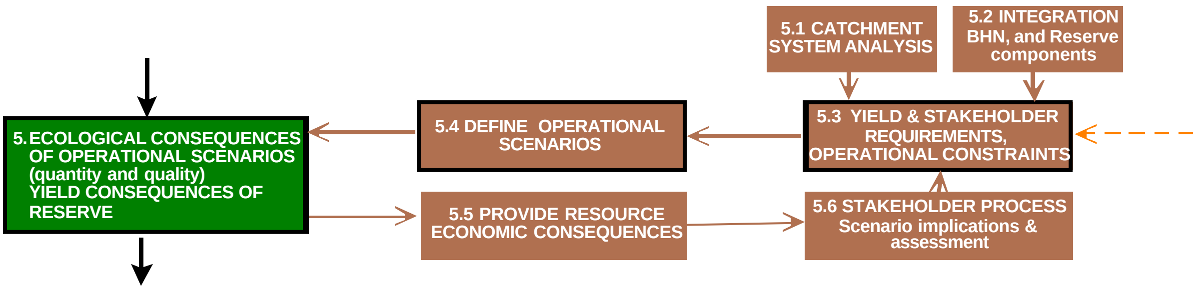
7. ASSESSING OPERATIONAL SCENARIOS *(5)*



7.1 INTEGRATION

7.1.1 Water quality

The water quality approach is

- to establish a water quality category for each water quality Resource Unit (for selected water quality variables as well as an overall water quality category);
- to establish numeric values for the selected water quality variables for each category;
- to translate these into resource quality objectives for water quality;
- to develop a data-base and model which relate instream concentration and flow;
- to use the model to describe what happens to water quality under different flow conditions.

Water quality and quantity resource objectives are therefore developed independently, and then integrated. The integration comprises providing the decision maker with information on instream water quality conditions under a variety of flow scenarios. These flow scenarios can include the recommended IFR. The decision maker will then be in a position to determine whether quality source controls and/or dilution are required as part of water quality management to achieve the resource quality objectives.

7.1.2 Estuary

Prior to assessing the operational scenarios, the quantity results of all the components should be integrated and/or matched before supplying it to the yield modeller. This has rarely been undertaken to date. The following approach is recommended and will be tested during the Thukela Ecological Reserve study.

- Compare the results for a specific state (ERC) of the river with the same estuary ERC.
- Establish whether they can be matched or whether minor changes are required that does not have negative consequences on either the river or estuary.
- Make the changes and use the Desktop Model or IFR model to supply the results in the correct format to the yield modeller.
- This matched flow regime as modelled will therefore result in the same ERC in the river and in the estuary.

Or, if the results do not match then

- Compare the results of any river ERC with any ERC of the estuary.

- Establish whether any of them can be matched or whether minor changes are required that does not impact on the relevant ERC for either the river or estuary.
- Make the changes and use the Desktop Model or IFR model to supply the set of results in the correct format to the yield modeller.
- This matched flow regime as modelled will result in an ERC for the river and a different ERC for the estuary.

Or, if the results are significantly different then

- Accept the estuary scenario for a specific ERC and extrapolate the resulting river inflow required for this. Determine the consequences and resulting ERC for the river and;
- Accept the river scenario for a specific ERC and determine the consequences and resulting ERC for the estuary.
- Supply both (or more) of these scenarios to the yield modeller as Reserve Scenarios.
- These do not represent matched scenarios. They do however represent a scenario which will supply a Reserve scenario to the river or estuary with an associated description of the consequences on either.

7.1.3 Wetland

A wetland integration exercise has only once taken place during a pilot test for RDM methodologies on the Pienaars River. In this case there was no problem with matching the results as the wetland represented a river flood driven wetland with a single hydraulic control.

Once the wetland Reserve methodologies are established, integration must be further investigated. It is highly likely that in most cases a similar approach than for estuaries can be followed.

7.1.4 Groundwater

From the viewpoint of the river component of the Reserve, the integration of the groundwater component largely involves an understanding of the hydrological processes that are associated with the generation of baseflows in the river. If these are considered to be mainly contributed from true groundwater (i.e. from groundwater that is potentially exploitable as a resource) then integration is extremely important as any utilisation of groundwater could affect the river's baseflows. In such situations it would be necessary for the groundwater Reserve team to take into account the low flow requirements of the river Reserve and ensure that their recommendations do not result in baseflow reductions that are lower than the river Reserve. Alternatively, it would be necessary to identify this as an issue for concern that might affect the way in which DWAF manages the catchment's water resources in an integrated manner.

It should be remembered that the river baseflows are not normally quantified on the basis of any assumed hydrological process, they are merely the low amplitude, high frequency component of the total flow regime.

Unfortunately, the mechanisms and processes involved in the interaction between surface water and groundwater are not always clearly understood for South African catchments and it is therefore not a simple task to quantify the real contribution of groundwater to river baseflows. For example, it has been noted that the baseflow contribution to many rivers in the high rainfall, steep topography regions of the country is a great deal higher than the quantified available groundwater resources in such catchments. The conclusion is that there are other hydrological mechanisms supplying river baseflows than drainage from what is considered to be the groundwater resource.

7.1.5 Basic Human Needs

As the Basic Human Needs (BHN) Reserve at this stage functions according to a bulk volume with a fixed assurance, this volume does not need to be integrated into the Ecological Reserve components and can be provided directly to the yield modellers.

7.2 CATCHMENT SYSTEM ANALYSIS, YIELD REQUIREMENTS AND OPERATIONAL CONSTRAINTS

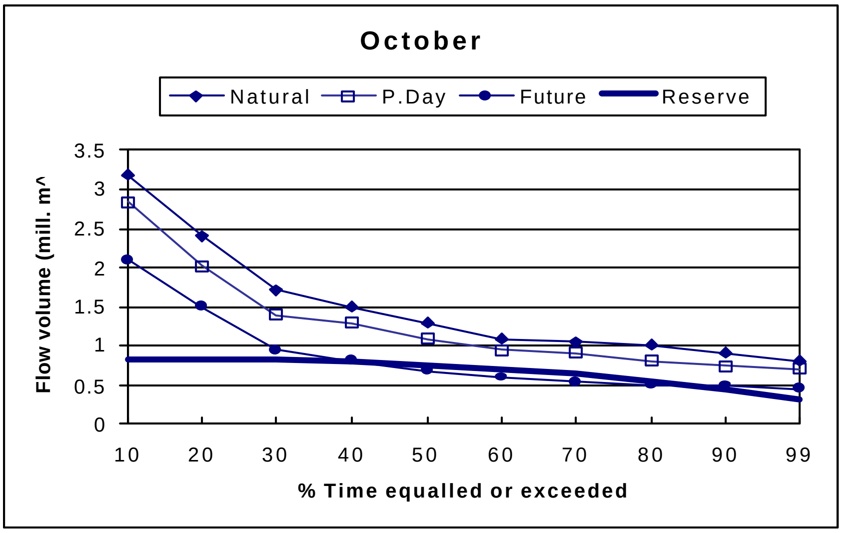
One of the important issues related to the scenario assessment process is that all of the possible methods used in step 4 (see Figure 2.2) of the Reserve determination process should generate the same format output. It has been recognised that the most useful type of output for the scenario assessment stage is a table of flows (expressed as volumes or as mean monthly flows) for each month of the year and for several levels of assurance. The high assurance flows represent the drought requirements of the Reserve, while the moderate to low assurance flows represent the maintenance and higher requirements. Overall, the tables (illustrated by the bold 'Reserve' line in Figure 7.1) provide a continuum of Reserve requirements, which are expected to be equaled or exceeded with the frequency of the specified assurances. Natural variations in streamflow are assumed to be the driving force behind variations in the modified (Reserve) flow regime. If a flow occurs in the natural regime, that is equaled or exceeded 25% (for example) of the time, then the assumption is that a Reserve requirement with an assurance of 25% would be required.

While a catchment system analysis has been identified in the flow diagram as an input to the whole scenario assessment process (step 5 in Figure 2.2), it actually forms part of the iterative process, which identifies the ecological consequences of different operational scenarios. The exact form that the process of identifying the consequences takes will depend upon the nature of the water resource developments in the catchment and the purpose for which the Reserve is being set. Thus, catchments without major storage dams and where the developments are mostly distributed abstractions and streamflow reduction activities will be treated in a different way to complex catchments where the Reserve will be partly managed through the definition of reservoir operating rules. A brief summary of some of the technical issues associated with this step are provided here.

In the former case, managing for the Reserve will be mostly related to the control of abstraction licenses and ensuring that abstractors conform to the terms of their licenses. The catchment system analysis required in step 5.1 in the flow diagram therefore involves primarily an identification of natural water availability, present day and potential future water uses, all expressed in a way that allows comparison with the quantified Reserve scenarios. Water uses refer to all possible uses including run-of-river abstractions, abstractions and impacts of small farm dams, return flows, land-use changes and streamflow reduction activities. An approach that has a lot of potential is to make use of natural flow duration curves (for each calendar month of the year), which can then be adjusted to account for both present day water uses and applications for new water use licenses (Figure 7.1). The output from the ecological Reserve scenario determination process (step 4 in the flow diagram) is in the same format and can be compared with both the present day and license application (future situation) results. Where the adjusted duration curves lie below the Reserve requirement assurance curve then the Reserve will not be met (for 35% {80%-45%} of the time in the October example at full development illustrated in Figure 7.1) and the ecological consequences can be assessed. Alternatively, it is also possible to investigate the consequences (to existing, or new users) of meeting the Reserve at the expense of water users. In the example used (Figure 7.1), future users would have to be restricted during October for periods when the 80% to 45% assurance flows for the Reserve are required. At this stage no consideration is given to how such restrictions may be managed, the focus would be on the possible impacts of such restrictions.

Where major dams form part of the existing or planned water resource developments, the situation becomes far more complex and the relatively simplistic analysis represented by Figure 7.1 is no longer applicable. Under these circumstances it would be necessary to configure a systems model (such as the WRYM – Water Resources Yield Model – currently in use by DWAF and its main consultant water resource engineers). These models traditionally operate on a monthly time step and comprise a complicated network of natural flow inputs, storages, losses and abstractions, return flows and transfers (internal and external). Most of the abstractions and transfers are defined through a set of supply assurance rules, in a similar and compatible way that the Reserve scenarios are now defined. Integration of the Reserve as an additional 'user' in the system is therefore relatively straightforward. The main consideration in the model is that the assurances of the flows required to satisfy the Reserve are linked to duration curve % points of the natural flows that occur in any one month during the model run.

Figure 7.1 Natural, present day and future flow duration curves plotted together with a Reserve scenario assurance curve for the month of October.



The WRYM can be run under many different scenarios that allow for a range of priority options to be evaluated. It is therefore possible to examine the effect on the Reserve of prioritising the water users, or the effect on the yield (and therefore the water users) of giving the Reserve requirements the highest priority. The Reserve determination methods also need to allow the assurance rules for the low and high flow components of the Reserve to be separately quantified. One possible operational scenario may be to satisfy the low flow requirements of the Reserve through managed releases, but not to manage the high flows through releases (possibly because the existing dam infrastructure does not allow for the releases of high flows) and to assume that the high flows at the Reserve site will be provided by reservoir overflows and downstream tributary inflows.

The output from WRYM (as a flow time series or as duration curves) at the Reserve site can then be examined relative to the workshop defined requirements of the Reserve, the assumptions assessed and the ecological consequences of not satisfying the high flow requirements specified. However, it should be recognised that the monthly volume output from the WRYM model is not ideal from the point of view of examining the ecological consequences of reductions in high flows. It is usually necessary to make some attempt to translate that information into the effects on patterns of daily flows.

Frequently, the main impacts on the yield are caused by the high assurance (i.e. lower flows) components of the Reserve. Therefore one of the processes involved in the scenario assessment step may be to develop alternative Reserve scenarios that will have a lower impact on the yield, but will still maintain the ecological functioning of the system in a certain ecological category. The compatibility of the outputs from the Reserve scenario determination (step 4 in Figure 2.2) with the input requirements of the WRYM model allows for a high degree of flexibility in the management option combinations that can be assessed.

In the case of either the simple, distributed development situation, or complex situations where the WRYM is used, it is straightforward to incorporate an allowance for the BHN Reserve.

While the monthly time-step is appropriate for most scenario assessments, it is frequently necessary to consider the high flow Reserve requirements in more detail to determine whether the system operation has the capability to meet such flows. This issue is normally associated with large-scale water resource developments where a major reservoir is involved. The most important factor to consider is the capacity of the dam outlet works to release flows to satisfy the flood requirements of the Reserve. It is also necessary to take into account the fact that the Reserve requirement may be specified for a point in the river downstream of the dam and the effects of attenuation and losses should be accounted when quantifying the necessary releases. It is possible that existing or design outlet works will not have the required capacity. Under such situations it may be necessary to try and include an estimate of the frequency with which spillages from the reservoir will satisfy the high flow requirements of the Reserve in the ecological assessment. This is clearly not a simple and straightforward task to perform with a model that is based on a monthly time step. More detailed investigations, at the daily time scale, may therefore be required to provide the necessary information. However, no clear guidelines on the methods to use in such circumstances have been developed to date.

7.3 ECOLOGICAL CONSEQUENCES

The various operational scenarios must be evaluated to supply the ecological consequences. These consequences are defined in different ecological river states, i.e. the resulting ERCs. The following step by step process is undertaken.

- The operational scenarios are modelled and the results of the scenarios at each IFR site is supplied in the format of a duration graph. (Fig 7.2)
- These figures are analysed and the major differences (if any) from the Reserve requirement identified and described.
- Specific points on the duration graph (eg 20%, 60%, 90%) are investigated. The flow rates at these percentiles are defined according to the associated hydraulic parameters. (Fig 7.3)
- The specialists evaluate the ecological consequences, provide the resulting ERCs for the different components and agree on an Ecostatus ERC. (Fig 7.4)
- It is highly likely that some of the scenarios result in the same ecostatus ERC and they must still be evaluated according to different level of impact. By using expert judgement, all the scenarios are ranked and placed on a scale from zero (recommended IFR / least impact) to 10 (no IFR scenario/ most impact). It is quite obvious why a scenario with an ERC of C is better than one with an ERC with a D. However, where one has 3 scenarios all with an ERC of a C, the ranking must be motivated and explained.

It must be noted that during this step ecological consequences only are supplied; no recommendations are made on acceptability of scenarios. It is the function of the Reserve specialists to provide as much information as possible to allow informed decision -making; it is not Reserve specialists' task to make decisions.

Fig 7.2 Example of the duration graph of operational scenarios at an IFR site for a dry month

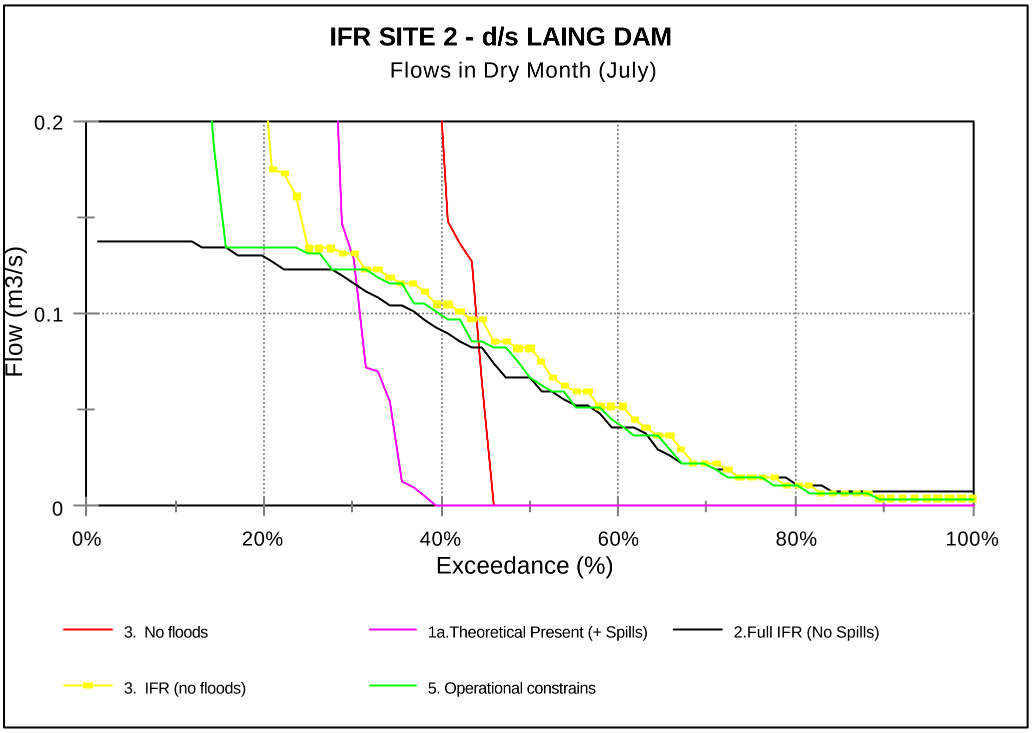
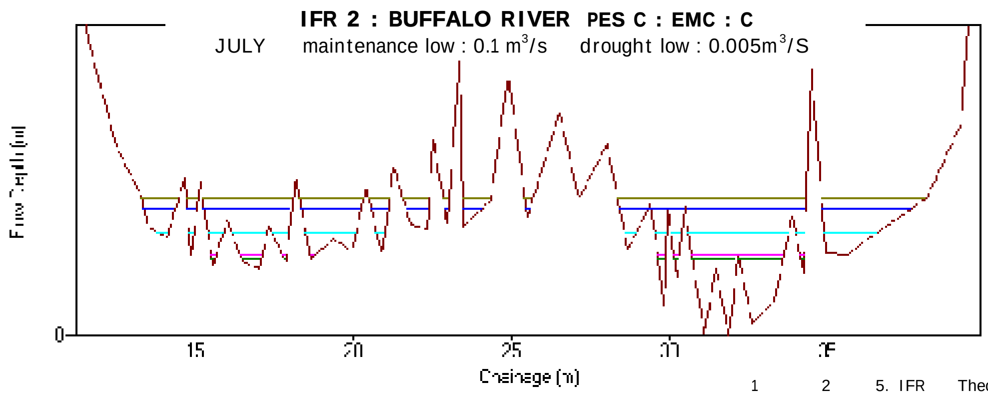


Fig 7.3 Example of the hydraulic parameters associated with the scenarios for different percentage points



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	1 No IFR	2 IFR rule	5. IFR Oper con	Theor Present
25%	0.52	0.123	0.131	0.35
Depth (m)	0.29	0.22	0.22	0.27
m/s	0.29	0.17	0.18	25
Wet per (m)	19.6	11.6	11.6	17.7
55%	0	0.052	0.052	0
Depth (m)		0.2		
m/s		0.1		
Wet per (m)		9.2		
75%	0	0.015	0.015	0
Depth (m)		0.17		
m/s		0.05		
Wet per (m)		5		
90%	0	0.007	0.004	0
Depth (m)		0.17	0.16	
m/s		0.02	0.02	
Wet per (m)		5	4.3	

Fig 7.4 Example of the ecological consequences of different scenarios

COMPONENTS	PES	TR	Long term (10 yrs)	EMC	1	3	5	1A
Geomorphology	C	0 -	C D	C	C D	C	C	C D
Riparian vegetation	C D	-	D E	C D	D	C D	C D	D
Fish	C D	-	D	C	D	C	C	C
Aquatic invertebrates	C	0	C	C	D	C	C	D
Ecostatus	**C**			**C**	**D**	**C**	**C**	**D**

Fig 7.5 Example of the ranking of the different scenarios

RANKING

SCALE	SC	CLASS
0 (IFR rule)	**2**	**C**
1		
2		
3	5	C D
4	3	C D
5		
6		
7		
8		
9		
10 (NO IFR)	**1+1a**	**D E**

7.4 RESOURCE ECONOMICS

Resource economics do not form part of this TOR. As this forms an integral part of the stakeholder procedure, the classification procedure and the decision making process, a short description of what the aim would be of resource economics are provided below. It must be noted that resource economics in general and specifically in the context of the Reserve is pioneering in nature, given the relative lack of precedents in South Africa.

A range of supply and demand scenarios for a set of proposed water flows and quality conditions must be developed. It will, for example, address questions such as “what will the supply of goods and services be for a flow of X% and quality of Y% of the current condition and how will values differ from the status quo?” These scenarios will form the basis of economic models where various variables can be altered to reflect potential changes/responses in demand, prices and finally values. In addition, some services have greater economic significance than others and there will need to be a selection of priority services to investigate in more detail. Where information gaps arise, data collection and primary research will be necessary. Models will then need to be run and evaluation made of their approximation of reality.

This process will result in the development of a set of bioeconomic models that best reflect priority services supplied by the river. These models will then be populated with relevant variables to generate outputs that will approximate the outcomes of changes to the economy resulting from changes to the flow and quality of water in the river.

7.5 STAKEHOLDER ASSESSMENT

The stakeholder process do not form part of the TOR.

During this stage of the Reserve assessment, some interaction with the stakeholders will be required and all the scenarios (Reserve and operational) as well as the consequences of each scenario (quality, ecological, economical) could be provided to stakeholders at this stage.