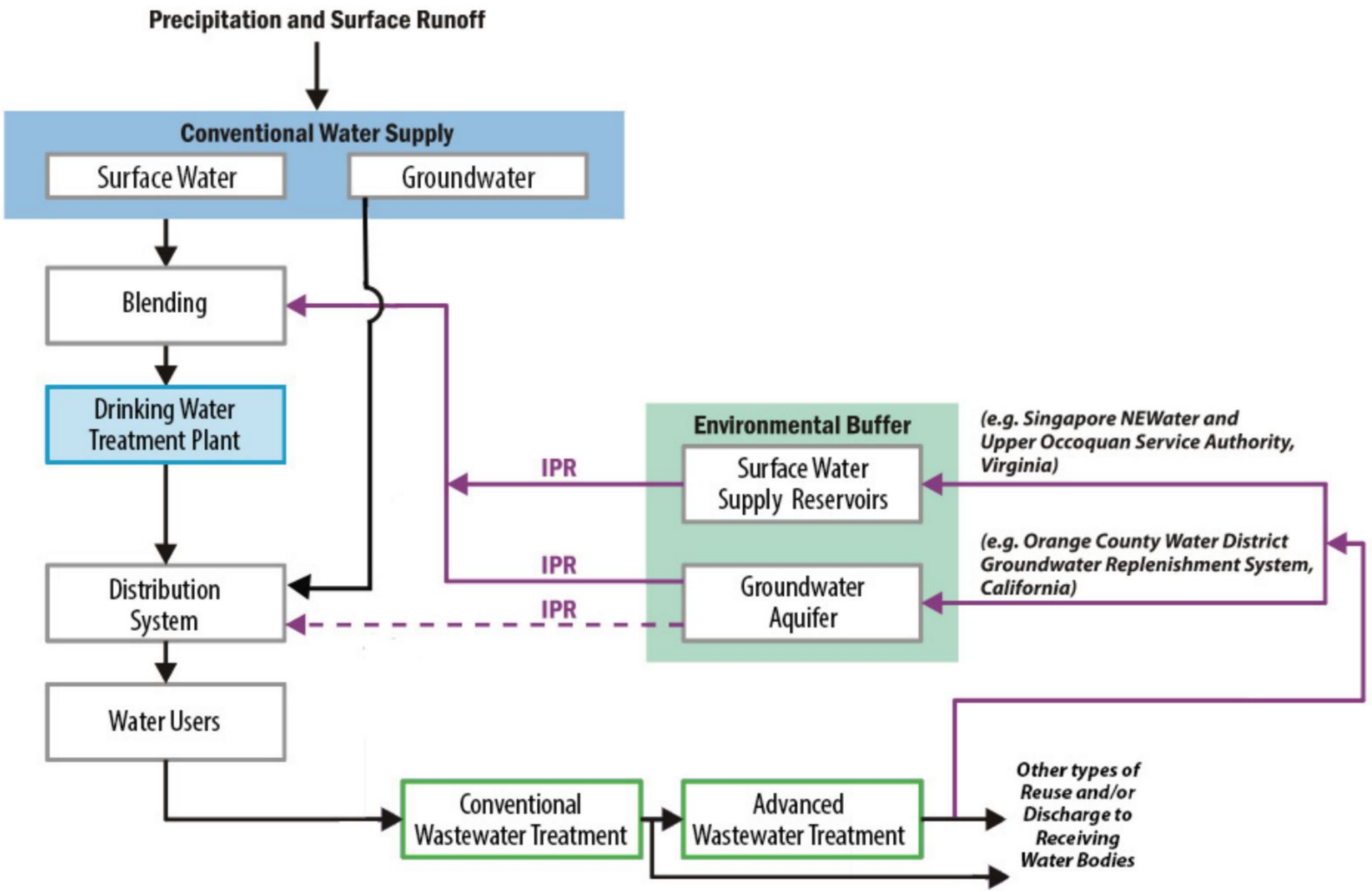
Period	Estimated Growth (%)
1958 - 1960	12.5 %
1961 - 1962	10 %
1963 – 1969	8.5 %
1970 - onwards	7 % (on 1969)

Review of Windhoek's Water Supplies – September 1960, Annex. B, pg. 67

DPR to Augment the Potable Water Supply of Windhoek

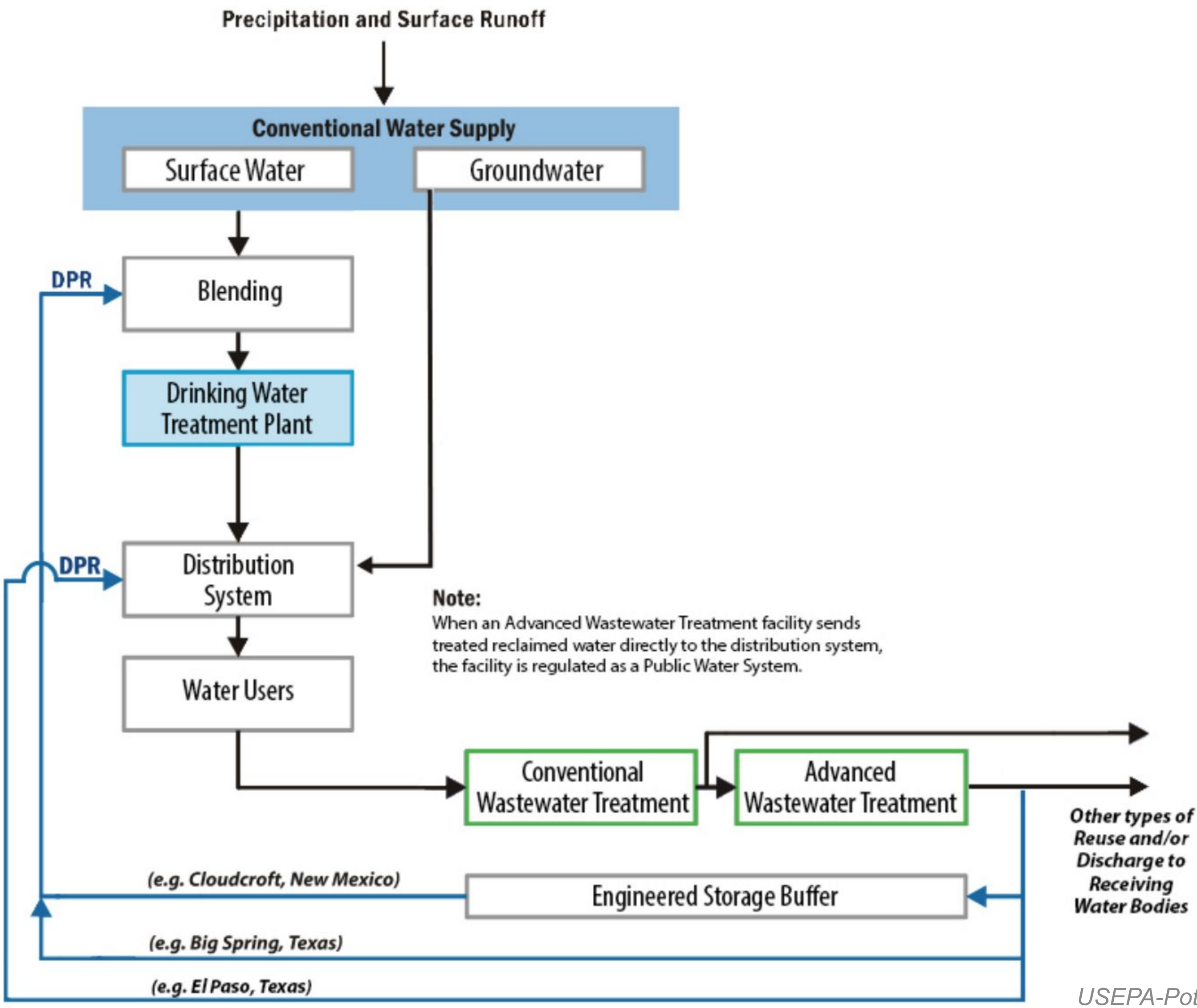
Water Loss Control	• Implemented with Immediate Effect • Large Scale Pipe replacement and increased meterage resulted in reduction of losses from 20% to 7.5% by 1961
Diversion of Michaelis River to Avis Dam	• Not considered economically viable
Diversion of overflow from Hofnung Dam to Avis Dam	• Not considered economically viable
Gammams III Dam Scheme	• Confluence of Gammams, Aretaragas & Augeigas River – 2km downstream of Gor. Dam • Calculated safe yield used in conjunction with existing Goreangab Dam -1.6 Mm^3/a • More expensive than Swakop Dam Scheme per m^3 of water
Swakop Dam Scheme	• Estimated safe yield of 7.14 Mm^3/a (5.14 Mm^3/a to Windhoek) – 1st State Scheme to WHK • Benefit of Supply to Okahandja (2.0 Mm3/a) • Construction & Operational Cost – Distance of 70km and Elevation of 250m
Purified Sewage Effluent Reuse (DPR)	• Supply potential of 33.3% of all water produced • CoW - Technically viable; Administration not convinced • Most economical operated in conjunction with exiting Goreangab Scheme

What is Indirect Potable Reuse (IPR) ?



USEPA-Potable Reuse Compendium,

What is Direct Potable Reuse (DPR) ?



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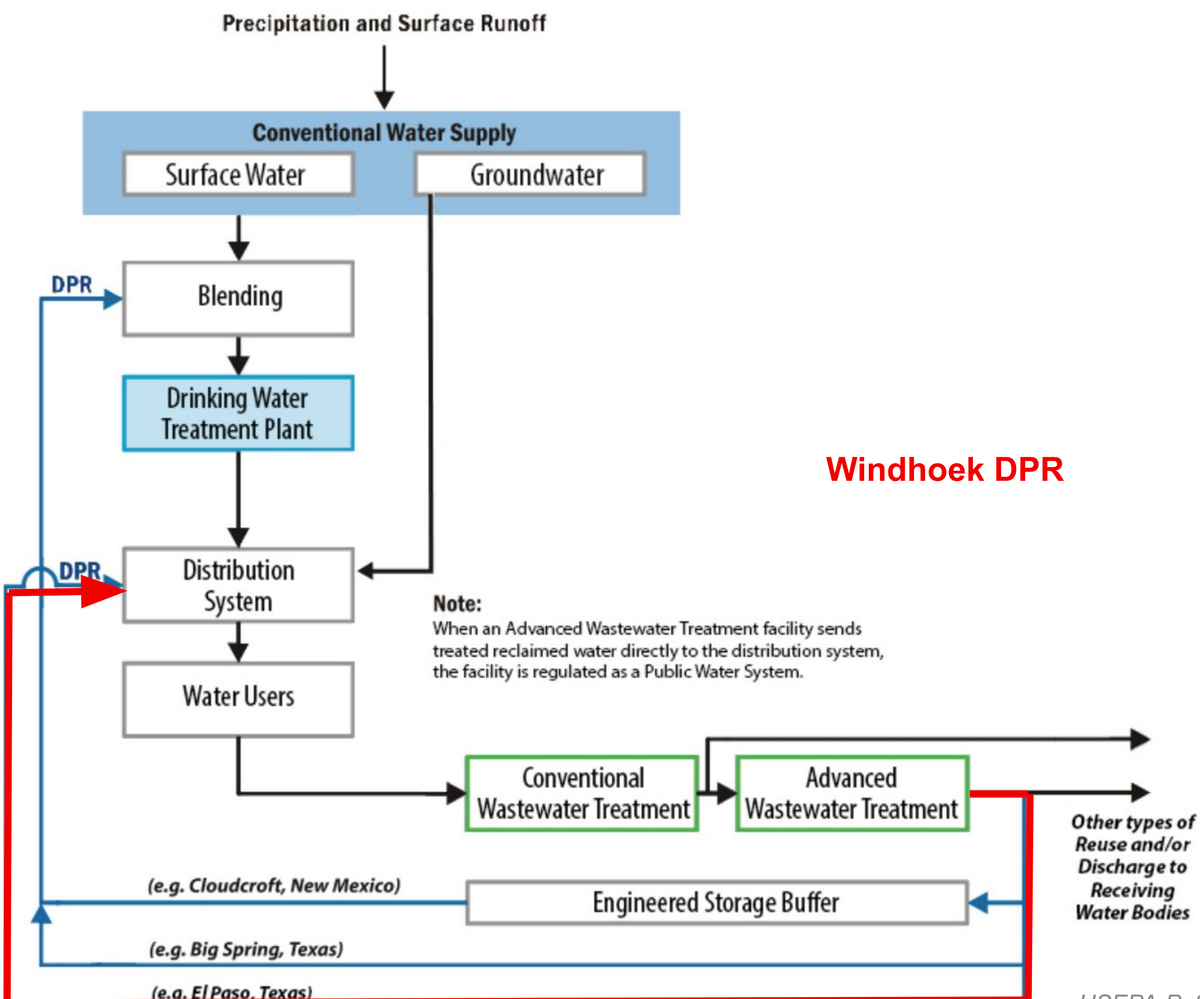


USEPA-Potable Reuse Compendium,

Implementation

- Initially planned to commence in 1961 but delayed implementation
- CoW and Council for Scientific and Industrial Research (CSIR) teamed up and renewed contract in 1961
- Extensive pilot testwork 1962 – 1965
- Design of 4,800 m^3/d (1.6 Mm^3/a) full scale plant
- Construction started in 1967 and was completed in 1968
- **Production started 18th October 1968**
- In the following drought schenario the plant immediately supplied 15 – 25% of the potable supply of CoW
- Swakop Dam Scheme (S von Bach Dam) was completed in 1970 and the water purification plant in 1971

DPR to Augment the Potable Water Supply of Windhoek

Journal American Water Works Association

American Waterworks Association Journal — January, 1968.

Wastewater Reclamation as a Water Resource

—Dwight F. Metzler and Heinz B. Russelmann—

A paper presented on Jun. 6, 1967, at the Annual Conference in Atlantic City, N.J., by Dwight F. Metzler, Deputy Comr., N.Y. State Dept. of Health, and Heinz B. Russelmann, Acting Director, Bureau of Water & Sewerage Utilities Management, Div. of Pure Waters, N.Y. State Dept. of Health, Albany, N.Y.

WASTEWATER reclamation offers a practical and immediate way to increase the net amount of water available for use. Renovation of wastewater ranks along with storage in surface or underground reservoirs as a practical method for meeting the growing demand for water.

This article will discuss some of the fundamental philosophies that underlie water reuse. The national problem of water supply is examined and suggestions are made for employing water reuse with careful attention to protecting the consumer.

Reporting on proposals for water reclamation and reuse goes back at least three decades. Most of the attention has been directed at experimental work to achieve higher and higher efficiencies in waste treatment, motivated by the need to minimize stream pollution. Now that it is possible to achieve a treatment effectiveness that can restore wastewaters to their original condition, it becomes necessary to investigate the value of treated water and how it can be used. The first hurdle, the technology of treatment, is rapidly being overcome. The second hurdle, the reasonable utilization of these waters as an essential resource, is the present problem. Although the accomplishment of 100 per cent restoration is not yet possible for all parameters of quality, the technology has already reached that point where full renovation lies within reach. It is now a cogent element that must serve as an alternative in water resources planning.

The literature amply covers the technology of treatment for both improving conventional waste treatment and for advanced treatment techniques, but there has been little exploration of the fundamental philosophies that must accompany wastewater use if the technological achievements are to be used to maximum effectiveness. This article, therefore, will address itself to the problems of water supply needs and the inescapable fact that water reclamation will serve increasingly as the mechanism for meeting water supply needs.

Land reclamation in various forms has received the attention of the midwest and western regions of this country for more than three generations. It sprang from the short-sighted exploitation of land and timber resources and the need to restore ravaged lands to usefulness through irrigation. With the opening of the west, the great natural wealth seemed to be inexhaustible. By the end of the nineteenth cen-

of money are invested in an effort that still does not satisfy all user requirements.

What has been critical in this respect? Three factors: (1) waste treatment applied has been inadequate, pressing for the development of advanced treatment methods; (2) performance in waste treatment has not been fully responsible because of lack of surveillance; and (3) extensive treatment continues to be necessary in order to meet water quality objectives.

Return on Investment

Traditionally, two investments have been made in the sequence of water use. Water is conveyed large distances from relatively pure sources and submitted to complete treatment. After use, the waters are again submitted to extensive treatment for discharge to waste and the small measure of downstream uses which must be satisfied.

Investment for wastewater treatment now demands a greater return. This can be achieved by narrowing the objective and placing wastewater treatment in the positive sense. Imagine wastewater as a water resource in the same sense as an upland impoundment. This water source now lies within the community that invests in treatment to benefit that community primarily. A high degree of treatment can render the water usable for drinking, and, when blended with the primary water supply source, will provide a highly dependable supply.

The best system is a single production center using common administration, staff, and structures for both water supply treatment and wastewater treatment, thereby realizing considerable economies. The high degree of operational integrity which will be necessary will at the same time enhance pollution control.

What are the risks involved? The environment produces hazards which must be guarded against. Public health practice has always sought maximum protection and it is for this reason that maximum performance effectiveness is demanded, even in the face of minimum hazard. The fundamental sequences of water supply treatment are essentially the same, whether waters are drawn from a polluted source or one relatively free of pollution. Additional stages of treatment are provided consistent with the nature of the water to be treated. The costs for additional treatment of polluted water must be weighed against the transportation of relatively unpolluted waters from greater distances and the impoundments designed for safe dependable yields. The tremendous advances made in waste treatment will shortly demonstrate that all undesirable, objectionable, or hazardous materials can be removed or altered or controlled so that they will be of no consequence to water use. Modern sophisticated means of quality measurement can provide fail-safe control and divert inadequately treated waters when necessary.

Example of Reclamation

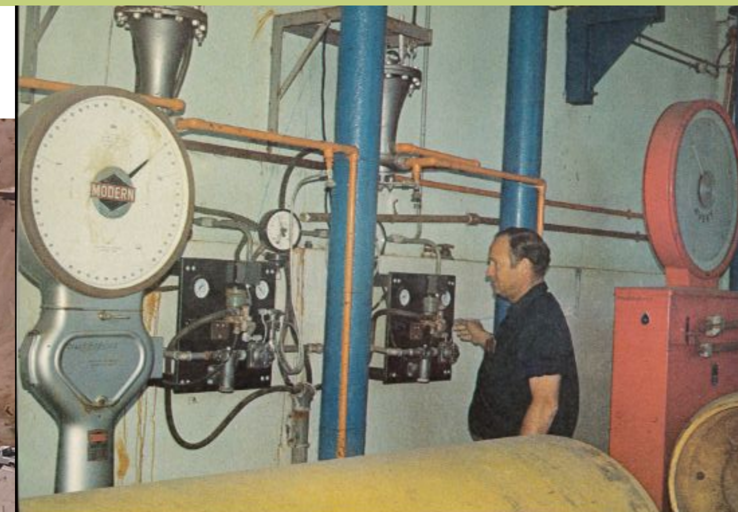
The experience at Chanute, Kan., was a highly successful indicator of the potential for direct water reuse. The severe drought in Kansas in 1956 resulted in a virtually dry Neosho River. The 4,000-sq mi drainage area yielded only the wastes of upstream communities. Much of the river flow past Chanute during the drought was made up of sewage plant effluent, and the city had been using this water for several months without known ill ef-

Case Study of Chanute, Kansas, USA

Implementation

- In 1970 the Stander Plant was built in Pretoria as continuous research and demonstration plant
- In 1979 Gammams Water Care Works were upgraded from biofilters (humus tanks) to activated sludge
- At the beginning 4 different and independent laboratories monitored the performance of the reclamation plant
- In 1982 it was declassified as a “research facility”

Implementation



Implementation

Implementation

Upgrade	Wastewater treatment (#1)	Maturation ponds (Retention time)	Upgrade	Windhoek Direct Potable Reclamation (#2)	Capacity
1962-1979	Biological filters PI	14-10 days	1968-1976	Goreangab Mark I	4.8 Ml/d
			1976-1980	Goreangab Mark II	4.8 Ml/d
1979-1994	Activated sludge Nutrient Removal PII	10-6 days	1980-1986	Goreangab Mark III	4.8 Ml/d
			1986-1994	Goreangab Mark IV	7.2 Ml/d
1994-2016	Activated sludge Nutrient Removal PIII	6-3 days	1994-2001	Goreangab Mark V	14.4 Ml/d
			2002-2016	Goreangab Mark VI	21 Ml/d

#1 PI: Primary settling - Biofilters - Secondary settling - Maturation ponds (14 days)

#1 PII: Primary settling - Five-stage Bardenpho nutrient removal activated sludge - Secondary settling - Maturation ponds (10 days)

#1 PIII: Primary settling - UCT or modified Johannesburg nutrient removal activated sludge - Secondary settling - Maturation ponds (6 days)

#2 Mark I: [Carbon dioxide], [Alum], Algae Flotation, Foam Fractionation, [Alum + Lime], [Breakpoint chlorination], Settling, Rapid sand filtration, Activated carbon, [Chlorine], Blending

#2 Mark II: [Lime], Settling, Ammonia stripping, [Carbon dioxide], [Chlorine], [Alum + Lime], Settling, [Carbon dioxide], Rapid sand filtration, [Breakpoint chlorination], Activated carbon, [Chlorine], Blending

#2 Mark III: [Chlorine], [Alum + Lime], Settling, [Breakpoint chlorination], [Alum + Lime], Settling, Rapid sand filtration, [Chlorine], Activated carbon, [Chlorine], Blending

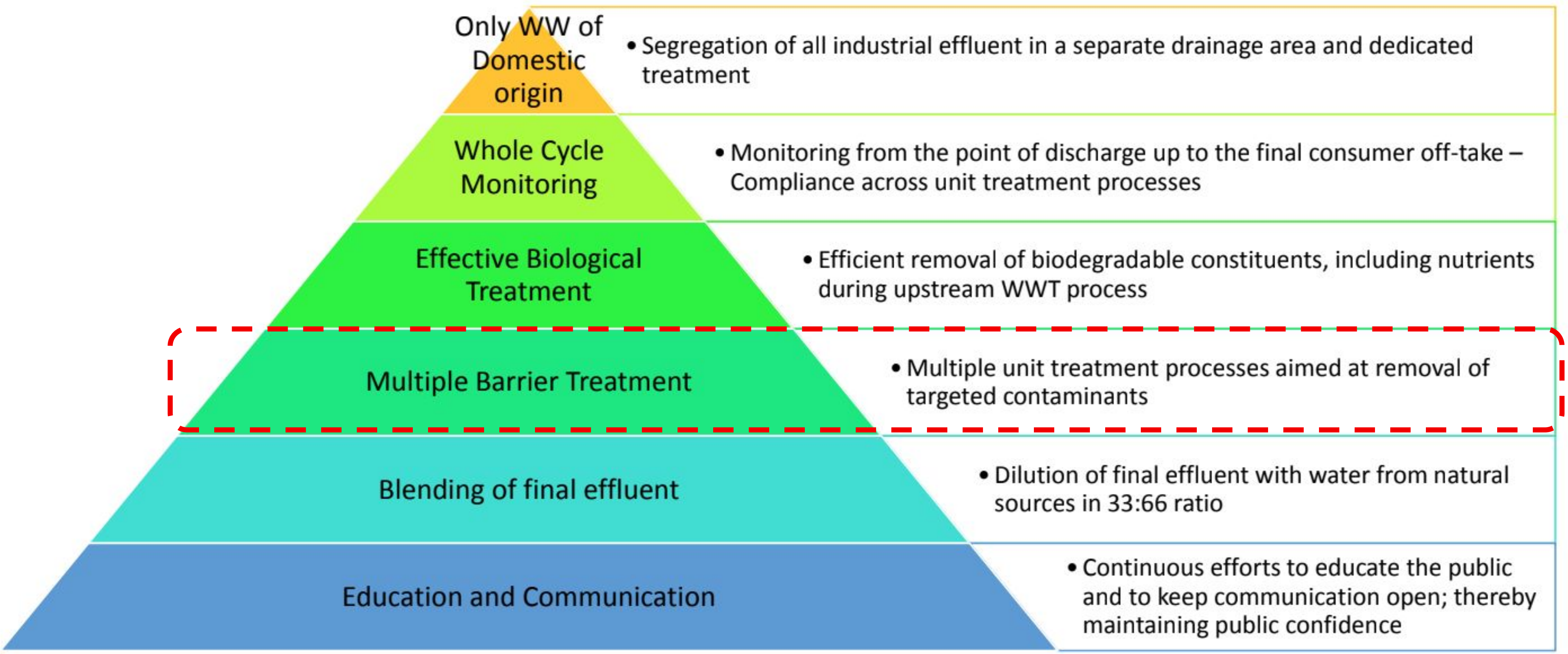
#2 Mark IV: [Alum + Lime], Dissolved air flotation, [Chlorine], [Alum + Lime], Settling, Rapid sand filtration, [Breakpoint chlorination], Activated carbon, [Chlorine], Blending

#2 Mark Va: [Ferric], Dissolved air flotation, Rapid sand filtration, Activated carbon, [Break point chlorination], [Stabilisation: Lime], [Chlorine], Blending

#2 Mark Vb: [Ferric], Dissolved air flotation, RSF(ftw) - RSF(ftw)+GAC, Activated carbon, [Break point chlorination], [Stabilisation: NaOH], [Chlorine], Blending

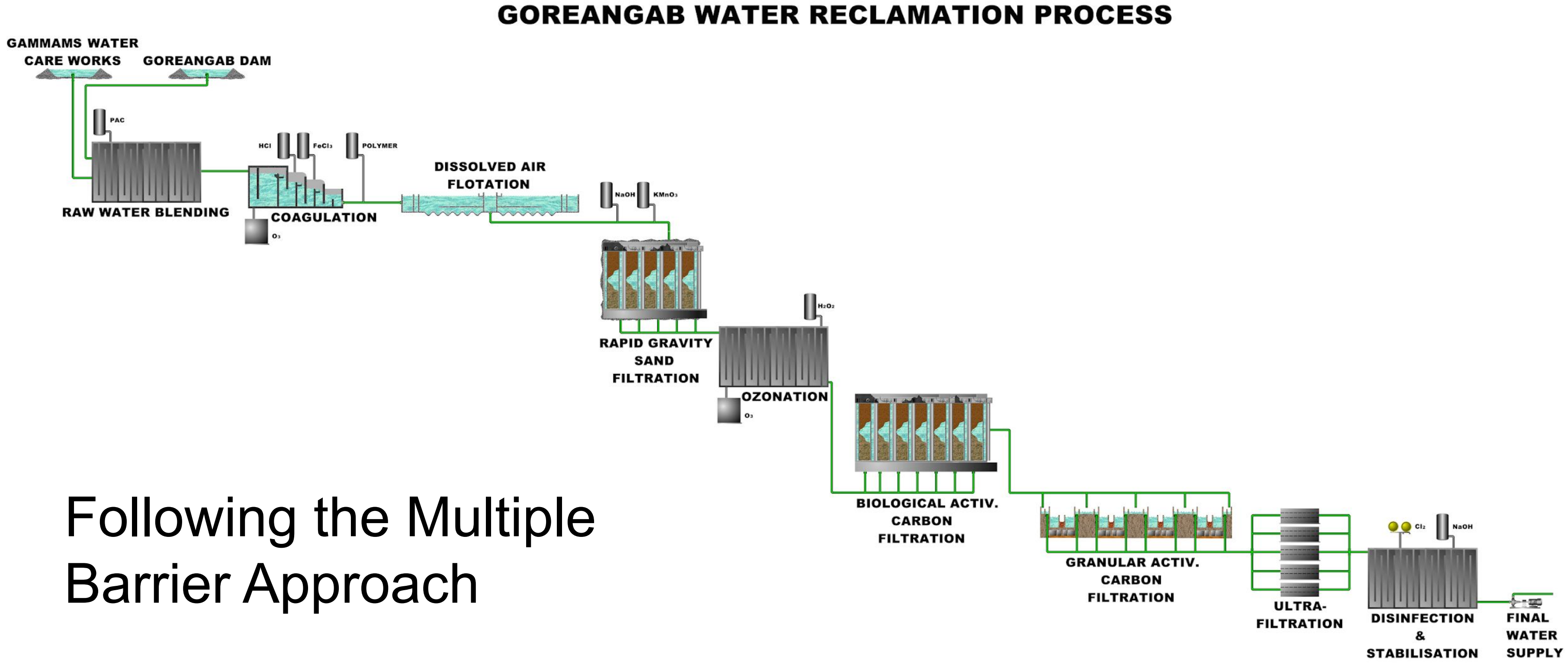
#2 Mark VI: PAC, [Pre Ozonation], [Ferric], Dissolved air flotation, [MnO4 + NaOH], Rapid sand filtration (ftw), [Ozonation, H2O2], BAC+GAC, Ultra filtration, [Chlorine], [Stabilisation: NaOH], Blending

Principles of Windhoek DPR



Implementation

The process flow of the New Goreangab Water Reclamation Plant – A design with the experience of decades:



Following the Multiple Barrier Approach

Implementation

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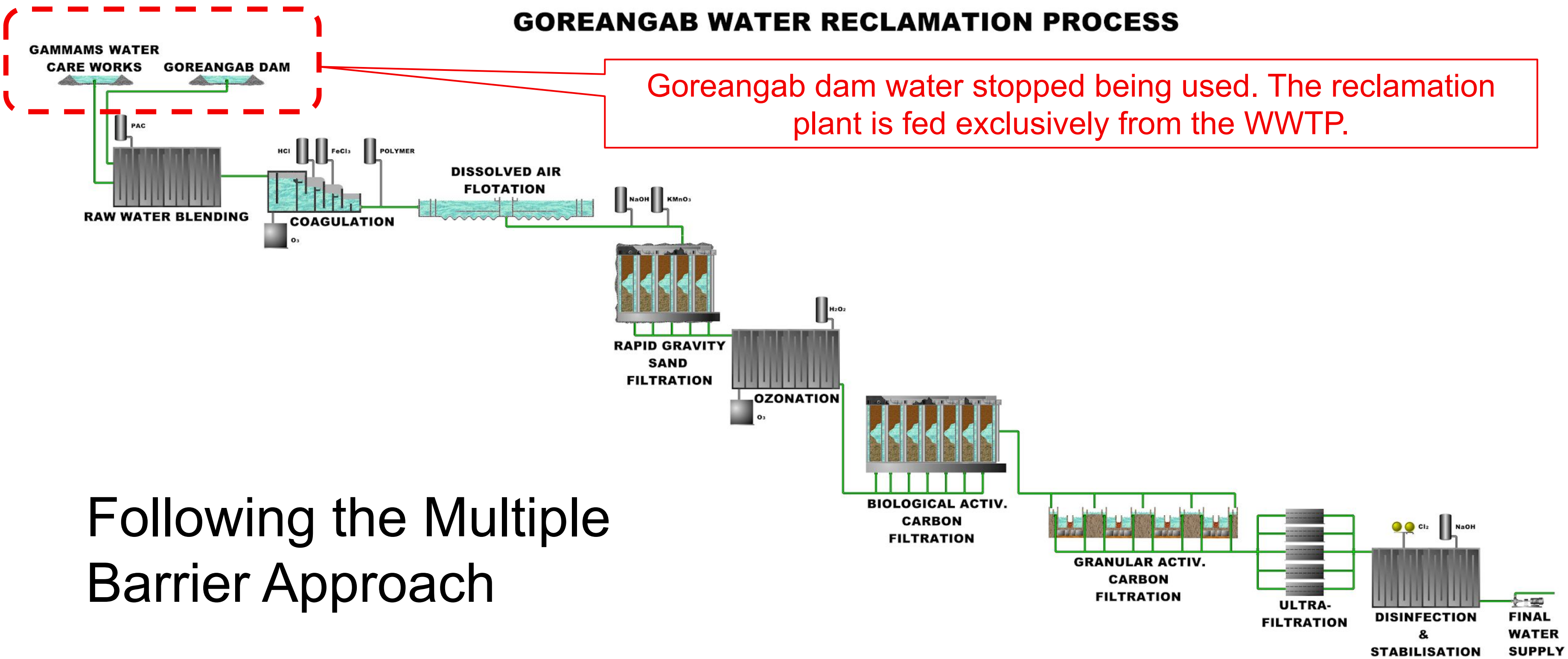

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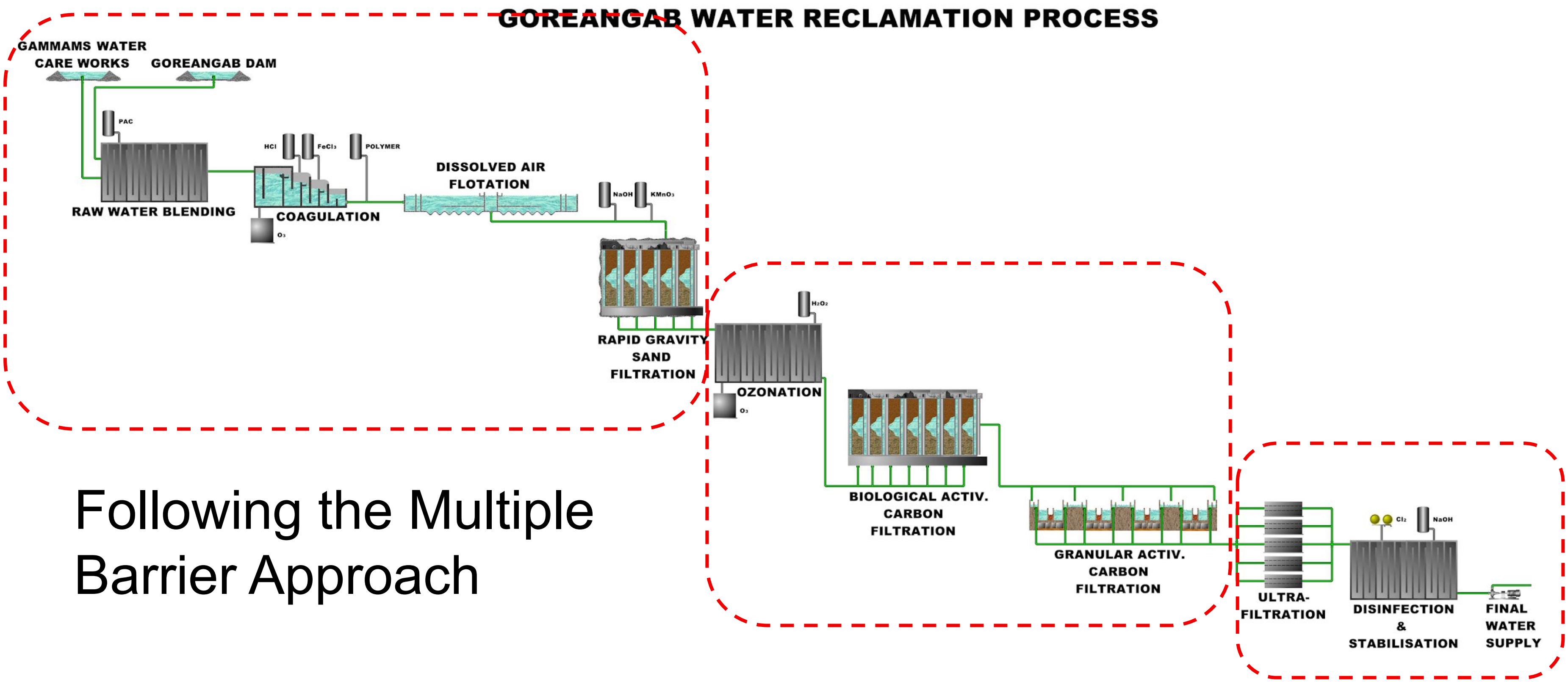
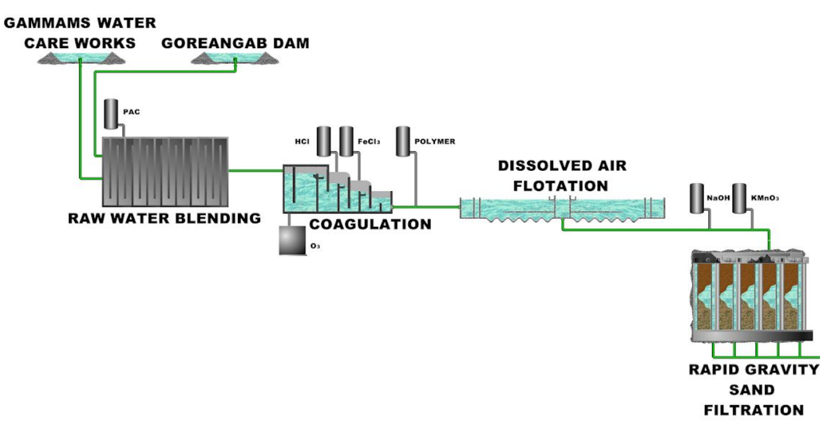


Following the Multiple Barrier Approach

Implementation

Pretreatment:

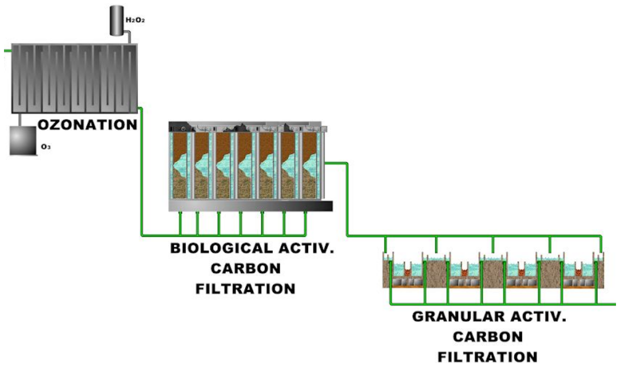


- Pre-ozonation
- Coagulation
- Dissolved Air Flotation
- Rapid Gravity Sand Filtration

Provides excellent TSS polishing for downstream advanced treatments

Implementation

Advanced treatment:

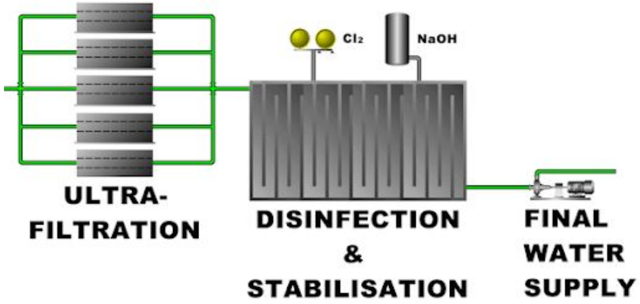


- Ozonation
- Biological Activated Carbon filters
- Granular Activated Carbon Filters

Removes dissolved macro- and micro pollutants, provides effective disinfection

Implementation

Polishing and final disinfection:



- Ultra-Filtration membranes
- Chlorine disinfection
- Caustic soda stabilisation
- Distribution for blending in potable water network

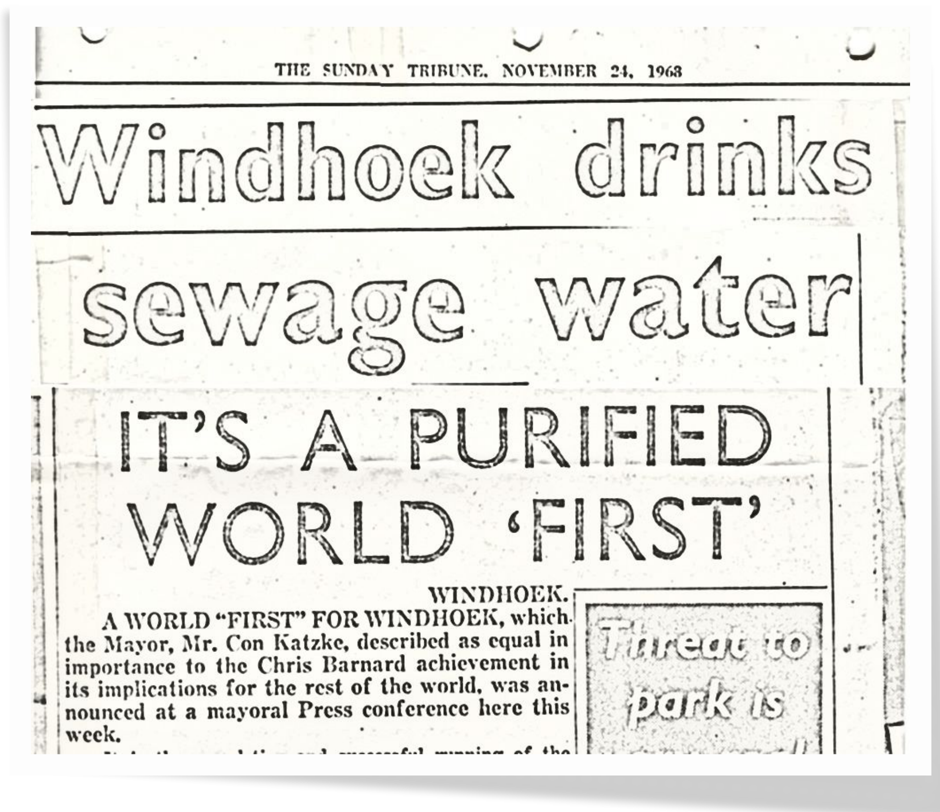
Final stages of disinfection and polishing

The team

WINGOC - Windhoek Goreangab Operating Company (Pty) Ltd
A PPP in the drinking water supply
Since 2001

Public Acceptance

- Press conference 22nd of November 1968
- Three quarters of the test committee had chosen the purified sewage water as being preferable.
- Chief Scientist Report: “We did not reveal too much. Generally the news was accepted calmly, hence the public is accepting the development nicely.”
- Reduction of Windhoek‘s reliance on external water sources by 20 – 25%. An achievement equal to the first heart transplant.



THE SUNDAY TRIBUNE, NOVEMBER 24, 1968

Windhoek drinks sewage water

IT'S A PURIFIED WORLD 'FIRST'

WINDHOEK.
A WORLD "FIRST" FOR WINDHOEK, which the Mayor, Mr. Con Katzke, described as equal in importance to the Chris Barnard achievement in its implications for the rest of the world, was announced at a mayoral Press conference here this week.

Threat to park is

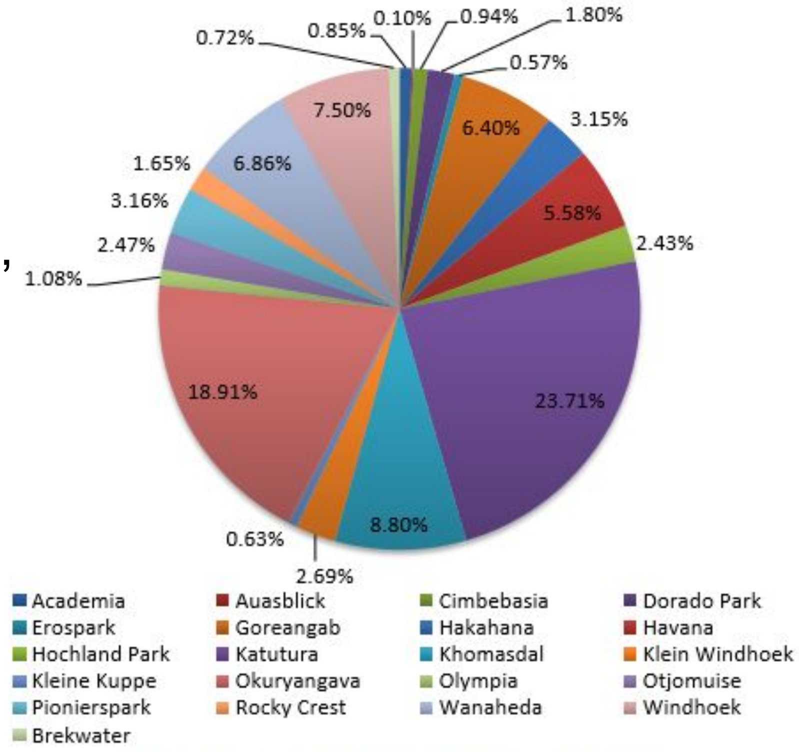
Public Acceptance

- The water shortage and a lack of feasible alternatives supported the initial decision and implementation.
- In 1982/83 the residents of Windhoek criticised the City Council for unused effluent downstream of the reclamation facility.
- In 1984 the council decided CR 432/8/84 to increase the capacity to 7,600 m^3/d
- In 1996/97 during a drought scenario – with again similar public sentiments – an emergency expansion was agreed on.

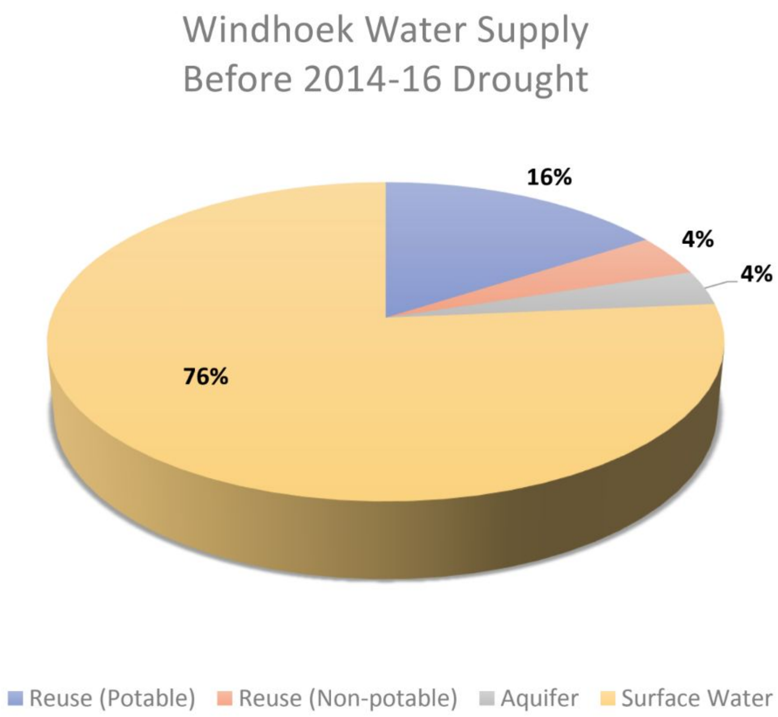
Public Acceptance

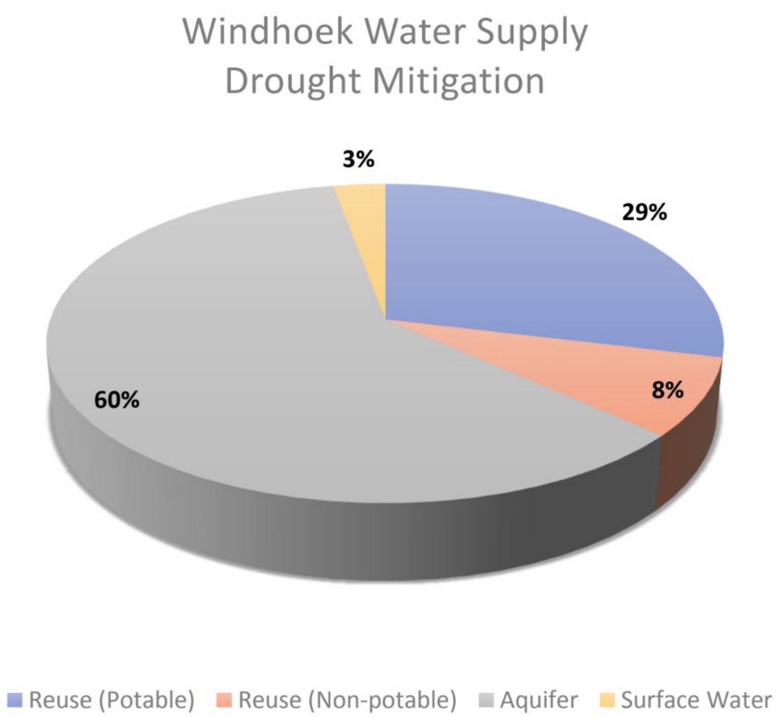
Public acceptance study:

- Equitable distribution (1832 surveys in 21 townships, diverse sampling (gender, age, education and residence time), multiple choice
- **85% - water is good enough to drink**
- **79% - water is safe to drink**
- 51% know about water recycling
- **44% know about DPR**



Impact





Water Demand Management during drought -> 15-25% reduction in water demand

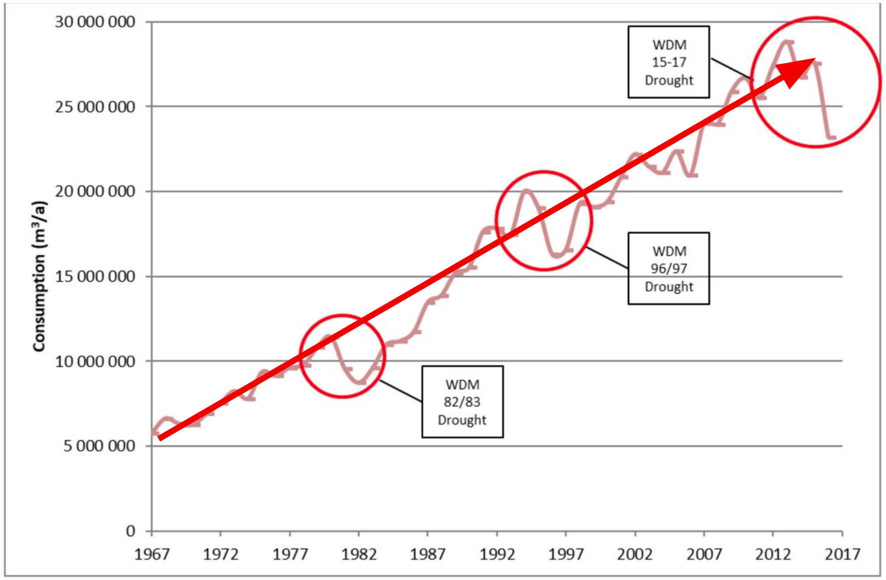
Impact

WEEKLY PRODUCTION INCLUDING DEMAND MANAGEMENT AND SOURCE DIFFERENTIATION Period: 29/07/2019 to 05/08/2019				
	SOURCE TARGET (NamWater modelled figures)	% SOURCE SUPPLIED VS TARGET	SOURCE SUPPLIED	% OF DEMAND
NAMWATER (Surface Water)	163,712	110%	179,663	33%
WINGOC (Potable Reuse)	119,096	101%	119,870	22%
BOREHOLES (Groundwater)	182,192	81%	148,238	27%
TOTAL WATER DEMAND MANAGEMENT ACHIEVED	> 15%		91,580	17.0%
TOTAL PRODUCTION			**539,350**	**100%**

Current and future of DPR in Windhoek

Ongoing challenges:

- Quantity:
    - population and demand continue to increase
    - periodic draughts puting water supply under tight pressure (draught 2015-2017)
- Quality:
    - increasing challenges linked to salinity and bromates with increased percentage of DPR

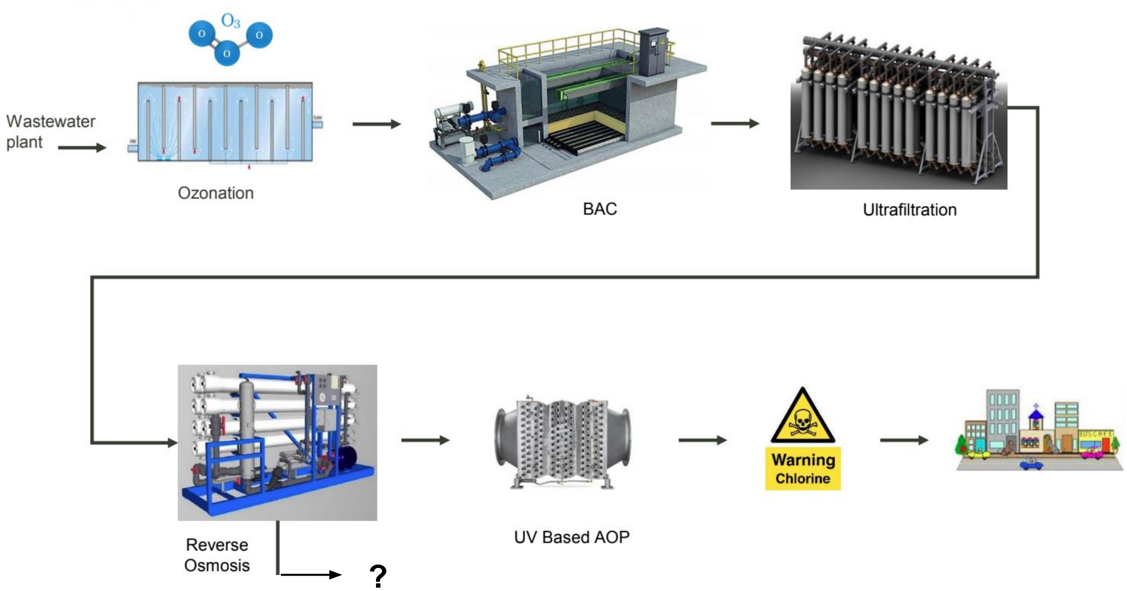


Need to consider additional water resources:

- Water transfer from perennial rivers
- Seawater desalination
- Build a second DPR plant

Current and future of DPR in Windhoek

- Second DPR plant option assessed as the most feasible option
- Capacity equivalent to current plant, thus doubling the capacity for DPR
- Option to use for groundwater recharge when not in drought situation
- Upgrade required on WWTP to increase capacity
- Will require salt removal barrier to deal with increasing TDS
- Challenge is brine management - enhanced RO recovery process



Concluding remarks on DPR

- *Potable water of high quality can be achieved by DPR*
- *Is a practical and economical option to be considered in water scarce areas in combination with other options*
- *Is not easy to implement, primarily due to the challenge of public acceptance*
- *As a consequence, it requires commitment at all levels and a high level of political will*
- *Requires professional operation, continuous monitoring, training and research to improve systems and adapt to new and upcoming challenges*

The continuous success of Windhoek's DPR scheme for more than 50 years should be used as an inspiration for change in currently unsustainable water management practices

Acknowledgments

City of Windhoek

Pierre van Rensburg
Piet du Pisani
Ben van der Merwe

wingoc every drop counts
A JOINT VENTURE
VEOLIA WABAG

Thomas Honer

Windhoek – more than 50 Years of Direct Potable Reuse

More Information:

- www.wingoc.com.na

The Water Reclamation Plant:

- https://www.youtube.com/watch?v=5ksqtUtljI0
- https://www.youtube.com/watch?v=t15FsW-ZI-c

Recent Report on Windhoek:

- https://www.retroreport.org/video/why-earth-s-driest-places-may-hold-the-key-to-the-future-of-water/

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Thank you very much!