

VEGETATION SPECIALIST STUDY

With reference to potential dam sites in the Vioolsdrif and Komsberg areas

for

Lower Orange River Management Study

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Summary

1. A new dam on the Lower Orange River is one of a suite of options available to Namibia and South Africa to improve the water supply and meet environmental flow requirements.
2. The current study investigated nine dam sites in two broader areas (Komsberg and Vioolsdrif).
3. A dam site in the Vioolsdrif area would affect overall a less developed stretch of riparian landscapes and habitats, but stretches of the river in this area are invaded by alien vegetation.
4. A dam site in the Komsberg area would affect large stretches of relatively pristine riparian woodlands, though interrupted by agricultural developments.
5. All dam options investigated would inundate approximately 50-70 km of riparian habitat in a presently little developed area which is a major environmental impact.
6. To serve both objectives, improving the ecological status of the Lower Orange River and improving water supply to this area, should a dam be constructed, an area equivalent to the area to be inundated by the proposed dam will need to be preserved in form of a formal conservation area and bad management practises along the entire Orange River need to be addressed.
7. Further studies will need to address habitat loss, impacts on other ecosystem components and the process of alien plant invasions in more detail.

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1. Introduction

In order to improve the water supply to development projects and meet environmental flow requirements of the Orange River a new dam is one of the options being investigated within the reaches of the Lower Orange River. Out of a number of dam options, two areas were identified for the current study. EnviroScience had been tasked to undertake a field assessment of the vegetation in these areas and to determine the effect of dam position and required supporting infrastructure on vegetation, wilderness aspect and landscapes.

The two areas under investigation in the current study are Vioolsdrif (near 28°47' S and 17°57' E) and Komsberg (near 28°30 S and 19°46 E). Four potential dam sites were provided by the engineers in the Vioolsdrif area (Figure 1), five in the Komsberg area (Figure 2).

Focussing on landscapes, habitats and riparian vegetation, this report presents a description of the individual dam sites, a comparison of the two broader dam areas and finally overall comments and recommendations to the proposed dam development *per se*.

The Terms of Reference for this study were:

- to assess the vegetation and impacts thereon – both riparian vegetation and adjacent vegetation along the Lower Orange River, with particular focus on two sites of potential dam development (Vioolsdrif and Komsberg)
- to assess the impact of dam walls, infrastructure and construction camps
- to assess the impacts of inundation of the various dams and
- to assess the impacts on wilderness, landscape and “sense of space”, tourism and recreation values and any other aspects that may present opportunity costs or benefits.

2. Approach and methodology

2.1 Field survey

A field survey was undertaken during the period 22 October to 3 November 2003. All nine dam sites were accessed by vehicle (where possible), boat or on foot and a description of the vegetation was compiled. In addition descriptions were also made of the vegetation along possible access routes and of parts of the areas inundated by the potential dam sites. These included stretches of the Orange River in the Augrabies National Park and at Haakiesdoorn (Goodhouse) and Gaidip. These descriptions also included notes of affected habitats and land use. In order to determine the potentially inundated areas, belt transects were laid at selected sites and detailed measurements of topography and vegetation were made. These included a determination of slope and relative altitude as well as photographs to accompany the description.

2.2 Descriptions and evaluation

The evaluation was undertaken at two levels of scale.

(1) A detailed description of the individual dam sites was compiled, including the following parameters:

- position (latitude and longitude)
- affected vegetation (riparian and adjacent)
- topography
- habitats
- existing disturbance
- alien vegetation and
- other aspects.

Recommendations were included where a statement regarding environmental impacts of a possible dam at this site could be made.

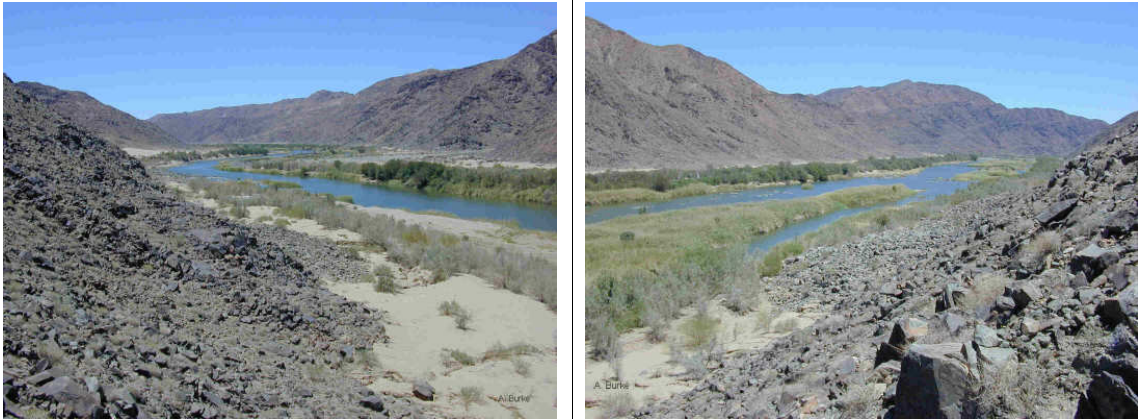
(2) Summarising the detailed descriptions, a comparative matrix of the two broad dam areas (Violsdrif and Komsberg) was constructed. This included a description of the riparian and adjacent vegetation as well as a number of criteria to evaluate environmental aspects. These included:

- existing disturbance
- inundated areas
- impacts associated with access routes and infrastructure, and
- other impacts.

3. Description of individual dams sites

3.1 Vioolsdrif area

The descriptions of the four potential dam sites in the Vioolsdrif area follow a west to east direction.

Vioolsdrif A	
	
Position	28°45.34' S and 17°48.86' E
Access route	Existing track on south-bank to weir (28°45.78' S and 17°43.80' E), difficult from there upstream; north-bank: existing track for about 4 km from west, then very steep slopes reaching to the river banks – very difficult and major road construction would be required. The road construction impacts would be larger than the impacts of dam construction.
Affected riparian vegetation	<i>Prosopis</i> sp. – <i>Tamarix usneoides</i> woodland on drybank (northbank), <i>Acacia karoo</i> woodland on south-bank, <i>Phragmites australis</i> reed beds
Affected adjacent vegetation	Directly affected by inundation: <i>Sisymbrium sparteum</i> – <i>Zygophyllum microcarpum</i> shrubland on sand plain and footslopes, <i>Zygophyllum cf album</i> dwarf shrubland on mountain slopes
Topography	Narrow river valley
Habitats	Mountain slopes, river banks (dry- and wetbank), boulder areas, islands, backwaters
Existing disturbance	<ul style="list-style-type: none"> ▪ <i>Prosopis</i> species invading ▪ some burned patches on north-and south-bank
Alien vegetation	<i>Prosopis</i> species (<i>P. glandulosa</i> and <i>P. velutina</i>), <i>Ricinus communis</i>
Other...	<ul style="list-style-type: none"> ▪ A weir downstream of site A has to some extent stabilised flow conditions for approximately 5 km length of this stretch of river. As a result riparian habitat diversity along this stretch is reduced and no boulder areas, backwaters, sand banks or islands were present at the time of the survey (low flow conditions). ▪ The south-bank west of the potential dam site A is invaded by <i>Prosopis</i> species.
Recommendation	<ul style="list-style-type: none"> ▪ If a dam site is considered in this area, it should be moved as far west as possible towards Vioolsdrif to inundate, as far as possible, already disturbed areas and alien vegetation, rather than less disturbed stretches of river further upstream.

Violsdrif B



view upstream

Position	28°46.45' S and 17°55.62' E
Access route	Existing track via Haib River in Namibia, could be upgraded without major impacts.
Affected riparian vegetation	<i>Prosopis</i> species - <i>Tamarisk usneoides</i> woodland on drybank, <i>Phragmites australis</i> on wetbank, localised patches of <i>Rhus pendulina</i> and <i>Acacia karoo</i> woodland on south-bank. <i>Gomphostigma virgatum</i> on boulders in riverbed.
Affected adjacent vegetation	Directly affected by inundation: <i>Sisyndite spartea</i> shrubland on sand plain and <i>Zygophyllum cf album</i> dwarf shrubland on mountain slopes
Topography	Narrow river valley with wider section of sand deposit on north-bank
Habitats	Mountain slopes, river banks, boulder areas, islands, backwaters
Existing disturbance	<ul style="list-style-type: none"> ▪ burned sections ▪ patches with <i>Prosopis</i> species invading, particularly in burned areas
Alien vegetation	<i>Nicotiana glauca</i> , <i>Prosopis</i> species (<i>P. glandulosa</i> and <i>P. velutina</i>), <i>Ricinus communis</i>

Violsdrif C





view upstream





view downstream

Position	28° 47.37' S and 17° 56.89' E
Access route	Existing track via Haib River in Namibia to site B, from there narrow river valley and road build-up would be required, resulting in substantial construction impacts.
Affected riparian vegetation	<i>Prosopis</i> woodland on drybank (N), <i>Rhus pendulina</i> – <i>Salix mucronata</i> woodland on south-bank, <i>Gomphostigma virgatum</i> on boulders in riverbed, sections with <i>Ziziphus mucronata</i> on south-bank, <i>Phragmites australis</i> reed beds.
Affected adjacent vegetation	Directly affected by inundation: <i>Sisymbrium sparteum</i> shrubland on sand plain and footslopes and <i>Zygophyllum cf album</i> dwarf shrubland on mountain slopes
Topography	Narrow river valley
Habitats	Mountain slopes, river banks, boulder areas, islands
Existing disturbance	<ul style="list-style-type: none"> ▪ burned sections ▪ patches with <i>Prosopis</i> species invading, particularly in burned areas and in wetbank
Alien vegetation	<i>Prosopis</i> species (<i>P. glandulosa</i> and <i>P. velutina</i>), <i>Ricinus communis</i>

Violsdrif D	
 <p>view upstream</p>	 <p>view downstream</p>
Position	28° 48.16' S and 17° 58.72' E
Access route	Existing track via Haib River in Namibia to site B, from there narrow river valley and road build-up would be required, resulting in substantial construction impacts; or existing track via Krom River (this track was not investigated during the field survey)
Affected riparian vegetation	<i>Prosopis</i> sp. – <i>Tamarix usneoides</i> woodland on drybank (north- and south-bank), isolated <i>Salix mucronata</i> trees on south-bank, <i>Phragmites australis</i> reed beds
Affected adjacent vegetation	Directly affected by inundation <i>Sisymbrium spartea</i> shrubland on footslopes and sand plain
Topography	Narrow river valley at actual dam site, inland delta related to Krom River joining north-bank just upstream of dam site
Habitats	Mountain slopes, river banks (dry- and wetbank), boulder areas, islands
Existing disturbance	<ul style="list-style-type: none"> ▪ <i>Prosopis</i> species invading ▪ some burned patches on north-and south-bank
Alien vegetation	<i>Argemone ochroleuca</i> , <i>Prosopis</i> species (<i>P. glandulosa</i> and <i>P. velutina</i>), <i>Ricinus communis</i>

3.2 Komsberg area

The descriptions of the five potential dam sites in the Komsberg area follows a west to east arrangement.

Yas B	
 <p>view upstream</p>	 <p>view downstream</p>
Position	28°31.72' S and 19°35.24' E
Access route	Following existing track to approximately 10 km upstream of dam site on south bank; remaining possible access route extremely difficult with steep slopes reaching to river banks and very narrow sand deposit on south bank. Road along this section would require major built up, possibly blasting and hence pose a major impact.
Affected riparian vegetation	<i>Salix mucronata</i> – <i>Rhus pendulina</i> woodland, <i>Tamarix usneoides</i> woodland, <i>Phragmites australis</i> reed beds
Affected adjacent vegetation	<i>Sisyndite spartea</i> shrubland on sand plain and footslopes
Topography	Narrow river valley
Habitats	Mountain slopes, river banks, boulder areas, backwaters, islands, sand banks
Existing disturbance	<ul style="list-style-type: none"> ▪ localised burned patches of riparian woodland
Alien vegetation	<ul style="list-style-type: none"> ▪ None recorded
Recommendation	Not to be considered as possible dam site due to large impacts associated with access route and disturbance of relatively pristine wilderness area.

Yas E



view upstream



view downstream

Position	28°31.19' S and 19°41.25' E
Access route	Access along existing track almost to dam site; final section along river bank will require some built up, but likely no blasting.
Affected riparian vegetation	<i>Salix mucronata</i> woodland, <i>Tamarix usneoides</i> woodland on north- and south-banks, <i>Phragmites australis</i> reedbeds
Affected adjacent vegetation	<i>Sisyndite spartea</i> shrubland on sand plain and footslopes adjoining riparian woodlands, <i>Commiphora gracilifrons</i> shrubland on mountain slopes
Topography	Narrow valley at dam site and downstream, widening upstream
Habitats	Mountain slopes, river banks, boulder areas, islands
Existing disturbance	<ul style="list-style-type: none"> ▪ cattle and goat farming ▪ fishing ▪ burned sections of riparian woodland to gain access to river ▪ sections of river showing algae growth (likely due to fertiliser runoff upstream)
Alien vegetation	<i>Ricinus communis</i>

Skuitdrif







view upstream



view downstream

Position	28°30.07' S and 19°46.57' E
Access route	Following access route for Eskom-Nampower powerline, sections of which have recently been built up; last section can follow existing track which may require some minor build up.
Affected riparian vegetation	<i>Salix mucronata</i> – <i>Rhus pendulina</i> woodland, <i>Phragmites australis</i> reedbeds
Affected adjacent vegetation	<i>Sisyndite spartea</i> shrubland and sand plain and footslopes, <i>Monechma spartioides</i> shrubland on mountain slopes
Topography	Narrow river valley
Habitats	Mountain slopes, river banks, sand banks, boulder areas, islands
Existing disturbance	<ul style="list-style-type: none"> ▪ None recorded
Alien vegetation	<i>Ricinus communis</i>

Narries	
 <p>view upstream</p>	 <p>view downstream</p>
Position	28°29.72' S and 19°50.01' E
Access route	Following existing track through tributary on south-bank; final 5 km access difficult on north- and south-bank, as steep mountain slopes reach right to the water
Affected riparian vegetation	<i>Salix mucronata</i> – <i>Ziziphus mucronata</i> woodland
Affected adjacent vegetation	<i>Sisyndite spartea</i> shrubland on sand plain, <i>Enneapogon scaber</i> grassland on mountain slopes
Topography	Narrow valley
Habitats	Mountain slopes, river banks, sand banks, boulder areas, islands, backwaters
Existing disturbance	<ul style="list-style-type: none"> ▪ None recorded
Alien vegetation	<i>Nicotiana glauca</i> , <i>Ricinus communis</i>
Recommendation	Not to be considered as possible dam site due to diverse habitats, relatively pristine status of riparian vegetation, present use as private nature reserve and impacts associated with the building of access route.

Komsberg	
 <p>view upstream</p>	 <p>view downstream</p>
Position	28°26.37' S and 19°56.45' E
Access route	Following existing track via Daberas farmhouse (South Africa); the last section of the track will require some built up and possibly blasting or removing of few boulders.
Affected riparian vegetation	<i>Salix mucronata</i> and <i>Tamarix usneoides</i> woodland, patches of <i>Phragmites australis</i> and reed beds and <i>Cynodon dactylon</i> on wetbanks and islands, boulders with <i>Gomphostigma virgatum</i> ; recruitment of <i>Rhus pendulina</i> and <i>Salix mucronata</i> on sand banks near river.
Affected adjacent vegetation	<i>Sisymbrium spartea</i> – <i>Zygophyllum microcarpum</i> shrubland and sand plain and <i>Boscia albitrunca</i> shrubland on mountain slopes
Topography	Narrow river valley
Habitats	Mountain slopes, river banks, islands, boulder areas, backwaters
Existing disturbance	<ul style="list-style-type: none"> ▪ None in immediate vicinity of dam site
Alien vegetation	<i>Ricinus communis</i>
Recommendation	Not to be considered as possible dam site due to effect on relatively pristine riverine vegetation and dam position in a National Park.

4. Comparative assessment of the broader dam areas

At the present level of detail regarding technical information for different dam options, only a broad comparison of different aspects to be considered during the development of dam sites in the lower Orange River can be provided.

	Vioolsdrif	Komsberg
Affected riparian vegetation	<ul style="list-style-type: none"> ▪ some sections with <i>Rhus pendulina</i> – <i>Salix mucronata</i> woodland and <i>Acacia karoo</i> woodland ▪ large areas dominated by <i>Prosopis</i> species ▪ sections of river with <i>Prosopis</i> recruitment on islands and sand banks ▪ <i>Phragmites australis</i> reed beds and <i>Cynodon dactylon</i> lawns on wetbank and islands ▪ boulder sections with <i>Gomphostigma virgatum</i> ▪ <i>Tamarix usneoides</i> woodland on drybank 	<ul style="list-style-type: none"> ▪ <i>Rhus pendulina</i> – <i>Salix mucronata</i> woodlands along most sections of the river ▪ <i>Ziziphus mucronata</i> woodland along some sections ▪ islands and wetbanks with <i>Phragmites australis</i> reed beds and <i>Cynodon dactylon</i> lawn ▪ boulder sections with <i>Gomphostigma virgatum</i> ▪ <i>Tamarix usneoides</i> woodland on drybank
Affected adjacent vegetation	<i>Sisyndite spartea</i> shrubland, <i>Zygophyllum cf album</i> dwarf shrubland	<i>Sisyndite spartea</i> shrubland <i>Monechma spartioides</i> shrubland <i>Commiphora gracilifrons</i> shrubland
Existing disturbance	<ul style="list-style-type: none"> ▪ small stock and cattle grazing on north-bank and islands ▪ extensive fishing from north-bank ▪ signs of burning 	<ul style="list-style-type: none"> ▪ sections with irrigation agriculture on north- and south-banks ▪ fishing and burning of riparian woodlands in vicinity of agricultural developments
Alien vegetation	<ul style="list-style-type: none"> ▪ <i>Argemone ochroleuca</i> ▪ <i>Prosopis</i> species (<i>P. glandulosa</i> and <i>P. velutina</i>) ▪ <i>Ricinus communis</i> ▪ <i>Nicotiana glauca</i> 	<ul style="list-style-type: none"> ▪ <i>Nicotiana glauca</i> ▪ <i>Ricinus communis</i>
Impacts associated with access routes and infrastructure	Access to dam sites Vioolsdrif A, C and possibly D will require major road build up and hence there will be large construction impacts.	Access to dam sites Yas B, Komsberg and Narries will require major road build up and hence there will be large construction impacts.
Inundated areas	<ul style="list-style-type: none"> ▪ The section of river upstream of Vioolsdrif B to about the western border of Haakiesdoorn provides diverse habitats and a scenic landscape with wilderness aspect. ▪ Dam sites upstream of site B would affect areas with irrigation agriculture, some of which on the north-bank are presently abandoned and have been invaded by <i>Prosopis</i> species. 	<ul style="list-style-type: none"> ▪ The sections Yas B to Yas E and Suitdrif-Narries-Komsberg, as well as upstream of Komsberg would affect largely undisturbed area of diverse riverine habitats, with little infestation of alien vegetation. ▪ All dam sites would affect some areas with irrigation agriculture.
Visual impacts and	Although along sections of this stretch of river indigenous riparian woodlands have	This section of river provides stretches of almost pristine wilderness areas which

<p>impacts on “sense of space”</p>	<p>been replaced by alien <i>Prosopis</i> species, habitat diversity, the scenic landscape of this narrow river valley, remoteness and presently undeveloped status provide a wilderness area. This is particularly true for sections further upstream away from the existing weir and human influence at Violsdrif.</p>	<p>would be inundated and reduced to a homogenous water surface with no riparian vegetation. However, these wilderness areas are fragmented by large agricultural developments.</p>
<p>Other impacts</p>	<ul style="list-style-type: none"> ▪ possible inundation of cultivated areas near Goodhouse (South Africa) and on Farm Haakiesdorn (Namibia) 	<ul style="list-style-type: none"> ▪ a dam site at Komsberg would be in the Augrabies Falls National Park and would affect large sections of the Park’s riparian woodlands ▪ inundation of grape cultivations near Blouputs and Byna Bo (South Africa) and cultivated land on Stolzenfels (Namibia)

A dam site in the Violsdrif area would affect overall a less developed stretch of riparian landscapes and habitats but stretches of the river in this area are invaded by alien vegetation. A dam site in the Komsberg area would affect large stretches of relatively pristine riparian woodlands; yet these are interrupted by agricultural developments.

5. Overall assessment and recommendations

5.1 Balancing development options with negative environmental impacts

All proposed dam sites will affect remote, presently little developed, scenic stretches of the Lower Orange River which are wilderness areas and hence increasingly important assets for tourism, recreation and conservation. According to the information provided, approximately 50-70 km of river stretch, depending on dam position and final dam height, are to be inundated by a proposed dam at the Lower Orange River. Conversion of such a long stretch of diverse riparian habitats to a homogenous water surface with no riparian vegetation would have negative impacts on biota associated with these habitats, disrupt migration patterns of aquatic and riverine fauna and flora, effect the ecological functioning of the inundated area and would decrease the value of the affected landscapes as a wilderness area. The impacts on the reaches downstream of the proposed dam would largely depend on the finally adopted, regulated flow regime.

Further, in addition to construction impacts and the loss of habitat, secondary impacts associated with the proposed dam have to be envisaged. A dam and hence secured water supply will likely attract more people to presently undeveloped areas, and may result in unplanned settlements and likely larger-scale agricultural developments. All these will increase the pressure on natural resources in this area.

On the other hand, in the long-term undeveloped, remote wilderness areas will become increasingly more important as humans encroach more and more on remaining available space.

Hence overall, all proposed dam sites within the broader areas (Violsdrif and Komsberg) investigated would pose a negative environmental impact on the Lower Orange River.

The present ecological status of one the sections, Komsberg to Onseepans, of the Lower Orange River has been assessed as being in a D category (i.e. relatively poor) for most environmental aspects with a tendency for declining river health in future (Brown et al. 2003). Part of this poor status and projected decline in river health is attributed to a change in the natural flow regime due to dams upstream. The justification for the proposed new dam has been partially to regulate the flow and revert the flow regime back to more natural conditions. However, it needs to be noted that a large part of this poor status of river health is the effect of bad land management practices associated with farming, agricultural activities, urbanisation and natural resource use. Regulating the river flow will hence only be effective, if at the same time bad land management practices are changed for the better along the entire Orange River and adequate sections of riparian habitat remain free of human development.

Recommendation:

To counterbalance negative environmental impacts while not precluding development options, for any natural area lost along this stretch of river to a proposed dam site, an equivalent stretch of river and associated riparian habitats will need to be preserved in the form of a formal conservation area for future generations.

This recommendation is in line with guidelines provided by the World Commission on Dams and is the responsibility of the developers of the proposed dam and should be pursued in collaboration with relevant conservation authorities on both sides of the river.

5.2 Alien invasive vegetation

In terms of vegetation, while in the Komsberg area relatively pristine riparian woodlands would be inundated, a dam site in the Vioolsdrif area would affect indigenous riparian woodlands as well as vegetation where *Prosopis* species have encroached. Although the encroachment of *Prosopis* and other alien vegetation has partially been attributed to the altered flow regime of the Orange River, clearing of indigenous riparian vegetation is a major factor contributing to the spread of these alien species.

Again, inundating invaded areas and reverting the altered flow regime to more natural conditions would only partly address the problem with invasion of alien plants. Also the process of infestation is not entirely understood, nor has the effect of *Prosopis* infestations on the functioning of natural ecosystems been scientifically investigated.

Recommendation:

1. In order to address the *Prosopis* infestation problem along the Orange River, a scientifically backed case needs to be made for the eradication of the species (see “Working for Water”).
2. Should combating alien invasives become a management mandate along the Orange River, the process of infestation needs to be clearly understood and appropriate recommendations made for the eradication of the species (for example biological control agents are available to prevent further spread, but cutting and burning the trees without follow-up actions increases the problem).

This recommendation is not the responsibility of the dam project alone, but a broader issue which needs to be addressed in a concerted effort, if improving the ecological status of the Orange River is a major objective. This should include relevant authorities and institutions (forestry, agriculture) on both sides of the Lower Orange River.

5.3 Change in riparian habitats

The study on environmental flow conditions (Brown et al. 2003) makes reference to the increase in *Phragmites australis* reed beds and attributes this to the altered flow regime of the river. This has also been used as one criterium to determine the ecological status of the riparian vegetation. However, should this be used further as a major indicator, a thorough scientifically based investigation is warranted. *Phragmites australis* has always been part of the natural riparian vegetation, and whether or not an increase has occurred since the establishment of major dams and hence altered flow regimes, should be objectively established through a before-after comparison, for example using aerial photography.

Recommendation:

Should *Phragmites australis* be further used as an indicator of ecological status of the riparian vegetation, an objective assessment of its apparent increase should be undertaken.

6. Incomplete or unavailable information

- Technical information on potential dam sites, access routes and associated infrastructure at the time of the survey was of a preliminary nature and the study needs to be seen in this context.
- During the field survey incomplete information was provided by management staff at Augrabies National Park.

- Time constraints prevented a thorough literature review of aspects touched upon in this report.
- The field survey was undertaken in the dry season and short-lived components of the vegetation (herbs, grasses and geophytes) could thus not be identified. This is particularly true for the vegetation away from the river.

7. Further studies

1. Since the various dam options and the level of technical detail that had been provided for this study did not produce a clear answer with regard to the best and worst dam options from an environmental point, this will need to be investigated further. Once dam options have been narrowed down and dam height and subsequent inundation levels have been established more accurately, a comparison of loss of different habitat types should be undertaken using aerial surveys and remote sensing techniques. This would provide the necessary quantitative data to undertake an environmental assessment with regard to habitat loss.
2. In order to determine the environmental impacts associated with dam construction in adequate detail and to develop management guidelines, more detailed field investigations, particularly covering other components of the ecosystem (e.g. fish, invertebrates and birds) need to be undertaken.
3. The change in riparian habitats since the establishment of dams and increased land use pressure upstream needs to be scientifically backed by before-after comparative studies. Understanding these changes and their possible drivers is important to develop appropriate management guidelines to improve the ecological status of the Lower Orange River.
4. Similarly, *Prosopis* (and other alien plant) invasions need to be investigated in more detail to establish (a) whether or not the ecological functioning of the river has been affected and (b) to develop appropriate management guidelines.

8. References

Brown, C.A., Brenade, C., Brown, C., Boucher, C., Harding, W., Hattingh, J., Louw, D., Luger, M., Mare, M. Palmer, R. (2003). Lower Orange River Management Study – Task 8.3: Additional environmental flow tasks. Final draft report July 2003.

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9. Appendices

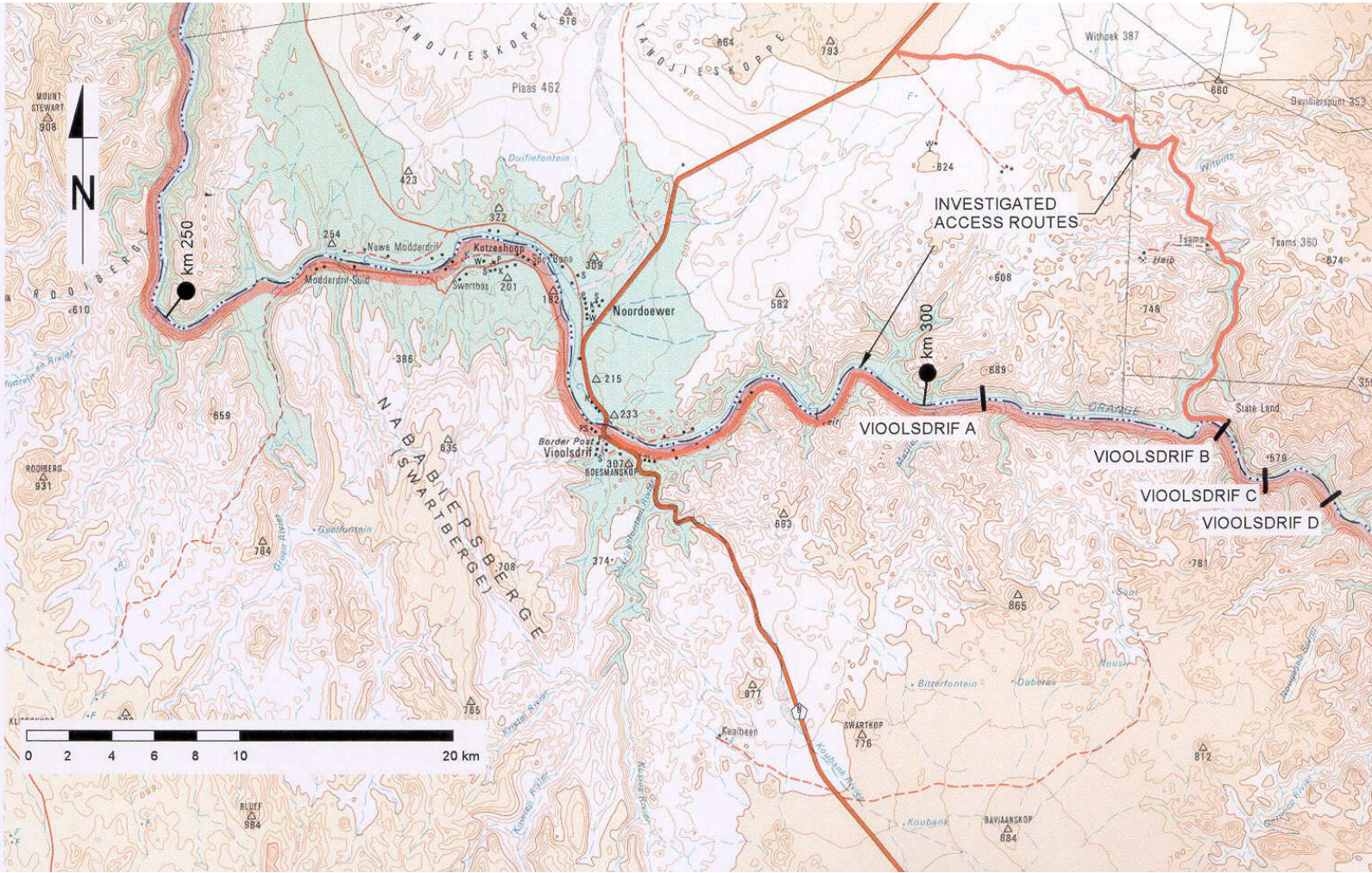


Figure 1: Potential dam sites and investigated access routes in Violsdrif area

Lower Orange River Management Study - Flora

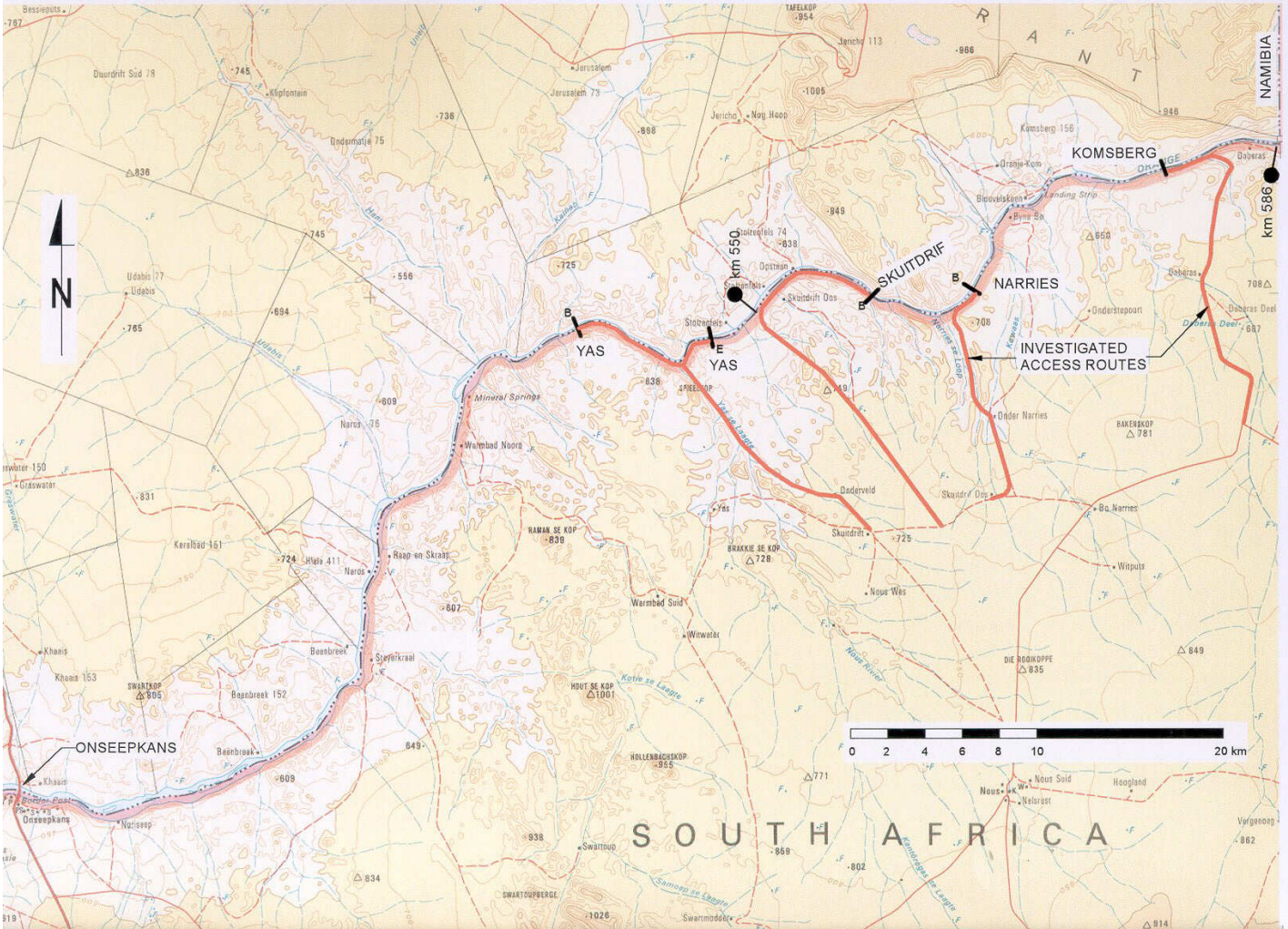


Figure 2: Potential dam sites and investigated access routes on Komsberg area.