National Microbiological monitoring programme

Quality Assurance of Microbiological quality for a Bulk Water Supply

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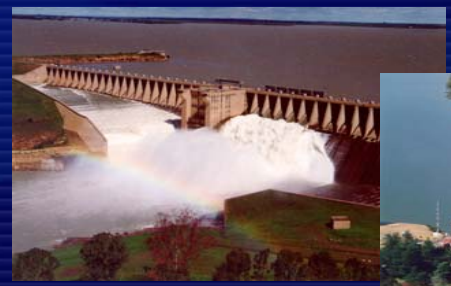
Introduction

- Safe water supply often taken for granted; Yet
- United Nations World Water Development report (2003)
  - 2 213 000 deaths/annum- water related
  - 82 196 000 DALYS (DALY = a lost year of healthy life)
  - 240% higher in developing countries compared to industrialised countries
  - Also not excluded from developed world (Hurdy et al 2002)



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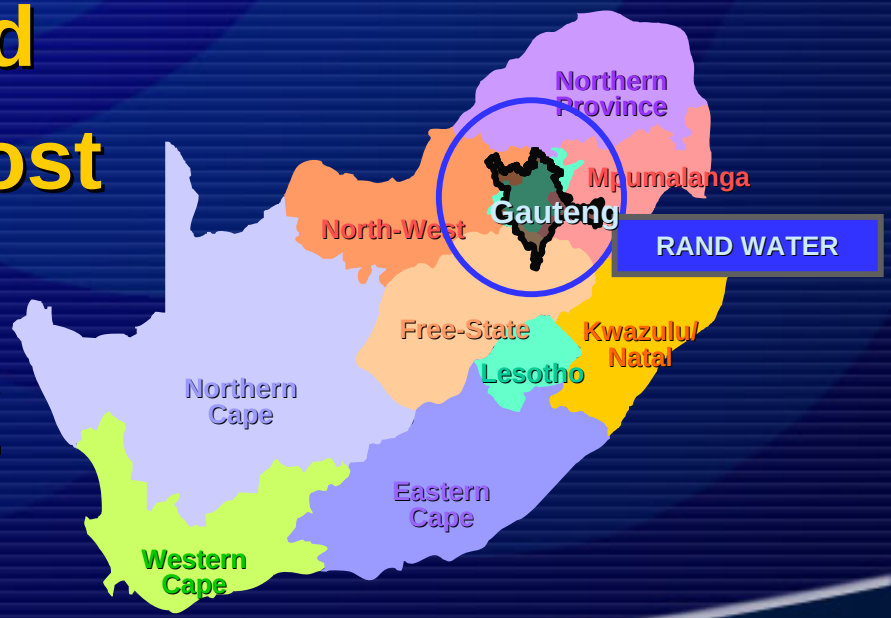
Success factors for a water supply industry

1. Uninterrupted supply water
2. Wherever it is required within our supply area
3. When it is required
4. At a reasonable cost
5. Water must be of acceptable quality

Area of Supply



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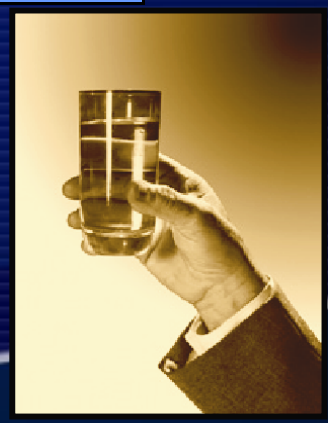
WHEN IS WATER QUALITY ACCEPTABLE

* Must be safe; for lifelong consumption
* Must be palatable (Taste, Odour and Feel);
* Must be aesthetically appealing (Clear);
* Should not contain any chemical or radiological substances deleterious to health;
* Should be free of pathogenic organisms;
* Be stable as far as possible.



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What are Pathogenic Organisms

- **Bacteria**
- **Protozoa**
- **Viruses**

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How should we protect our water?

- Holistic approach
- Risk assessment
- Evaluate system
- Monitor quality
- Audit quality
- Implement remedial actions

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International Search

- HACCP – Developed by NASA
- Water Safety Plan
  - WHO Geneva 2002
  - Australian and New Zealand Resource Management Councils (M Martin et al 2002)
    - Key Principles
      - *Holistic approach*
      - *Integrated system*
      - *Logic*
      - *Multiple barriers*
      - *Overarching*

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The Water Safety Plan

1. Assemble task team
2. Establish corporate commitment to water quality
3. Define scope of work
4. Construct System flow diagramme
5. Verify flow diagramme

Correct? — Yes / No

6. Conduct Hazard assessment
7. Identify quality and critical control points
8. Define operational limits
9. Establish monitoring programme
10. Verify items 6 - 9

Correct? — Yes / No

11. Establish corrective action
12. Verify product quality
13. Support services

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Assemble Task Team

Division	Post Description	Expertise
Water Technology	Manager Water Quality and Environmental Services	Project manager
	Manager Process Technology	Extensive water treatment and processes expertise
	Manager Water Quality Assurance	Knowledge base pertaining to Water Quality Assurance systems
	Manager Technical Training	Broad knowledgebase of water treatment processes and training required to optimise manpower
	Manager Analytical Services	Key to analytical services required And associated expertise
	Manager Water Quality Marketing	Responsible for water safety plan support services
Production	Chief Engineer Potable Water Production	Operational management input to WQSP
	Station Operations managers	Evaluation and management input to WQSP
	Station Chemists	Detailed knowledge base of Water Quality Control methods and procedures
	Water Quality Services Technologist	Integrated water quality control
	Senior Water Quality Technician	Systems flow diagrams
Sales and Customer Services	Manager Bulk Water Services	Management input regarding water distribution systems
	Station Chemist	Detailed knowledge base of distribution system and associated water quality problems.
Engineering	Chief Process Engineer	Engineering components of water quality management
Corporate Services	Legal Advisor	Input as to Rand Water's legal commitment
	Corporate ISO 9001 Advisor	Integration of WSP into ISO 9001 system

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Five Key Components

1 Commitment to Water Quality

2 Supply chain evaluation

3 Monitoring critical points

4 Management Plans

5 Independent Audit

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Commitment to water quality

Production standard

SANS 0241

Class 0 – 95%

Supply specifications

SANS 0241

Class 1 – 95%

Class 2 – 99%

Benchmark

WHO

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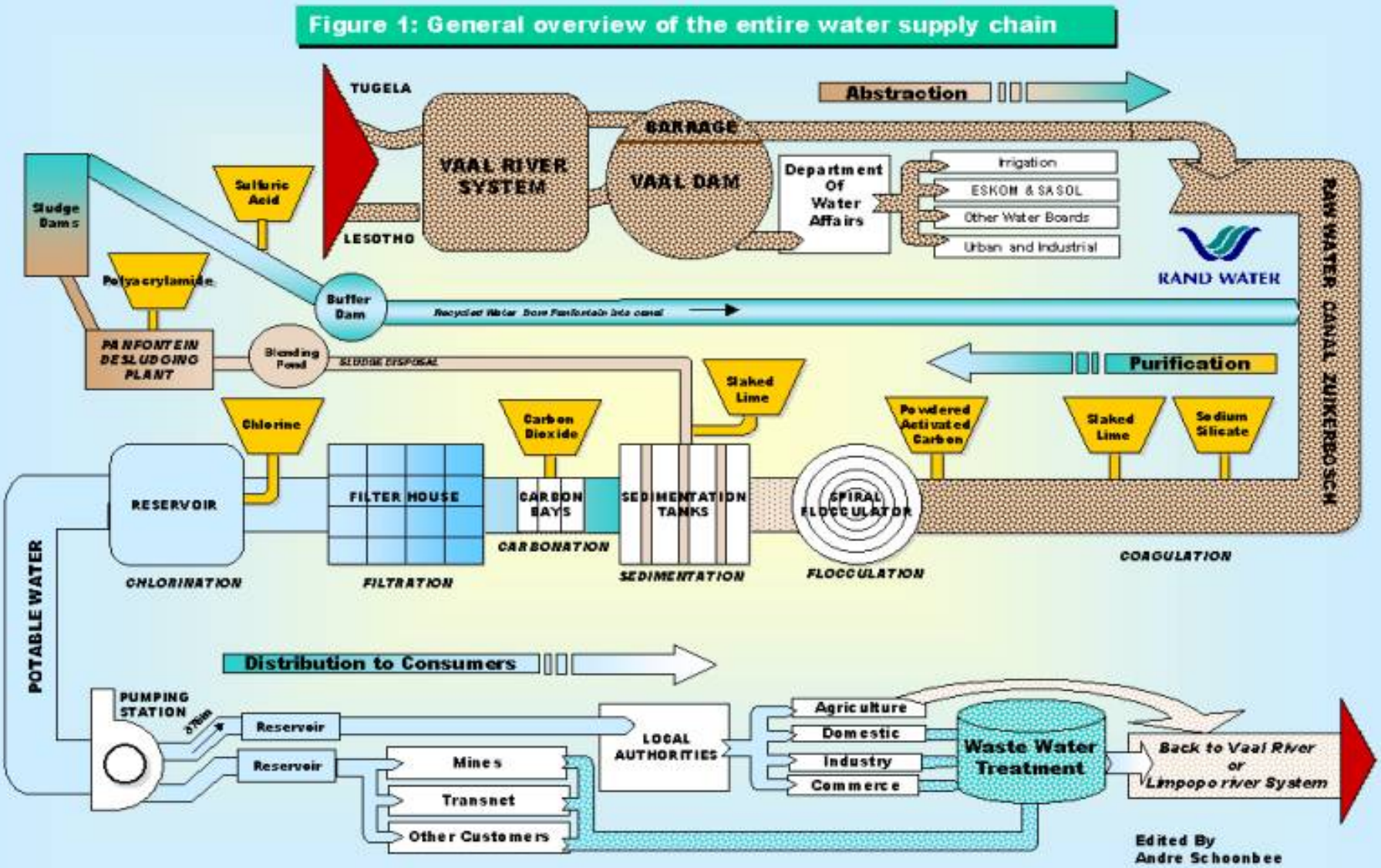
SANS 0241 2001

1	2	3	4	5
Determinants	**Units**	**Allowable compliance contribution [a]**		
		95 % of samples, min.	**4 % of samples, max.**	**1 % of samples, max.**
		Upper limits		
Heterotrophic plate count	count/mℓ	100	1 000	10 000
Total coliform bacteria	count/100 mℓ	Not detected	10	100
Faecal coliform bacteria [b]	count/100 mℓ	Not detected	1	10
E. coli [b]	count/100 mℓ	Not detected	Not detected	1
Somatic coliphages	count/10 mℓ	Not detected	1	10
Enteric viruses	count/100 mℓ	Not detected	1	10
Protozoan parasites *(Giardia/Cryptosporidium)*	count/10 mℓ	Not detected	Not detected	1

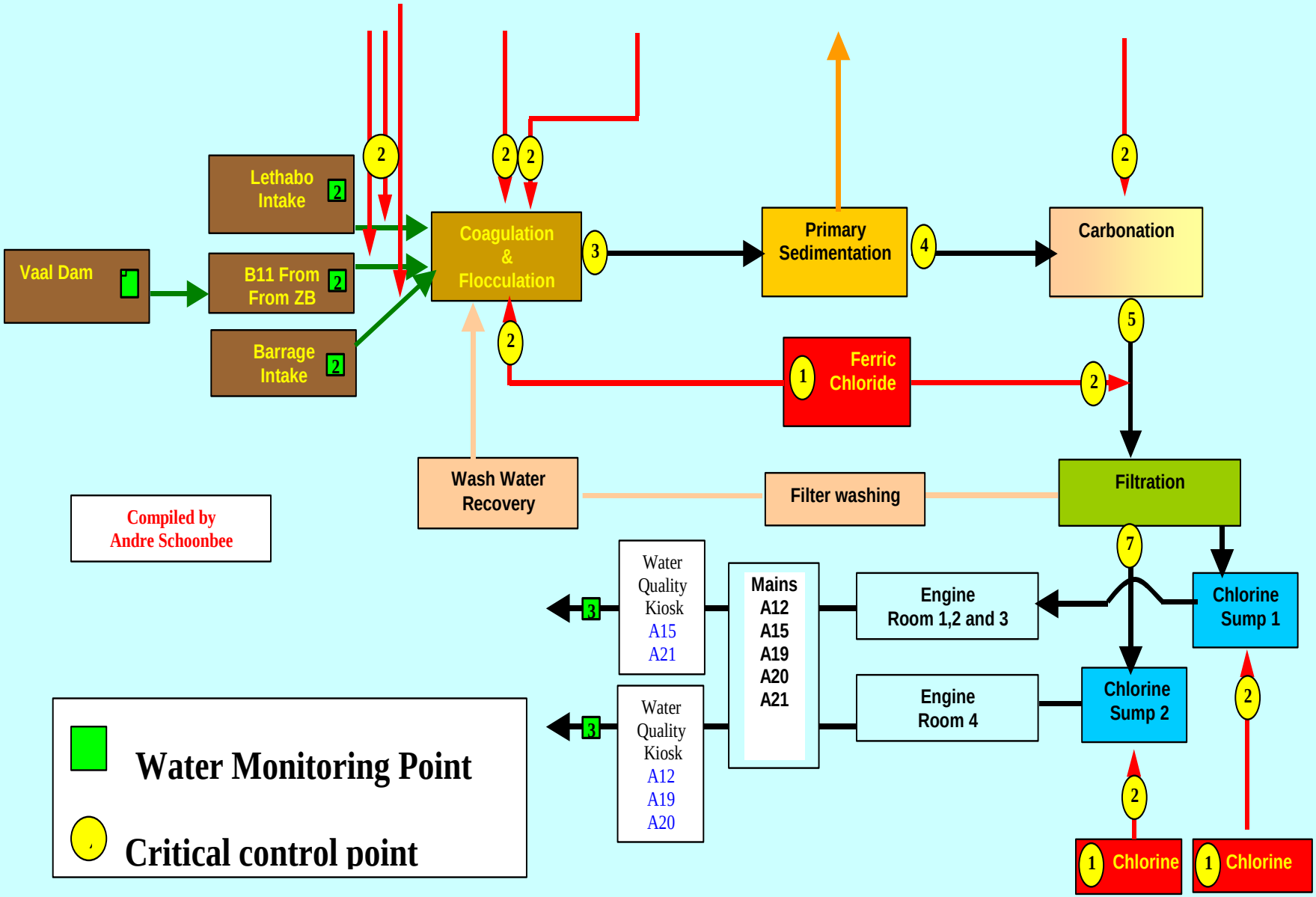
[a] The allowable compliance contribution shall be at least 95 % to the limits indicated in column 3, with a maximum of 4 % and 1 % respectively, to the limits indicated in column 4 and column 5. The objective of disinfection should, nevertheless, be to attain 100 % compliance to the limits indicated in column 3.

[b] In most instances it will not be necessary to conduct both these tests; one or the other will normally suffice as the required indicator.

Supply Chain Evaluation



Supply Chain Evaluation



Risk Assessment

J Mullenger et al 2002

Risk Factor Matrix:		Severity of consequences				
		Insignificant No impact/not detectable *Rating: 1*	Minor Customer Complaint *Rating: 2*	Moderate Impact on Customer Supply conditions *Rating: 3*	Major Impact on Supply conditions *Rating: 4*	Catastrophic Public Health Risk *Rating: 5*
Likelihood	Almost Certain 5 *Once a day* *Rating: 5*	5	10	15	20	25
	Likely 4 *Once a week* *Rating: 4*	4	8	12	16	20
	Moderate 3 *Once a month* *Rating: 3*	3	6	9	12	15
	Unlikely 2 *Once a year* *Rating: 2*	2	4	6	8	10
	Rare 1 *Once every 5 years* *Rating: 1*					

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Supply Chain Assessment

Process step	Hazard event	Critical Quality/ control point identification Refer Diagramme 1.6.1 Procedure 1.6.	Risk Refer Diagramme 1.6.2 Procedure 1.6	Critical/operational limits	Monitoring	Corrective action	Verification of water quality
QCP 1 Raw water resources	Contamination of water emanating from the Vaal Dam Catchment	Vaal Dam catchment Sampling sites (Refer WSP Proc No 1.7 and figure 1.7.2)	Aesthetic 12 Algal cells 12 Macro element 4 Trace metals 2 Path organisms 4 Radioactivity 1 Organics 4	Refer Barrage in- stream water quality guidelines – background and management levels – WSP Doc No 1.8	Refer Catchment sampling and analyses schedule WSP Proc 1.9	Reporting of catchment water quality information at Catchment forums WSP Proc 1.12	On line water quality verification on CIMDSS WSP Proc 1.11
CCP 1 Control quality and delivery of treatment chemicals	Sub- Standard or contaminated water purification Chemicals Delivery problems	Production Sampling sites (Refer WSP Procedure 1.7 Annexure 1 WSP Figures 5 to 14)	Incorrect concentration levels 4 Increased costs 6 Late deliveries 10 Substandard water quality 4	Refer relevant Bulk chemical contract specifications WSP DOC No 1.8	Refer relevant site Verification procedures of incoming materials WSP Doc No 1.9	Refer relevant site Chemical non-conformance procedure WSP Doc No 1.12	Not Applicable
CCP 2 Control of treatment chemical dosing	Sub standard water quality Costs	Production Sampling sites (Refer WSP Procedure 1.7 Annexure 1 WSP Figures 5 to 14)	Turbid water 12 Stability problems 12 Disinfection problems 15 PH 12	Refer relevant site operational dosing procedures WSP Doc No 1.8	Refer to relevant site Production water quality monitoring schedule WSP Doc No 1.9	Refer Water Production operational dosing procedures WSP Doc No 1.12	Water Production LABWARE system WSP Doc No1.11

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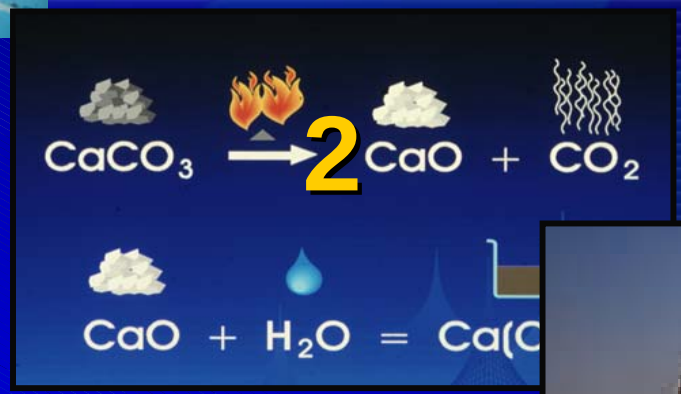
Monitoring systems

Four components



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Monitoring Systems

- **Three tier**
- **Routine**
- **Problem Centered**
- **Diagnostic Framework**

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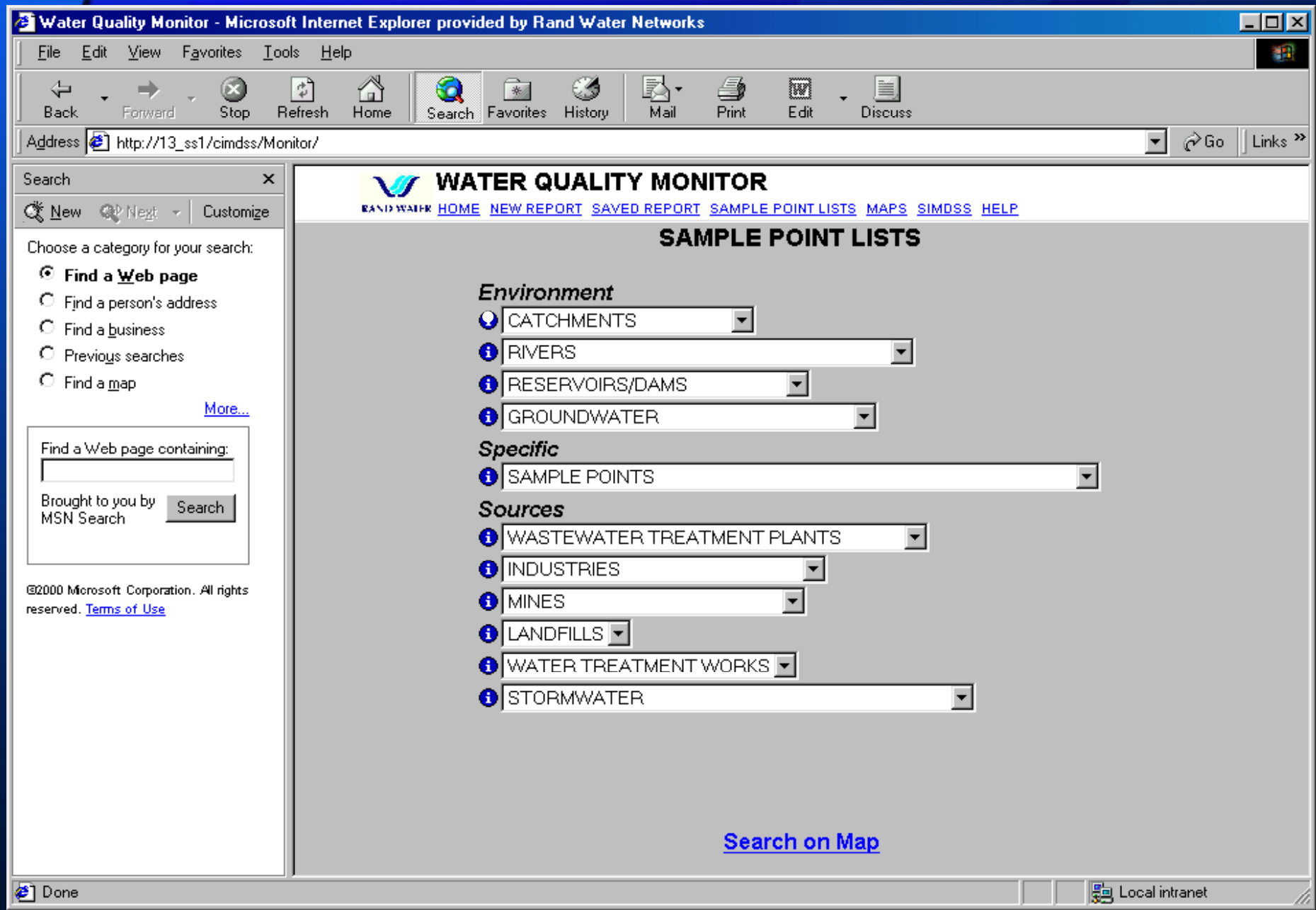
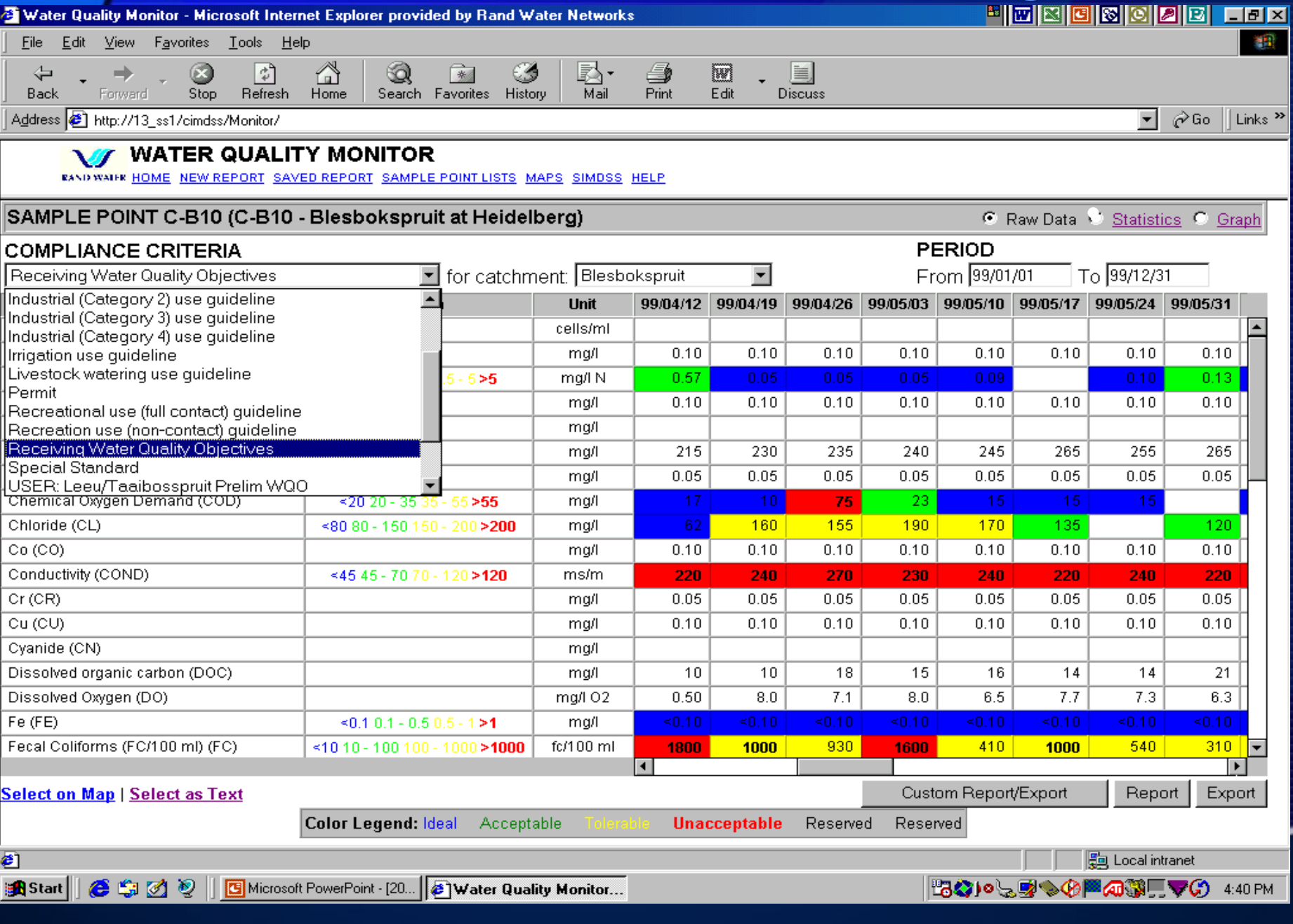
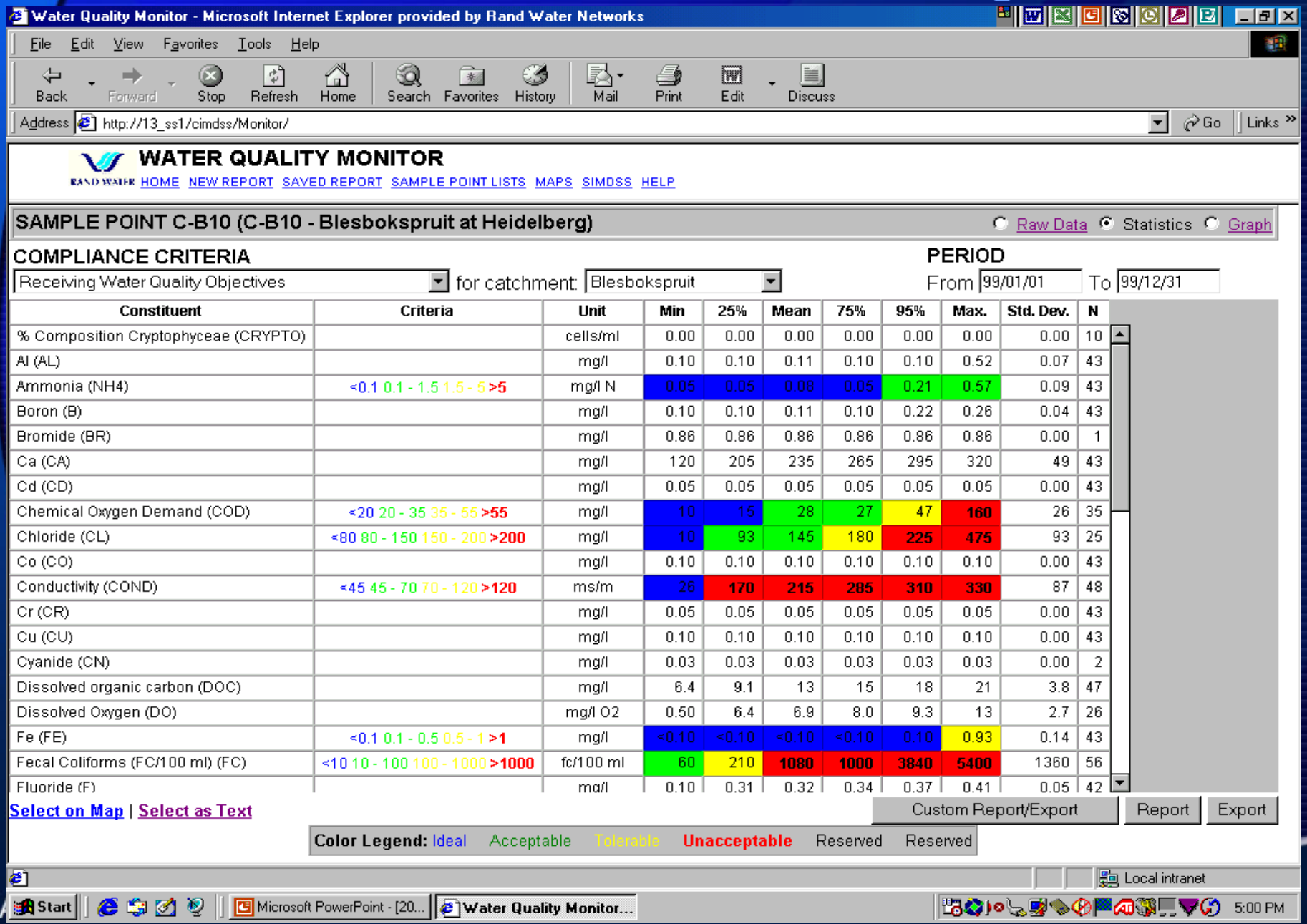
Routine Monitoring



Routine Monitoring

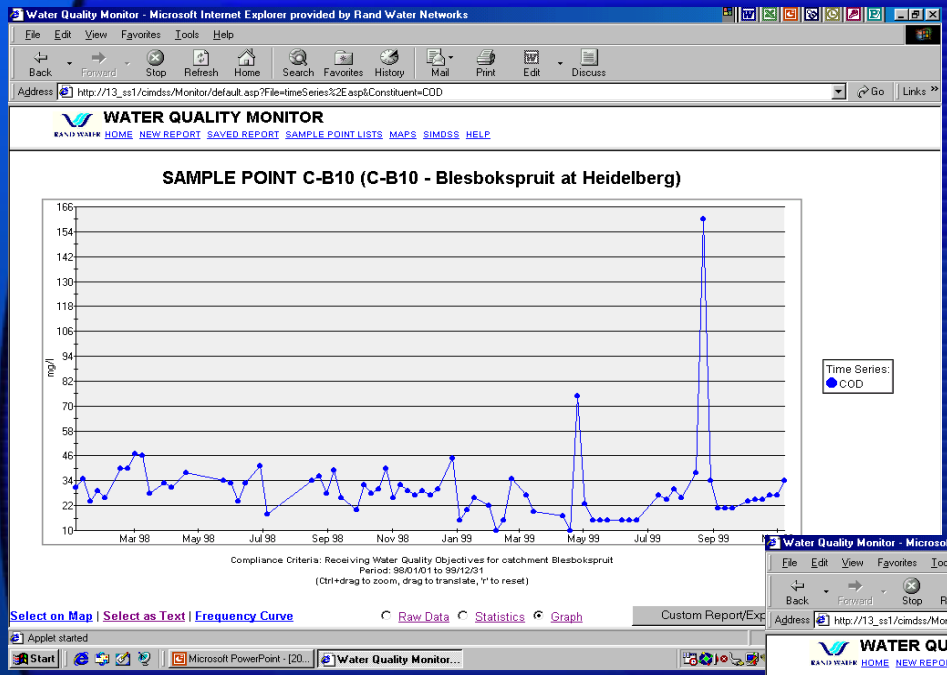


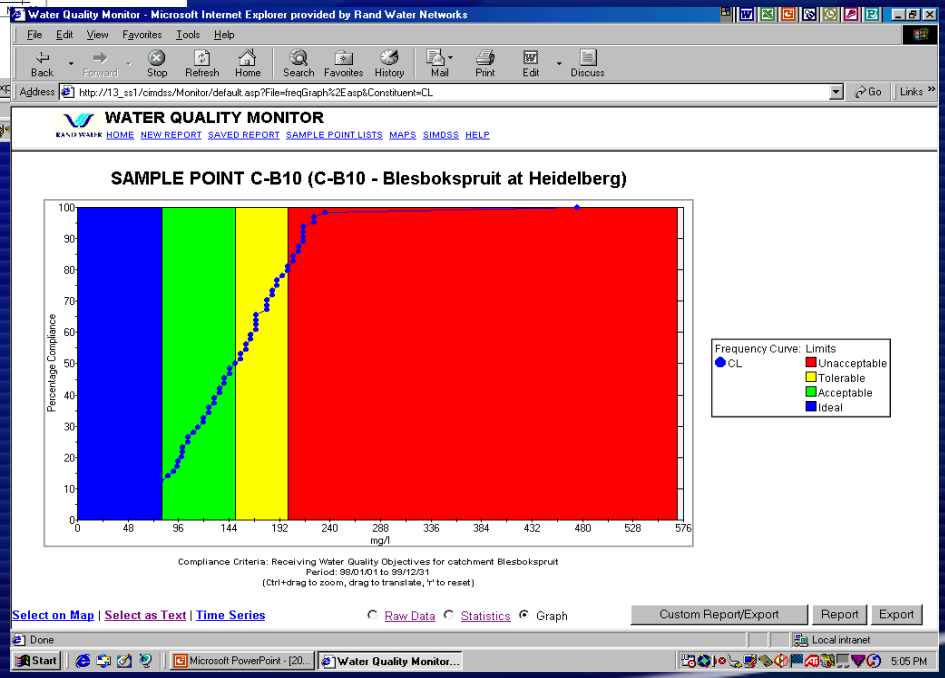
Routine Monitoring



Constituent	Criteria	Unit	Min	25%	Mean	75%	95%	Max.	Std. Dev.	N
% Composition Cryptophyceae (CRYPTO)		cells/ml	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10
Al (AL)		mg/l	0.10	0.10	0.11	0.10	0.10	0.52	0.07	43
Ammonia (NH4)	<0.1 0.1 - 1.5 1.5 - 5 >5	mg/l N	0.05	0.05	0.08	0.05	0.21	0.57	0.09	43
Boron (B)		mg/l	0.10	0.10	0.11	0.10	0.22	0.26	0.04	43
Bromide (BR)		mg/l	0.86	0.86	0.86	0.86	0.86	0.86	0.00	1
Ca (CA)		mg/l	120	205	235	265	295	320	49	43
Cd (CD)		mg/l	0.05	0.05	0.05	0.05	0.05	0.05	0.00	43
Chemical Oxygen Demand (COD)	<20 20 - 35 35 - 55 >55	mg/l	10	15	28	27	47	160	26	35
Chloride (CL)	<80 80 - 150 150 - 200 >200	mg/l	10	93	145	180	225	475	93	25
Co (CO)		mg/l	0.10	0.10	0.10	0.10	0.10	0.10	0.00	43
Conductivity (COND)	<45 45 - 70 70 - 120 >120	ms/m	26	170	215	285	310	330	87	48
Cr (CR)		mg/l	0.05	0.05	0.05	0.05	0.05	0.05	0.00	43
Cu (CU)		mg/l	0.10	0.10	0.10	0.10	0.10	0.10	0.00	43
Cyanide (CN)		mg/l	0.03	0.03	0.03	0.03	0.03	0.03	0.00	2
Dissolved organic carbon (DOC)		mg/l	6.4	9.1	13	15	18	21	3.8	47
Dissolved Oxygen (DO)		mg/l O2	0.50	6.4	6.9	8.0	9.3	13	2.7	26
Fe (FE)	<0.1 0.1 - 0.5 0.5 - 1 >1	mg/l	<0.10	<0.10	<0.10	<0.10	0.10	0.93	0.14	43
Fecal Coliforms (FC/100 ml) (FC)	<10 10 - 100 100 - 1000 >1000	fc/100 ml	60	210	1080	1000	3840	5400	1360	56
Fluoride (F)		mg/l	0.10	0.31	0.32	0.34	0.37	0.41	0.05	42

Routine Monitoring





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Problem Centered Investigations

2.2 Fish Deaths

Number of dead fish	< 10	> 10	> 100	> 1000	
Fish species	All of the same species?		Yes	No	
	Different species?		Yes	No	
Species	Carp	Yellow Tail	Bass	Barbel	Mud Fish
Number					
State of decomposition	Still dying	All dead	Advanced	Other	
Size of fish	All of same size?		Yes	No	
	Different sizes		Yes	No	
When was the first death observed?					
Has a similar problem been noted before?					
Other dead fauna?	Birds	Crabs	Rodents	Other	
Any other live fauna?	Daphnia		Yes	No	
	Chironomids		Yes	No	
	Dragon Fly larvae		Yes	No	
	Water beetles		Yes	No	
	Snails		Yes	No	
	Worms		Yes	No	
Water body covered by flora?	% cover	< 25	< 50	< 75	< 100
	Type	Algae	Floating	Floating	Submergent
		Plant	Floating	Floating	Emergent
	Chlorophyl				
Is the flora affected?	No	Yes	Slightly	Severely	Totally
Is Yes, give details					

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Catchment Diagnostic Framework

- Assists in understanding the current state of and trends in water resources.
- Provides feedback on changes in water resources.
- Improves the chances of successful adaptation to external changes.
- Ensures attainment of set goals and guidelines.
- Provides a framework in which to manage water resources effectively.

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Indicator Based

CDF Indicators

- Indicators (5) & elements (31)
- Indicators
  - Socioeconomic (10 elements)
  - Resource condition (7 elements)
  - Water quality (9 elements)
  - Management (3 elements)
  - Institutional arrangements (To be added)

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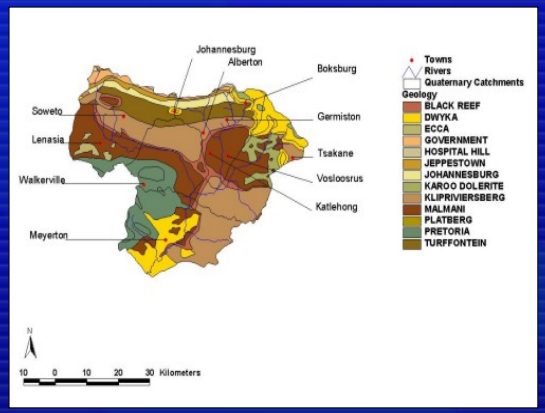
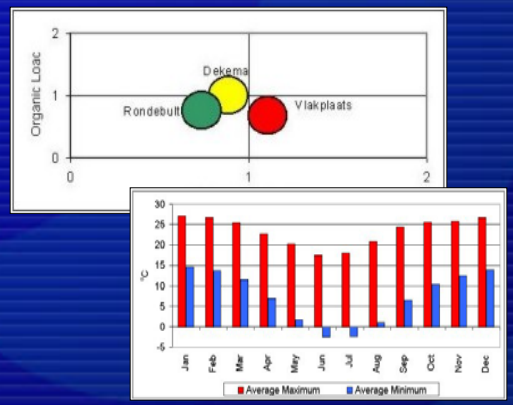
CDF In Action

- **The CDF consists of 2 main components:**
  - **(1) the Catchment Description - Maps, graphs, tables, data and information**





Variable	Units	K25	K18	K19
COD	mg/l	27.34	27.75	27.59
Conductivity	mS/m	82.93	78.73	83.52
Feacal coliforms	counts/100ml	37,265	12,968	13,409
Fe	mg/l	0.05	0.06	0.05
Mn	mg/l	0.3	0.32	0.77
Na	mg/l	64.02	60.45	71
NH4	mg/l	0.33	2.83	0.2
NO3	mg/l	4.07	4.15	4.53
pH	pH units	8	7.98	8
PO4	mg/l	0.71	1.09	0.73
SO4	mg/l	161.18	157.38	159.79

- (2) the Catchment Diagnostic Index (CDIX) - Rating and scoring system

Indicator Score	Definition	Colour Code
0	Poor	Purple
1	Below Average	Red
2	Average	Yellow
3	Above Average	Green
4	Excellent	Blue

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Rietspruit Catchment CDIX

Indicator	0	1	2	3	4	Total
Resource condition – 1999	3	0	0	0	4	16
Resource condition – 2002	1	1	0	0	5	21
Water quality – 1999	1	2	4	2	0	16
Water quality – 2002	0	4	4	1	0	15
Water quantity – 1999	3	0	0	0	0	0
Water quantity – 2002	3	0	0	0	0	0
Socioeconomic – 1999	2	2	0	2	4	24
Socioeconomic – 2002	2	3	0	1	4	22
Management – 1999	0	0	1	0	1	6
Management 2002	0	0	1	0	1	6
Total score – 1999						62
Total score – 2002						64
Percentage (Total/124) – 1999						50
Percentage (Total/124) – 2002						52

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Management Plans

- **ISO 9001 operation systems in respect of all processes *(existing)***
- **Set operational limits**
- **Remedial action part of every unit process procedure**
- **Develop protocols to take effect if operational limits are exceeded**
  - ***Taste and odour***
  - ***Pathogenic protozoa***
  - ***Communications***

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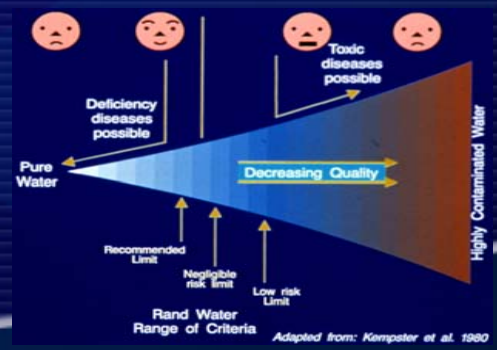
Independent verification

- **Within Rand Water**
  - *QC separated from QA*
  - *Two tier system of evaluation*
  - *Monthly reports to MANCO, The Board and Customers*
  - *Internal laboratory proficiency testing*

External To Rand Water

- *Fully accredited laboratory*
- *External ISO 9001 Audit*
- *Independent audit CSIR/SABS*



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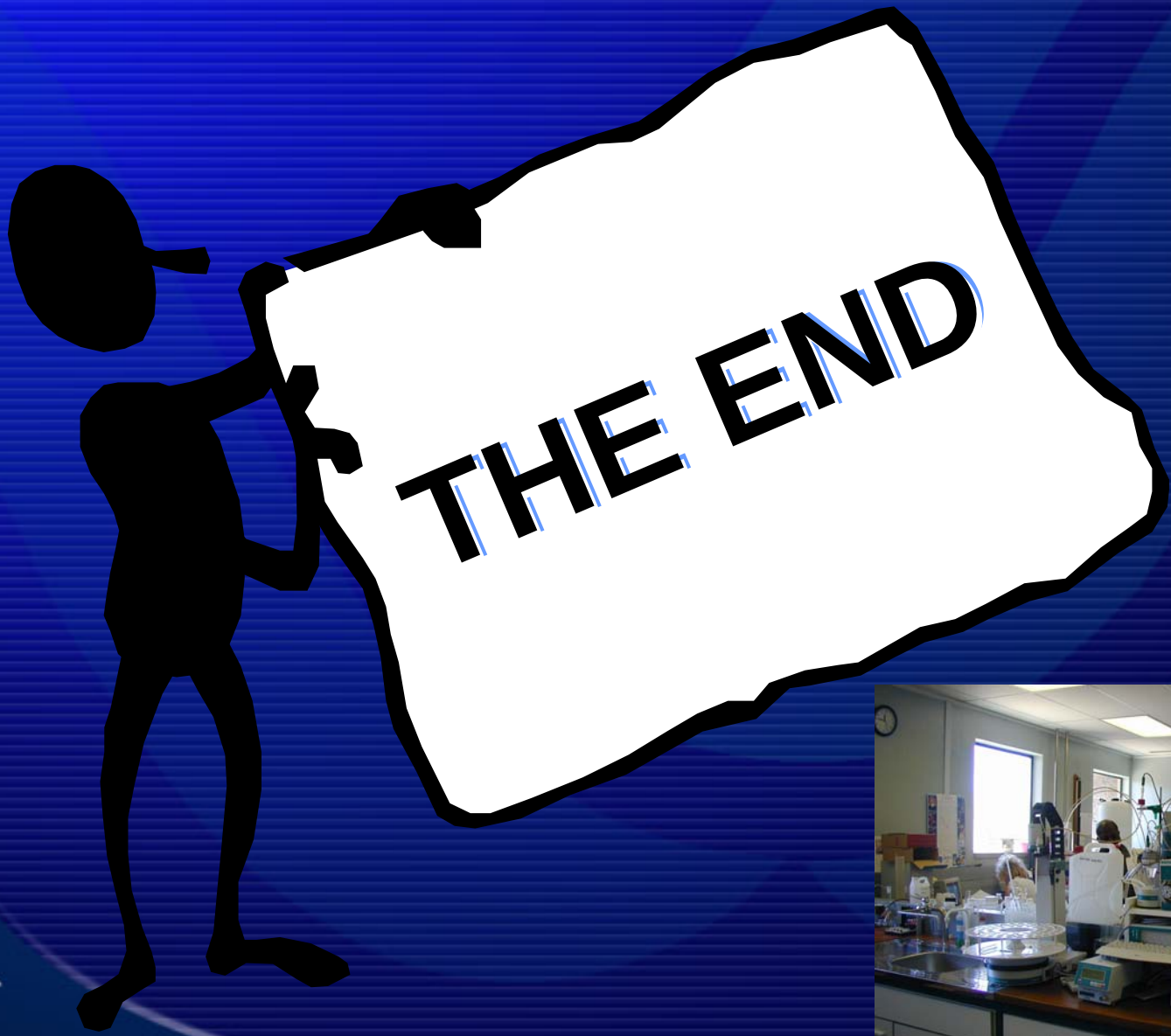

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