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WOODFORD DALE RIVERBANK EROSION MANAGEMENT PLAN

Prepared by
Gary Blumberg and Associates Pty Ltd in association with
Jeffery & Katauskas Pty Ltd

for

Clarence Valley Council

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1 INTRODUCTION

1.1 CITATION

This plan shall be referred to as the Woodford Dale Riverbank Erosion Management Plan *(the Plan)*.

1.2 RESPONSIBILITY OF CLARENCE VALLEY COUNCIL

The control and management of landuse and development along the riverbank at Woodford Dale is the responsibility of Clarence Valley Council *(CVC)*. The ownership, preparation and implementation of the Woodford Dale Riverbank Erosion Management Plan is the joint responsibility of CVC, service authorities and landowners. Before the recent council merger, these responsibilities were divided between Clarence River County Council and Maclean Shire Council.

1.3 DISCLAIMER

It is not suggested that the Plan wholly addresses the problems that face owners or occupiers of affected riverbank land at Woodford Dale either now or in the future. It is recommended that all such owners and occupiers actively seek independent advice to assess the present level of risk and monitor that level of risk from time to time, and also take such steps as they are advised or think fit for the safety and protection of persons or property.

In particular, CVC does not accept or undertake any responsibility for any future injury or property damage that might occur if any part of the riverbank collapses.

1.4 BACKGROUND

Woodford Island is a large island located on the Lower Clarence River some 10 km upstream of Maclean in north-east NSW. The western shore of the island is threatened by bank instability in the vicinity of Woodford Dale.

Woodford Dale Road runs close to the crest of the threatened bank. The main water supply for the Lower Clarence Valley servicing approximately 15,000 people is located within the road reserve. Localised placements of rock have been made over the years by the former Maclean Shire Council to protect the road and water main. Following a major slip at Woodford Dale in 1989, a vehicle load-limit of 8 tonnes was imposed in the vicinity of the slip.

More recently, bank slips have occurred opposite and downstream of Munro Island, particularly following flooding in 2001 (**Photos 1** and **2**). Out of a concern that this activity may have placed the riverbank at further risk of failure, Clarence Valley Council *(CVC)* initiated a Riverbank Management Study in 2002, and the development of a Riverbank Management Plan.

Photo 1 **Slip at Houghs Lane opposite Munro Island, March 2001. Photo courtesy CVC.**

Photo 2 **Slip along Woodford Dale Road in vicinity of Munro Island, March 2001. Photo courtesy CVC.**

Gary Blumberg & Associates *(GBA)* Pty Ltd, Consulting Engineers, in association with Jeffery & Katauskas Pty Ltd *(J&K)*, Consulting Geotechnical Engineers, were retained by CVC to undertake the necessary investigations.

1.5 RIVERBANK MANAGEMENT AREA

The Riverbank Management Area *(RMA)* covered by the Riverbank Management Plan shall conform with the study area subject to the Investigation Report (GBA, 2003).

The RMA comprises a 4.5 km stretch of Woodford Dale Road running along the subject riverbank. Four precincts within the RMA are distinguished as summarised in **Table 1.1**.

TABLE 1.1 RIVERBANK INSTABILITY PRECINCTS IN RIVERBANK MANAGEMENT AREA

Riverbank Instability Precinct	Bank Length	Approximate Chainage (km) (1)		Typical Bank Crest Level (m AHD)
		Start	End	
Upstream				
2 Opposite Heilaman Island	1,500 m	Ch 0	Ch 1.5	5.0
3 Woodford Dale	1,500 m	Ch 1.6	Ch 3.1	4.5
4 Opposite Munro Island	1,200 m	Ch 4.7	Ch 5.9	4.0
5 Downstream Munro Island	300 m	Ch 6.3	Ch 6.6	3.0
Downstream				

Notes (1) Refer **Section 1.4** for definition

(2) Precinct definitions are retained from MSC (1993). Note that Precinct 1-Brushgrove is not currently a concern to CVC. However, the Investigation Report recommended that its precinct status be retained as acknowledgement of its previous identification as a potential problem area, and also to distinguish it from the other higher priority precincts at Woodford Island.

An overview of the RMA is shown in **Figure 1.** A more detailed site layout showing the western portion of Woodford Island and the adjoining Main Arm of the Clarence River between Brushgrove in the south, and Bluff Point Ferry in the north, is presented in **Figures 2A** through **2J**.

Although the RMA is generally referred to as Woodford Dale, this can be confusing since Woodford Dale is a place name falling within the RMA (**Figure 1**). Also Woodford Dale Road extends through the full RMA, passing upstream and downstream of Woodford Dale. Reference to Woodford Dale in the Riverbank Management Plan is not necessarily be confined to the place, but may encompass the full RMA.

1.6 SCOPE OF RIVERBANK EROSION MANAGEMENT STUDY

Gary Blumberg & Associates (GBA) and Jeffery & Katauskas *(J&K)* developed a Scope of Work to meet the requirements of the Study Brief.

The Scope of Work was broken down as follows:

- site inspections
- asset appraisal
- assessment of bank geometry and long-term movement
- assessment of bank slip behaviour
- management options
- Riverbank Management Plan
- meetings

The deliverables for the project were separated into an Investigation Report, followed by a Riverbank Management Plan. This document presents the Riverbank Management Plan. Copies of the Investigation Report *(GBA, 2003)* are retained by CVC.

It was not the intention of the consultancy to dwell on the causative processes of bank erosion at Woodford Dale. This had been considered in some detail in MSC (1993). Rather, the Study Brief sought to review and reiterate the existing process understanding, while focus study resources to developing the most appropriate management strategy.

1.7 RIVERBANK CHAINAGE AND LEVEL DATUM

The Investigation Report and Management Plan adopts a convention for riverbank chainage starting at Ch 0.00 km at the upstream confluence of Woodford Dale Road and the riverbank in the vicinity of Towell's property, and terminating at Ch 6.74 km at Bluff Point Ferry. Riverbank chainages are shown in **Figure 2**.

Also, all reference to Relative Level *(RL)* in the report is given in metres above Australian Height Datum *(AHD)*. Based on information set out in PWD (1988), AHD is 0.91 m above Iluka Port Datum.

1.8 ACKNOWLEDGEMENTS

GBA acknowledges the assistance provided by Mr Ian Dinham in steering the project on behalf of CVC. We also wish to thank particularly for their respective inputs Mr Peter Wright and Mr Paul Roberts of J&K, and Mr Greg Mashiah of CVC.

GBA would also like to record the assistance provided by the following persons:

- Mr Phil Sneesby — Country Energy
- Mr Terry Commerford — CVC
- Mr Bob Clout — DPWS Aerial Photogrammetry
- Mr Bill Heath — DLWC Property and Land Information
- Mr Alan Gordon — DPWS Survey
- Mr Bruce Walker — Jeffery & Katauskas
- Ms Edith Dobbin — Maclean Historical Society
- Mr Gary McCudden — CVC
- Mr Phil Dawson — CVC
- Mr Jim Spencer — CVC
- Mr Dave Morrison — CVC
- Mr Neil Heinz — North Coast Water
- Mr Jeff Craigie — North Coast Water

2 GLOSSARY

acceptable risk	A risk for which, for the purposes of life or work, we are prepared to accept as it is with no regard to its management. Society does not generally consider expenditure in further reducing such risks as justifiable.
alluvium	Sediment deposited by the action of a river.
bank *(of river)*	Lateral boundary of a river or stream taken to extend from beyond the crest of the bank at natural ground level down to the toe at the base of the bank which is usually underwater.
bank slip	A loss of soil at or near the crest of a bank attributed to activating forces exceeding stabilising forces. Activating forces include the weight of soil and pore water, and surcharge loads. Stabilising forces comprise friction along the failure plane, contributed to by the strength of the soil.
bankfull flow	Flood flow which results in the water level rising to the top of the bank.
crest *(of riverbank)*	Top of bank.
erosion	Physical removal of sediment by flowing water.
factor of safety (FOS)	The capacity for a bank slip measured as the ratio of the stabilising forces divided by the activating forces. If FOS is greater than 1, then the stabilising forces exceed the activating forces and theoretically the bank should be stable. Minimum acceptable FOS values against bank slips are typically 1.5 for everyday environmental conditions *(usually dry weather)*, and 1.25 for unusual environmental conditions *(typically wet or post-flood drawdown conditions)*.
flood drawdown	Refers to elevated water table conditions in the bank that may prevail for a short period after the flood peak. An elevated water table would contribute to the forces acting to destabilise the bank.
geotechnical	Pertaining to the mechanics of soil and rock.
hazard *(bank)*	Risk associated with bank erosion and/or failure.
meander	A sinuous channel planform characteristic of alluvial floodplains.
reach	Defined length of river channel.
recession	Long-term retreat of the riverbank attributed to the combination of erosion and mass failure.

risk	A measure of the probability and severity of an adverse effect to health, property or the environment. Risk is often estimated by the product of probability x consequences.
scarp *(bank)*	Top of a steepened face on a bank attributed to a previous failure. The scarp typically coincides with the crest of a receding riverbank.
scour	See erosion.
slip *(bank)*	Relatively small bank failure.
slump *(bank)*	Relatively large bank failure.
thalweg	A notional line joining points of maximum depth along a river channel.
toe *(of bank)*	Base of the bank where the general slope of the bank intersects the general surface of the bed of the channel. The toe of a bank is usually underwater.
tolerable risk	A risk that society is willing to live with so as to secure certain net benefits in the confidence that it is being properly controlled, kept under review and further reduced as and when possible. In some situations risk may be tolerated because the individuals at risk cannot afford to reduce risk even though they recognise it is not properly controlled.

3 SUMMARY OF INVESTIGATION REPORT

This section sets out a brief summary of the findings of the Investigation Report for the Woodford Dale Riverbank Erosion Management Study. A copy of the Table of Contents from the Investigation Report is attached in **Appendix A**. Full copies of the Investigation Report are retained by CVC.

3.1 HISTORY OF RIVERBANK FAILURE AND PROTECTION

Limited information is available on riverbank failure and protection at Woodford Island. The sources of information are local authorities, newspapers and community anecdote. A history of bank erosion and protection has been developed from these sources. The newspaper articles demonstrate that riverbank erosion problems attributed to bank slips have afflicted the Woodford Dale area for at least 50 years. During this period the water main has either been threatened or damaged on at least two occasions. To mitigate the effects of the erosion, it is estimated that the former Maclean Shire Council placed some 15,000 tonnes of rock along the bank adjacent to Woodford Dale Road over the last 30 years.

3.2 APPRAISAL OF RIVERBANK ASSETS

Public and private assets located along the subject riverbank have been identified and valued. The estimated value of the public assets total approximately $ 5.1 million, some 95 % of these located either within the road reserve *(land, road pavement, water main, telephone and power)* or on the riverbank itself *(rock protection)*. Private assets adjacent to the road reserve, including dwellings and sheds but excluding private land, amount to a further $ 5.3 million. Most public and some private assets are potentially threatened by bank instability.

3.3 BANK FAILURE PROCESS

Recession on the outside of the bend in the study area is due to two distinct processes:

(i) intermittent localised slipping of the bank extending above the waterline; and
(ii) progressive erosion of slipped material below the waterline.

The first process is readily observed, but the second is hidden. The first process serves to relocate material from the upper portion of the bank to the lower portion of the bank, while the second process erodes and transports away the slipped material.

The two processes "feed" one another. That is, slipping occurs when the riverbank is steepened after sediment on the lower bank has been eroded away by river flows. After a slip occurs, the slipped material protrudes into the river, out from the general line of the bank. This protrusion attracts a concentrated proportion of current shear and hence experiences increased erosion. Once an area of bank has slipped, the accumulated material on the lower bank serves to stabilise the upper bank against further slips until such time as that accumulated material is removed by erosion, and the cycle starts again.

Wind and boat waves contribute to bank recession, although in this area of the river their influence is likely to be secondary to the primary mechanisms of slumping and erosion. Waves will undercut the bank immediately above the waterline. This contributes to steepening and subsequent slipping.

Bank slips at Woodford Island range in size and recurrence. Minor, moderate and major slips can be distinguished. Whereas minor slips occurring approximately every 2 to 4 years on average may typically affect a 2 to 3 m length of crest, major slips once every 30 to 50 years may consume 40 m or more and result in the loss of many hundreds of tonnes of soil. It would appear that prolonged rainfall or drawdown conditions following floods are required to trigger moderate to major slips, and the majority of minor slips. The slip that occurred at Woodford Dale in 1989 would be regarded as a major slip.

3.4 GEOTECHNICAL ASSESSMENT

J&K have carried out a separate geotechnical assessment, attached in full at **Appendix D**. Six boreholes were drilled to depths between 10 and 20 m to gauge subsurface conditions. Soil samples were retrieved for laboratory testing. Four riverbank models were developed for slope stability analyses, and minimum Factors of Safety *(FOS)* established for varying distances back from the crest of the bank.

3.5 PREDICTIONS FOR RIVERBANK INSTABILITY AND RECESSION

Of the total 6.7 km of riverbank in the study area, 4.5 km or almost 70 % is assessed to be threatened by instability.

The investigation has found unacceptably low FOS affecting a large proportion of Woodford Dale Road and the water main, particularly opposite Heilaman Island *(Precinct 4)*. The road opposite Munro Island is also relatively exposed. Because the riverbank is receding throughout the study area at between 0.1 and 0.2 m/yr, the bank threat in all areas will increase into the future.

The slope stability modelling established that generally the rock armour as placed at Woodford Island provides only a small benefit, mostly exhibited in the 'After Flood' analyses. The main exceptions were at SSS 2 *(Richardson property)* where the rock placement is much more substantial, and at SSS 3 *(opposite Munro Is)* where smaller upper bank slips are reduced. Rock also mitigated the impact of flood scour on bank stability.

The slope stability analyses have demonstrated that loading due to vehicles on Woodford Dale Road has a negligible influence on FOS, irrespective of whether the bank is in a dry-weather or post-flood situation. Furthermore, conservative modelling had showed that the degree of bank stability under loading from an 8 tonne truck *(the current load-limit at Woodford Dale)* is effectively the same as under loading from a 20 tonne truck.

The influence of trees on bank stability was also considered using the model. It was determined that typical mature trees growing along the crest of the bank had little influence on FOS, although the analysis took no account of the stabilising effect of tree roots.

It has been established that no dwellings in the study area are currently threatened, however this is expected to change in the next 20 to 50 years opposite Heilaman Island, and at Woodford Dale.

3.6 APPRAISAL OF COSTS AND RISKS

To assist gauge the cost-benefit associated with managing the riverbank instability problem, an estimate was made of the total cost associated with riverbank instability in the study area (**Table 3.1**). Direct and indirect costs were considered.

TABLE 3.1 PROVISIONAL ESTIMATE OF TOTAL COST ASSOCIATED WITH RIVERBANK INSTABILITY IN THE STUDY AREA

Cost Type	TIMEFRAME	
	Immediate	**50 years**
Direct		
Public Assets	$ 2.92 m	$ 3.57 m
Private Assets	$ 0.10 m	$ 0.66 m
Indirect		
Social hardship associated with temporary loss of infrastructure and services, indirect financial cost, public health impacts, impacts to the environment and litigation	$ 0.90 m (1)	$ 2.42m
TOTAL	**$ 3.92 m**	**$ 6.65 m**

Notes (1) Nominal *(realistic)* estimate based on 2 x the cost of loss of production to the sugar and fishing industries associated with a 2.5 working day cut in potable water supply

Direct costs pertain to the potential loss of threatened riverside assets and the need for these to be replaced in the event of a failure, and also any costs associated with temporary repairs to riverbank infrastructure and services. Indirect costs may be attributed to social hardship associated with the temporary loss of services, the indirect financial cost associated with the services interruption, the cost of any public health impacts, and impacts to the environment.

To further consider the poor slope stability predictions and to better understand its implication, a brief appraisal has also been made of the risks associated with the bank instability. Using a recent methodology developed by the Geomechanics Society of the Institution of Engineers Australia, this approach was found to reinforce the FOS findings and underscore the need for remediation.

3.7 RIVERBANK MANAGEMENT OPTIONS

The Investigation Report concludes with an assessment of the available riverbank management strategies, leading to the identification of three preferred long-term management options. The available structural strategies are rock protection, relocation of assets, and diversion of river flows by dredging. Planning and development controls, management of mature trees, monitoring and management of the load-limit along Woodford Dale Road are also canvassed as non-structural strategies. The non-structural strategies have an important application in mitigating the hazard, but they will not remove it altogether.

The three preferred long-term management options are listed below in **Table 3.2**.

TABLE 3.2 PREFERRED LONG-TERM RIVERBANK MANAGEMENT OPTIONS

Option		Preliminary Cost Estimates
1	Full Rock Protection	$ 9.2 million
2	Relocation of Threatened Public Assets	
	2A – Relocation to landward side of dwellings	$ 4.6 million
	2B – Relocation to allotment boundaries	$ 6.5 million
3	Combination of Asset Relocation (Pr 2 and 3) and Rock Protection (Pr 4 and 5)	$ 4.3 million

In August 2003, during the preparation of the draft Investigation Report, a meeting was called by CVC to discuss issues arising from GBA's three preferred long-term options for providers of infrastructure services. At this discussion, which involved CVC, North Coast Water, Country Energy and Telstra, it was generally agreed that a sharing of responsibility to safeguard services was worth pursuing. The costs associated with GBA's preferred long-term options were unlikely to be affordable, and some interim measure was needed.

To this end, a Services Contingency Option was canvassed between the service providers that essentially involved selection of an agreed route for eventual relocation of all services in the event that bank failures continue to occur which threaten those services, acquisition of a Service Easement and relocation of services into the new corridor on a needs basis, ie when a slippage occurs and services are cut, or when service authorities are undertaking service relocation or augmentation. CVC requested that the Services Contingency Option be included as a fourth preferred option in the draft Investigation Report.

The Services Contingency Option, **Option 2-SC**, essentially forms a part-implementation of GBA **Option 2**. The Services Contingency Option allows for services planning, while still provides for emergency access in the event of a bank failure affecting Woodford Dale Road.

The initial cost of implementing **Option 2-SC** is limited to the acquisition of the route, and the provision of an unsealed trafficable roadway. Legal costs would be involved, and depending on the balance of costs and benefits to landowners, some compensation may be required. Preliminary cost estimates to implement **Option 2-SC** range between $410,000 and $530,000. It should be noted that this only includes the provision of the contingency corridor. It makes no allowance for relocation of services, or indeed the continuation of CVC's existing rock placement strategy.

The implementation of **Option 2-SC** would be carried out over a period of say 2 to 3 years, controlled mainly by resumption planning and negotiation, and availability of funding. It could be expected that the Services Contingency route would provide a basis for permanent vehicle access to riverside dwellings in the long-term, protected from riverbank hazard, in accordance with **Option 2A** or **2B**.

The three core options will address the riverbank stability problem at Woodford Island, and each will ensure that public and private assets are protected over a reasonable planning period, in excess of 50 years. Although the management solutions are expensive, the estimated benefits are of the same order as the value of threatened assets, particularly for **Options 2A** and **3**. For these two options, immediate benefit-cost ratios are estimated at 0.8 and 0.9 respectively, increasing to 1.5 and 1.6 in 50 years time. The assessment of benefits makes a reasonable allowance for both direct and indirect benefits, including the financial implications of a temporary loss of potable water supply to the lower Clarence Valley.

Option 2-SC does not lend itself to a benefit-cost measure. The implementation of the easement route on its own will benefit property owners in that it provides for an alternative emergency access in the event that a bank slip cuts Woodford Dale Road. There is also a potential benefit in respect of alternative access for cane haulage. No benefit accrues to the other threatened services until such time as those services are relocated or augmented along the contingency route.

3.8 FUNDING ARRANGEMENTS

Grant funding opportunities available to local government bodies for managing riverbank hazard in NSW are extremely limited. In this instance, funding the bank management scheme is likely to be shared between CVC and the service providers who stand to benefit, particularly North Coast Water *(NCW)*. It would seem appropriate that the degree of apportionment in any cost-sharing should have regard to the relative direct and indirect benefits attached to individual threatened assets.

4 RIVERBANK MANAGEMENT PLAN

4.1 INTRODUCTION

The Investigation Report found that key public assets exist today at Woodford Island that are subjected to unacceptable risks of being involved in a riverbank failure. A range of available strategies for addressing the bank problem were considered. These comprised:

- Do Nothing
- Existing Remedial Actions *(Status Quo)*
- Structural Management Strategies
- Non-Structural Management Strategies

Doing nothing amounts to doing less than the authorities do at the present time. There would be no new placements of rock along the subject bank, nor would there be maintenance of existing rock protection works. As doing nothing does not attempt to manage the risk, it is not a responsible option and is discounted in the Investigation Report.

Furthermore, although CVC's existing remedial approach involving rock placement to shore up failed sections of bank is preferable to doing nothing, it is not sufficient to deliver sustained acceptable Factors of Safety against riverbank failures.

The proposed Riverbank Management Plan incorporates a mix of affordable structural and non-structural strategies, namely:

- Services Contingency Management Proposal
- Planning and Development Controls
- Management of Mature Trees
- Management of Woodford Dale Road
- Monitoring

This Plan has been developed by GBA in consultation with CVC. Community input was sought at the commencement of the Riverbank Management Study, and then through exhibitions of the draft Investigation Report *(GBA, 2003)* and Management Plan *(GBA, 2004)*. CVC has also written to affected residents to advise on the status of the investigation, and to seek followup input.

4.2 SERVICES CONTINGENCY MANAGEMENT PROPOSAL

In August 2003, during the preparation of the draft Investigation Report, a meeting was called by CVC to discuss with providers of infrastructure services, issues arising from GBA's three preferred long-term options (refer **Table 3.2**). At this discussion which involved CVC, North Coast Water, Country Energy and Telstra, there was broad agreement that, as the service providers, they shared the responsibility of safeguarding services. But, the costs associated with GBA's preferred long-term options were high and unlikely to be affordable. This was particularly the case since direct State or Federal funding was unlikely (**Section 3.8**).

A lower cost, interim measure was therefore needed.

The Services Contingency *(SC)* proposal was canvassed and developed in consultation with the service providers. The proposal essentially involves the following:

(i) Investigate and select an agreed route for eventual relocation of all services in the event that bank failures continue to occur which threaten those services.

(ii) The route, envisaged at between 15 and 20 m wide, would be expected to comprise a Right-of-Carriageway and Service Easement. The Service Easement would be acquired in favour of CVC. Although the route would not be a public road, CVC and nominated service providers would have access to the route at all times.

(CVC and the other service providers would acknowledge that where possible and practicable all or parts of the SC route could be located along existing roads on Woodford Island. There is no sense in acquiring and developing further accessways unless those that already exist are unsuitable. Ultimately the selected route would seek to balance desirable operational and funding aspects for the service providers, with landuse and amenity considerations of the land owners).

(iii) Relocation of services into the Service Easement, including vehicle access from Woodford Dale Road, would be on a needs basis, ie when a slippage occurs and services are cut, or when service authorities are undertaking service relocation or augmentation.

It is emphasised here that it remains the preference of CVC, North Coast Water, Country Energy and Telstra to repair and replace services along current access routes including Woodford Dale Road. Actual construction within the SC corridor would only be taken up as a last resort, in the event that a slippage is so severe as to render continued access no longer feasible.

(iv) CVC would continue to place "maintenance rock" along the subject riverbank. As described in the Investigation Report, this currently involves placements made once every 2 to 5 years on average.

It is noted that the scale of the placement depends on the size and extent of the slips. According to GBA (2003), whereas the placement at Woodford Dale following the 1989 slip involved in excess of some 2,500 tonnes of rock placed over a 50 to 75 m length of bank, placements opposite Munro Island and also further downstream towards the ferry within the last five years or so have used approximately 2,000 tonnes of rock spread over say 0.5 km. Minor placements *(typically less than 5 t/m)* are assessed to do little to mitigate the instability threat, particularly in areas upstream of Munro Island where toe depths mostly exceed say 5 m. The existing rock placements opposite Munro Island do improve bank stability locally, but the benefit is quickly lost away from the bank crest.

CVC currently spends between $40,000 and $45,000 per year on rock armouring in the study area *(as noted at Floodplain Management Committee meeting 8/8/02)*. This translates to a typical average placement of approximately 800 to 900 t/yr which is consistent with the above observations.

Unless the nature of the maintenance placement warrants otherwise as determined by Council's Engineer, it is a requirement of the SC Proposal that rock protection on the riverbank be placed using an excavator or dragline, rather than tipped from a truck which can result in the loss of rock out beyond the toe.

Notwithstanding the requirement to select an agreed route, the SC Proposal could feasibly comprise a part-implementation of **Option 2** developed in GBA (2003). In this case, two options are potentially available depending on the selection of the services route; Option A with the route located on the landward side of the dwellings, and Option B with the route at the common alignment of allotment boundaries. The SC Proposal facilitates long-term services planning, while still provides for emergency access in the event of a bank failure affecting Woodford Dale Road. A Services Contingency proposal based on **Option 2** is depicted in **Figure 3**.

The initial cost of implementing the SC Proposal is limited to any acquisition of the route, and the provision of an unsealed trafficable roadway if required. There would be legal costs associated with acquisition of a Right-of Carriageway and Service Easement. Depending on the existing zoning and use of the land comprising the route, and the level of benefit that may flow to the individual landowners in respect of the provision and maintenance of the Right-of-Carriageway *(eg alternative cane haulage route in the event that Woodford Dale Road is breached in a slip)*, some compensation to the landowner may be required. CVC does not envisage the need to fence the Services Contingency route.

The initial cost of implementing the SC Proposal will depend on the number of private properties that are affected through route acquisition. For an SC Proposal based on **Option 2**, an approximate property count based is summarised below in **Table 4.1**.

TABLE 4.1 APPROXIMATE NUMBER OF PRIVATE PROPERTIES AFFECTED BY A SERVICES CONTINGENCY PROPOSAL BASED ON OPTION 2

Option	Description	Approximate Number of Private Landowners	Approximate Number of Separate Private Allotments
2A – SC	Route on landward side of dwellings	15	22
2B - SC	Route at common alignment of allotment boundaries	17	22
Source	Investigation Report *(GBA, 2003)*		

The Investigation Report estimated that survey, legal and registration costs for creation of an easement would be approximately $10,000 per property. The cost to provide a basic, unsealed trafficable roadway including clearing where required *(over the full width of the easement)*, and nominal grading, rolling, compaction and some placement of crushed rock *(say average 50 mm thick),* over say a 4 m wide trafficable surface, is approximately $30/m. This does not include an allowance for filling to address any issues of flood frequency and drainage, placement of culverts, provision of driveway connections to homesteads, or any upgrading of existing roads *(GBA, 2003)*.

Assuming that separate allotments constitute a property for purpose of generating a cost estimate (**Table 4.1**), and allowing a contingency of 30 % to account for unforeseen items, environmental assessment, approvals, design development, tendering and supervision *(if required)*, and possible compensation to property owners, preliminary cost estimates to implement an SC Proposal based on **Option 2** are shown in **Table 4.2**.

Note that the these costings exclude CVC's current average expenditure on rock protection in the Riverbank Management Area *(RMA)*, estimated at between $40,000 and $45,000 per year.

The SC Proposal recognises that the water main constitutes a "very high risk" item *(GBA, 2003)*, but not so Woodford Dale Road. As such, the option must provide directly for the future relocation or augmentation of the water main, to be undertaken by North Coast Water. Note that the SC Proposal as described and costed above in line with **Option 2** does not include the road closures associated with the **Option 2**.

The SC Proposal does not lend itself to a benefit-cost measure. The implementation of the easement route on its own will benefit property owners in that it provides for an alternative emergency access in the event that a bank slip cuts Woodford Dale Road. There is also a potential benefit in respect of alternative access for cane haulage. No benefit accrues to the other threatened services until such time as those services are relocated or augmented along the contingency route.

TABLE 4.2 PRELIMINARY COST ESTIMATES TO IMPLEMENT SERVICES CONTINGENCY PROPOSALS BASED ON OPTION 2

Option	Description	Length of New Roadway along Route	Total Cost
2A – SC	Route on landward side of dwellings	3,200	$410,000
2B - SC	Route at common alignment of allotment boundaries	6,300	$530,000

Source Investigation Report *(GBA, 2003)*

It is envisaged that the implementation of the SC Proposal could be carried out over a period of say 3 to 4 years, controlled mainly by selection and agreement on a preferred SC route, resumption planning and negotiation, and availability of funding.

As noted above, there is no sense in acquiring and developing further accessways unless those that already exist are unsuitable. This would be established by CVC through a combination of consultation with the land owners, survey *(including a formal review by the service providers of the location of services as identified in* **Figure 2***)*, and engineer inspection. Also, GBA (2003) makes note of investigations undertaken in 1979 to widen Woodford Dale Road in Precinct 4 *(opposite Munro Island)*. GBA was unable to confirm the outcome of these investigations, although a larger setback to cane field boundaries was observed in this area. Any extension of the SC Proposal into Precicnt 4 along the lines **Option 2** would examine the relative cost-benefit associated with relocating Woodford Dale Road into any existing widened road reserve, versus the extension of Drews Lane. The selected route would seek to balance desirable operational and funding aspects for the service providers, with landuse and amenity considerations of the land owners.

It could be expected that the Services Contingency route would provide a basis for permanent vehicle access to riverside dwellings in the long-term, protected from riverbank hazard, such as in accordance with the other higher cost Options 2A or 2B (**Table 3.2**). The upgrade of the SC Proposal to a fully operational and long-term arrangement, free of riverbank hazard *(as per* **Option 2***)* would include as required the designated road closures, and construction of driveway offsets and private access roads. The approximate costs associated with upgrading the Services Contingency route to achieve a long-term solution is likley to be between $4 and $6 million *(using* **Option 2** *as an example, GBA 2003)*.

4.3 PLANNING AND DEVELOPMENT CONTROLS

The western margin of Woodford Island is not a prominent area in respect of strategic or long-term planning within Clarence Valley LGA. There are large property parcels which theoretically could be subdivided, however pressure for this type of development is not evident at this time *(Mr Dave Morrison, CVC 1/5/03 pers comm).*

As a response to the predicted future threat to private assets in the study area as described in the Investigation Report, it is proposed that CVC develop a measured set of building restrictions for the RMA. These would be expected to take a form similar to those developed for Precinct 2 at Palmers Island in which property was assessed to be not at immediate threat, but rather at threat in the longer-term.

It is proposed that the building restrictions in the RMA at Woodford Island include the following:

(i) a sunset clause whereby a Development Consent for a habitable building structure lapses when the crest of the riverbank comes within a certain minimum distance *(buffer)* of that structure. This buffer will ensure that the structure is not exposed to an unacceptable Factor of Safety under adverse bank stability conditions. Proposed buffer distances for individual precincts based on recommendations developed in GBA (2003) are given in **Table 4.3**;

(ii) to compliment (i), all new residential buildings and extensions to existing dwellings, potentially affected by riverbank threat in within 50 years, shall be relocatable and demountable respectively. Natural encroachment of the bank crest to within the buffer distances in **Table 4.3** are predicted to threaten buildings;

(An "extension" to an existing building shall refer to enlarging that building by more than 50% of the floor area that existed at the time of adoption of the Development Control Plan.)

(iii) in the event that a Development Consent lapses due to (i), the owner of the land would then be responsible for relocating the structure *(as far from the encroaching bank threat as practicable),* or full removal of the structure from the site. Prior to lodging a Development Application, the proponent will need to determine and confirm whether buildings are to be relocated or demolished in the event that the buffer is breached and the consent lapses;

(iv) the provision of servicing from the landward side of the development; and

(v) development controls should be further clarified in a Development Control Plan which will assist in advising future purchasers of consent requirements and restrictions on future development.

It is also recommended that potential residential subdivisions be restricted on private land which is either currently threatened, or predicted to become threatened, by riverbank instability. The planning timeframe for application of the building and subdivision restrictions is 50 and 100 years respectively, subject CVC's long-term planning objectives.

The anticipated cost associated with developing and implementing building and subdivision restrictions for the RMA, including a Development Control Plan, is approximately $10,000. No significant ongoing costs are foreseen.

TABLE 4.3 PROPOSED BUFFER DISTANCES TO TRIGGER LAPSE FOR DEVELOPMENT CONSENT OF HABITABLE BUILDINGS (1)

Riverbank Instability Precinct	Buffer Distance (m) (2)
Upstream	
2 Opposite Heilaman Island	17.0
3 Woodford Dale	10.0
4 Opposite Munro Island	14.0
5 Downstream Munro Island	10.0
Downstream	

Notes

(1) Definition of "habitable buildings" subject to advice by CVC.

(2) Measured as the shortest distance between the crest of the riverbank and part of the structure of the subject building, eg outer edge of building foundation

4.4 MANAGEMENT OF MATURE TREES

The Investigation Report examined a widely held view amongst residents at Woodford Island and CVC works personnel that large trees contribute to the bank stability problem. Fallen and leaning trees were observed by GBA during site inspections undertaken in late 2002. These appeared to be larger trees, and included both exotic and native species. Up to 10 problem trees were encountered along the riverbank in the RMA.

The Investigation Report established that there is a case for selective removal of problem trees along the subject riverbank. Accordingly, the RMP proposes that CVC give consideration to an interim set of measures, pending the preparation of a dedicated Riverbank Tree Management and Planting Strategy. This strategy should incorporate horticultural advice relevant to any biodiversity issues.

The interim proposal for management of mature trees along the subject riverbank is as follows:

(i) undertake lopping of problem trees located within the Riverbank Instability Precincts as defined in **Table 1.1**, where their trunks protrude from the ground on the riverside of the bank crest and where the following physical limits are exceeded:

  (a) for native trees - height > 15 m or trunk circumference > 1.3 m
  (b) for exotic trees - height > 20 m or trunk circumference > 2.0 m

(ii) cutting the tree trunks at ground level and leaving the root systems intact within the riverbank;

(iii) for each tree lopped, no less than two She Oak *(Casuarina)* saplings at least 1.5 m in height to be planted and securely staked, with the plantings made within 2 m of the trunk cut-off;

(iv) CVC to regularly inspect the saplings to ensure their survival and growth. If a replacement tree fails to achieve normal healthy growth, it should be replaced by CVC without unnecessary delay; and

(v) CVC to review the merits of these management measures every 5 years following adoption of the Plan. This review should include the physical limits for tree lopping, and the tree replanting strategy.

The cost of managing mature trees in the RMA as described above is estimated at $8,000 to attend to say 10 existing problem trees, followed by an average annual expenditure of approximately $5,000 *(GBA, 2003)*.

It is noted that Woodford Island is not included in the area covered by CVC's Tree Preservation Order.

4.5 MANAGEMENT OF WOODFORD DALE ROAD

4.5.1 Management of Road Load-Limit

It could be expected that CVC has a legal obligation to provide and maintain access to properties located along Woodford Dale Road. Although narrow in places yet used for cane transport, Woodford Dale Road is not on Council's list of priority roads for upgrading.

The existing 8 t road load-limit at Woodford Dale is an issue. It impacts on cane transport to and from Harwood Mill located further downriver. The imposition of the load-limit results in cane trucks needing divert to other more circuitous routes. The additional trucking is estimated to cost approximately $27,000 per annum.

The Investigation Report has found that the degree of bank stability under loading from an 8 tonne truck is effectively the same as under loading from a 20 tonne truck. Accordingly, it is proposed that the existing 8 tonne load limit be lifted to 20 tonnes.

Also, because of the threat of localised upper bank slipping, it is proposed that road signs be installed as required to prevent trucks parking on the river side of the road pavement. The fabrication and installation of appropriate signage is estimated to cost is the order of $300 per sign.

4.5.2 Night Time Warning to Motorists of Roadway Slip

Riverbank failure events have the potential to destabilise sections of Woodford Dale Road. If such a failure occurred at night, there would be no warning to motorists that may be traveling along the road. To reduce this potential hazard, it is proposed that a single line be marked along the riverside shoulder of Woodford Dale Road, where the road passes through the designated Riverbank Instability Precincts. The Investigation Report found that the full length of Woodford Dale Road within the designated precincts was at immediate threat of being involved in a slip, either during fairweather *(or low water table)* conditions, or after flood drawdown (GBA, 2003).

The estimated capital and average maintenance costs associated with marking a single line over the 4.5 km length of affected roadway (refer **Table 1.1** and **Figure 2**) is $12,000 and $2,400 per annum respectively.

4.6 MONITORING

It is usual for a riverbank to exhibit certain physical characteristics as a precursor to a slip event. These may not be evident to the casual observer, however if monitored specifically by trained personnel *(with appropriate equipment if required),* these signs should be identifiable, allowing emergency remedial measures to be taken to mitigate any impending hazard.

Monitoring may be used to identify the following physical characteristics:

- tension cracks and ground settlement;
- elevated groundwater table;
- bank scour; and
- bank steepening.

Given the circumstances at Woodford Island, it is recommended that CVC carry out bank inspections once a year from both land and water, and also after every bank-full flood event. A control bank survey similar to that undertaken by DPWS for the Investigation Report should be carried out once every 5 years.

The data gathered from these inspections and surveys should be reviewed by an experienced river engineer and an appraisal made as to whether the hazard may or may not have changed. The engineering report should then be tabled at the next meeting of the Maclean Floodplain Management Committee, with any followup actions determined by the Committee as required.

The estimated average cost to undertake the above monitoring program is $5,000 per annum, broken down in **Table 4.4**

TABLE 4.4 ESTIMATED MONITORING COSTS

Monitoring Element	Average Annual Cost
Annual bank inspections from land and water	$1,700
Additional inspections from land and water after bank-full flood	$500
Control bank survey *(every 5 yrs)*	$1,300
Survey review and hazard appraisal	$1,500
Total	**$5,000 pa**

4.7 EMERGENCIES

4.7.1 Responsibilities

It shall be the responsibility of the Local Emergency Management Committee *(LEMC)* comprising representatives of each of the emergency services organisations operating in the Maclean Local Government Area to prepare plans for the prevention of, preparation for, response to and recovery from any emergency arising in the event of a riverbank slip. Accordingly, it is recommended that this Riverbank Management Plan be referred to the LMEC for inclusion in the Local Emergency Management Plan *(LEMP)*.

CVC, North Coast Water, Telstra, and Country Energy will each be responsible for securing their own services.

4.7.2 Evacuation

The need for evacuation is not anticipated in the short-term, but will increase with time as the riverbank crest recedes at Woodford Dale.

Evacuation shall proceed at the direction of the Senior Police Officer stationed in the Maclean area. Any request for an evacuation shall be determined by the Local Emergency Management Committee. Results of all surveys and assessments relating to riverbank monitoring shall be made available to that Committee.

Should an evacuation occur, the police shall determine when residents may return to their dwellings. The Local Emergency Management Committee may request that any return be delayed until a survey has been undertaken to examine the effect of any scouring and/or bank steepening.

4.8 COMMUNITY EDUCATION

On-going community education should be undertaken on a regular basis, particularly following the results and reporting of monitoring and review activities. All affected residents shall be consulted by the Council prior to any changes to the Plan.

4.9 RIVERBANK MAINTENANCE

Pending the implementation of the Services Contingency Proposal (**Section 4.2**) which formalises the requirement for ongoing maintenance of the riverbank within the area covered by the RMA, CVC shall continue to place "maintenance rock" as per its current procedures.

A description of the likely timing and extent of such rock placements is given above in **Section 4.2**. As stated above, CVC currently spends between $40,000 and $45,000 per year on rock armouring in the RMA *(as noted at Floodplain Management Committee meeting 8/8/02)*. This translates to a typical average placement of approximately 800 to 900 t/yr.

Unless the nature of the maintenance placement warrants otherwise as determined by Council's Engineer, it is a requirement of the Plan that rock protection on the riverbank be placed using an excavator or dragline, rather than tipped from a truck which can result in the loss of rock out beyond the toe.

4.10 ADVICE ON SECTION 149 CERTIFICATES

Section 149(2) and 149(5) Certificates for all riverfront properties currently affected by the Plan or predicted to be affected by the Plan within a planning timeframe of 50 years shall disclose that the Plan restricts or potentially restricts the development of the land by reason of the likelihood of riverbank erosion and instability. The building restrictions shall be in accordance with the Planning and Development Controls described in **Section 4.3**.

5 REFERENCES

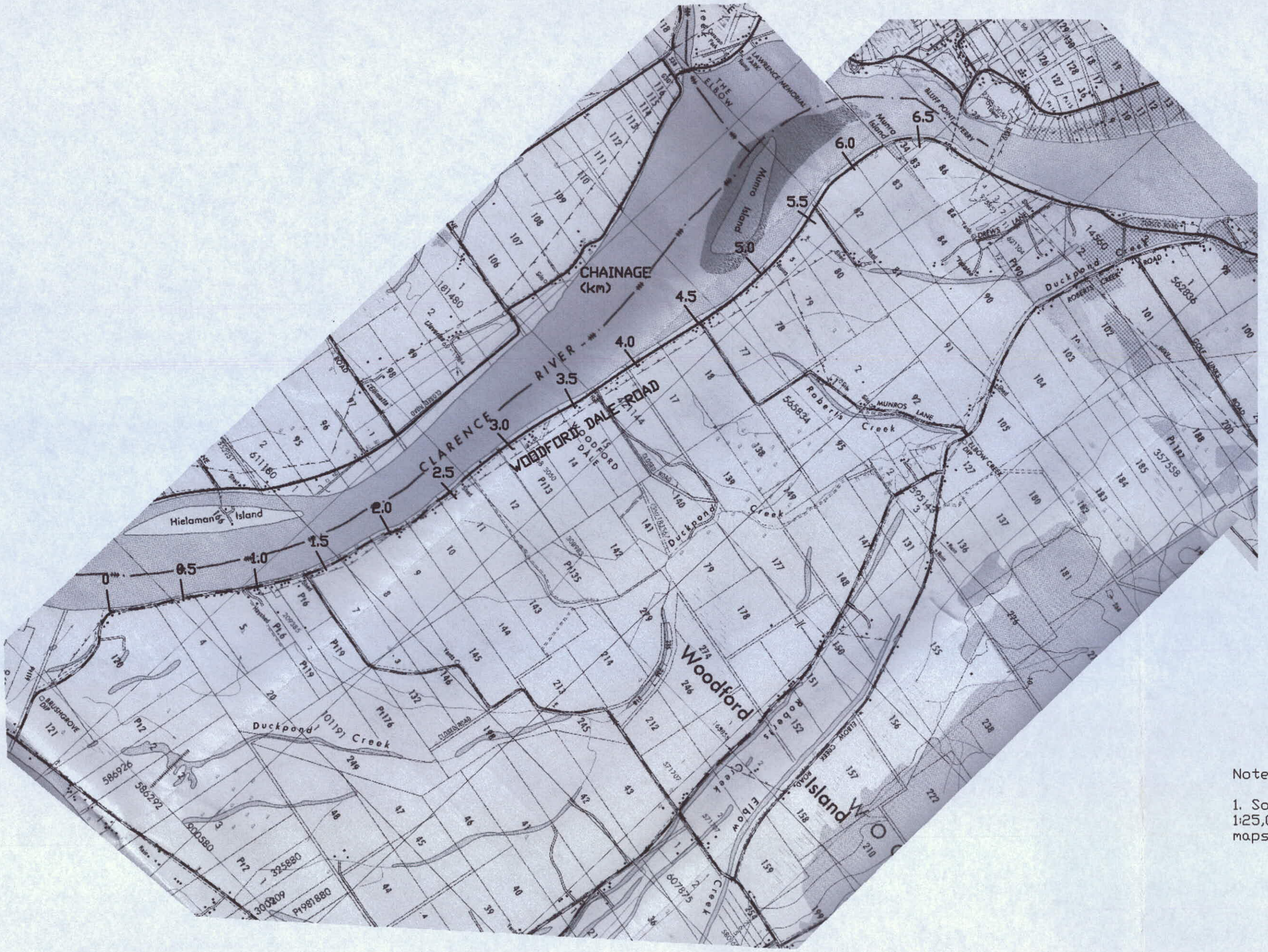
Gary Blumberg & Associates (2003)
Woodford Dale Riverbank Erosion management Study
Investigation Report
Prepared in association with Jeffery & Katauskas, Geotechnical Engineers, for CVC
August 2003

Maclean Shire Council (1993)
River Bank Erosion Study
Woodford Island, Clarence River
Prepared by Patterson Britton & Partners, August 1993

PWD (1988)
Lower Clarence River Flood Study
Report PWD 88066, ISBN 0730551342, December 1988

FIGURES

FIGURE 1



Notes

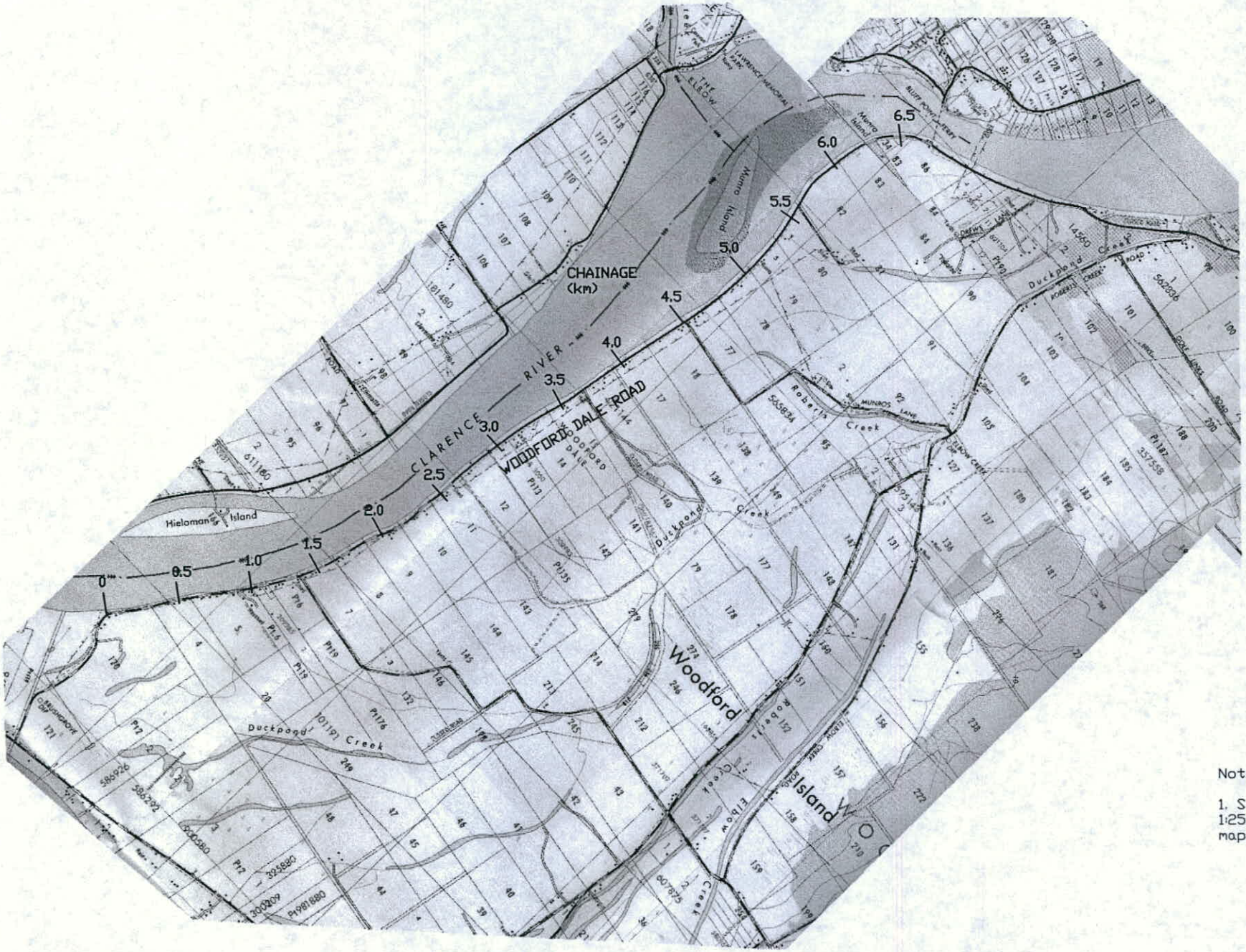
1. Source of base: CMA 1:25,000 topographic maps

0 500 m
SCALE

Gary Blumberg & Associates
J02-11/R51
Plot date: 31/5/04

STUDY AREA

FIGURE 1



Notes

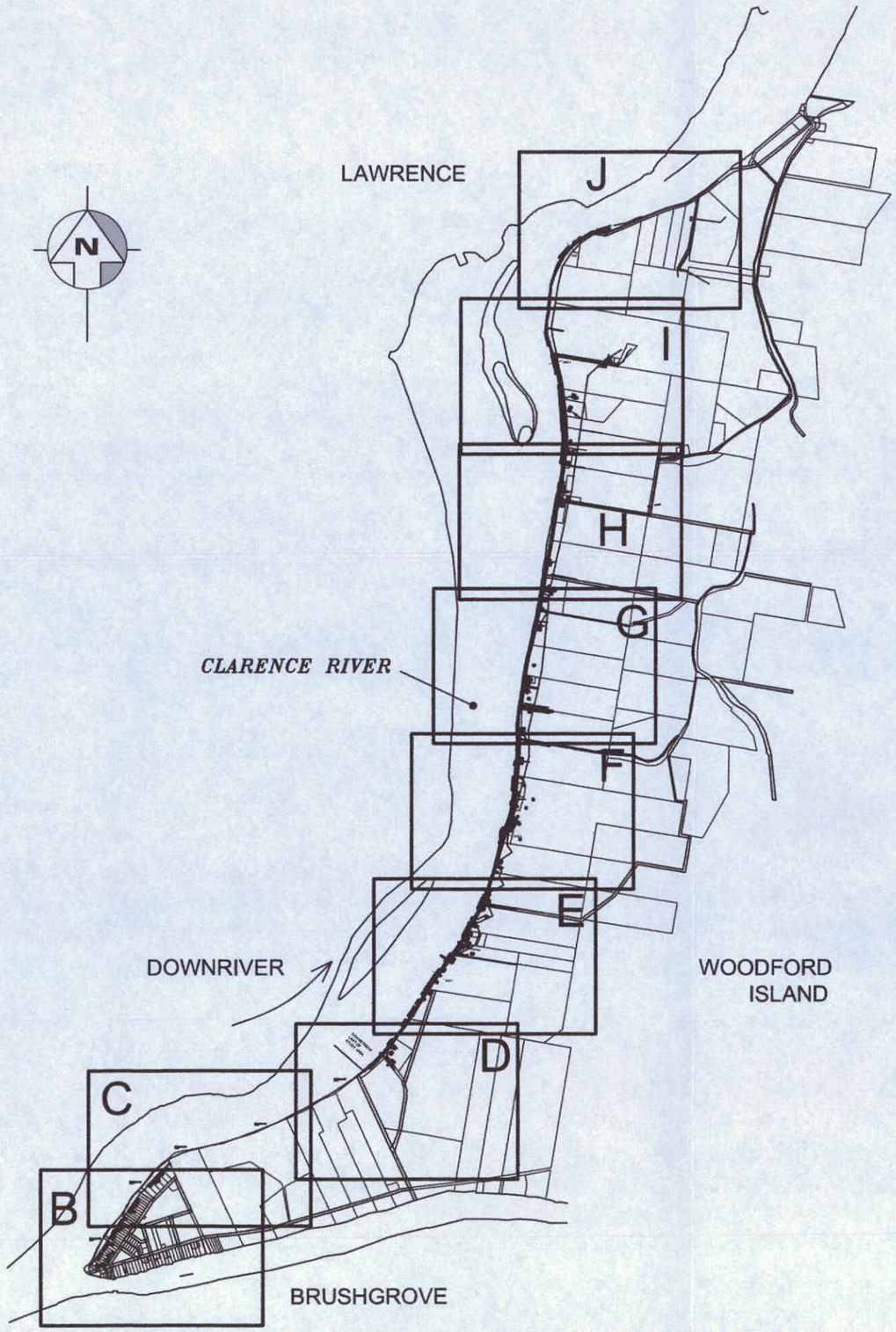
1. Source of base: CMA 1:25,000 topographic maps

0 500 m
SCALE

Gary Blumberg & Associates
J02-11/R51
Plot date: 31/5/04

STUDY AREA

FIGURE 2A



Notes

1. Source of base plan:
(a) MSC GIS for property and road reserve boundaries, and property owner and DP details
(b) 2001 airphoto for buolding structures and road pavement
(c) Telstra for trunk telephone services
(d) Country Energy for power services
(e) North Coast Water for water main
(f) DPWS Survey for location of river cross- sections
(f) GBA survey 8-9/8/02 to locate crest of bank and waterline and check location of riverbank assets

2. Location of all assets and features must be regarded as approximate, suitable for preparation of a Riverbank Management Plan. Estimated loctional accuracy +/- 5 metres.

0 800 1600 m
SCALE

SITE LAYOUT INDEX PLAN

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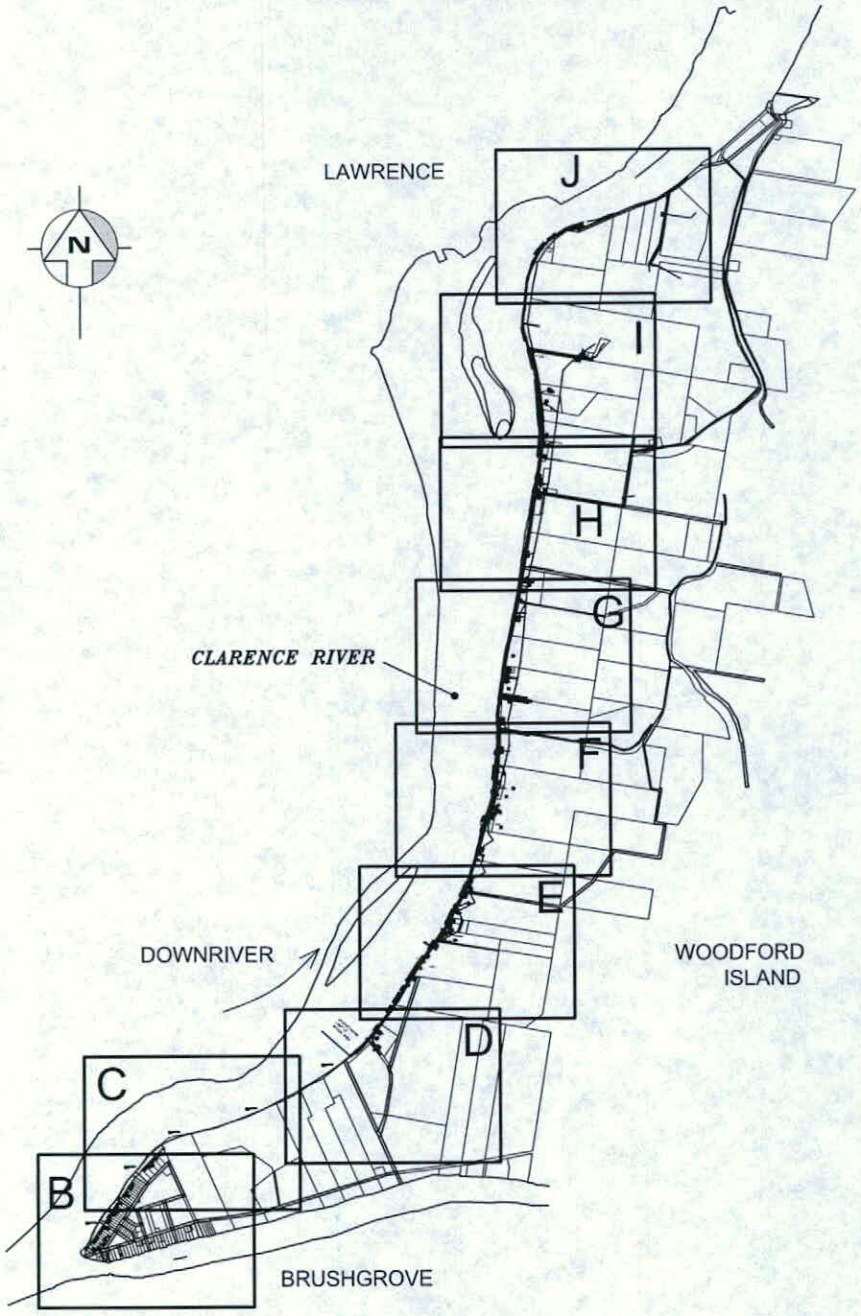
J02–11/R51
Plot date: 31/5/04

FIGURE 2A



Notes

1. Source of base plan:
(a) MSC GIS for property and road reserve boundaries, and property owner and DP details
(b) 2001 airphoto for buolding structures and road pavement
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(d) Country Energy for power services
(e) North Coast Water for water main
(f) DPWS Survey for location of river cross- sections
(f) GBA survey 8-9/8/02 to locate crest of bank and waterline and check location of riverbank assets

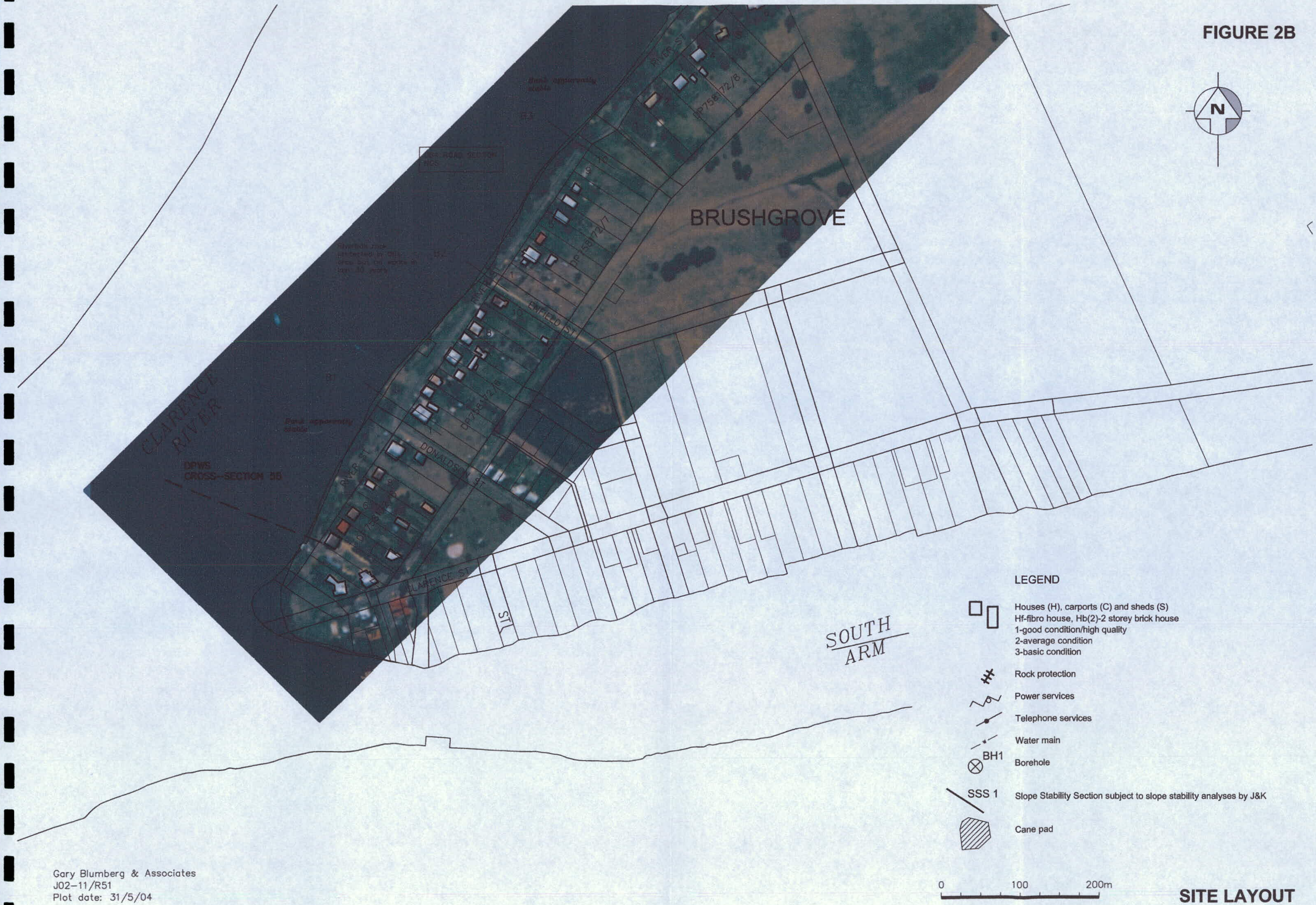
2. Location of all assets and features must be regarded as approximate, suitable for preparation of a Riverbank Management Plan. Estimated loctional accuracy +/- 5 metres.

0 800 1600 m
SCALE

SITE LAYOUT INDEX PLAN

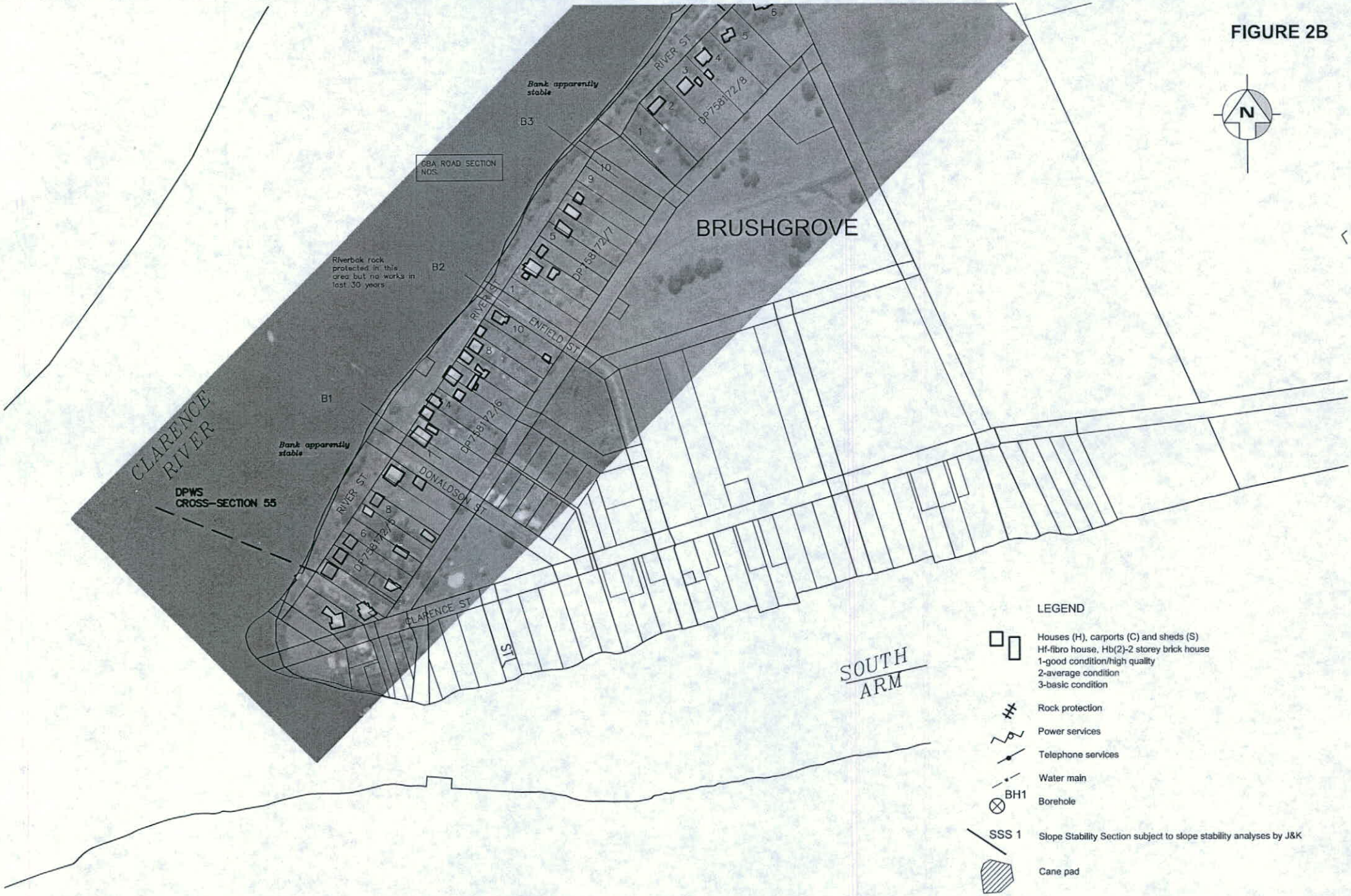
Gary Blumberg & Associates
J02-11/R51
Plot date: 31/5/04

FIGURE 2B



SITE LAYOUT

FIGURE 2B



SITE LAYOUT

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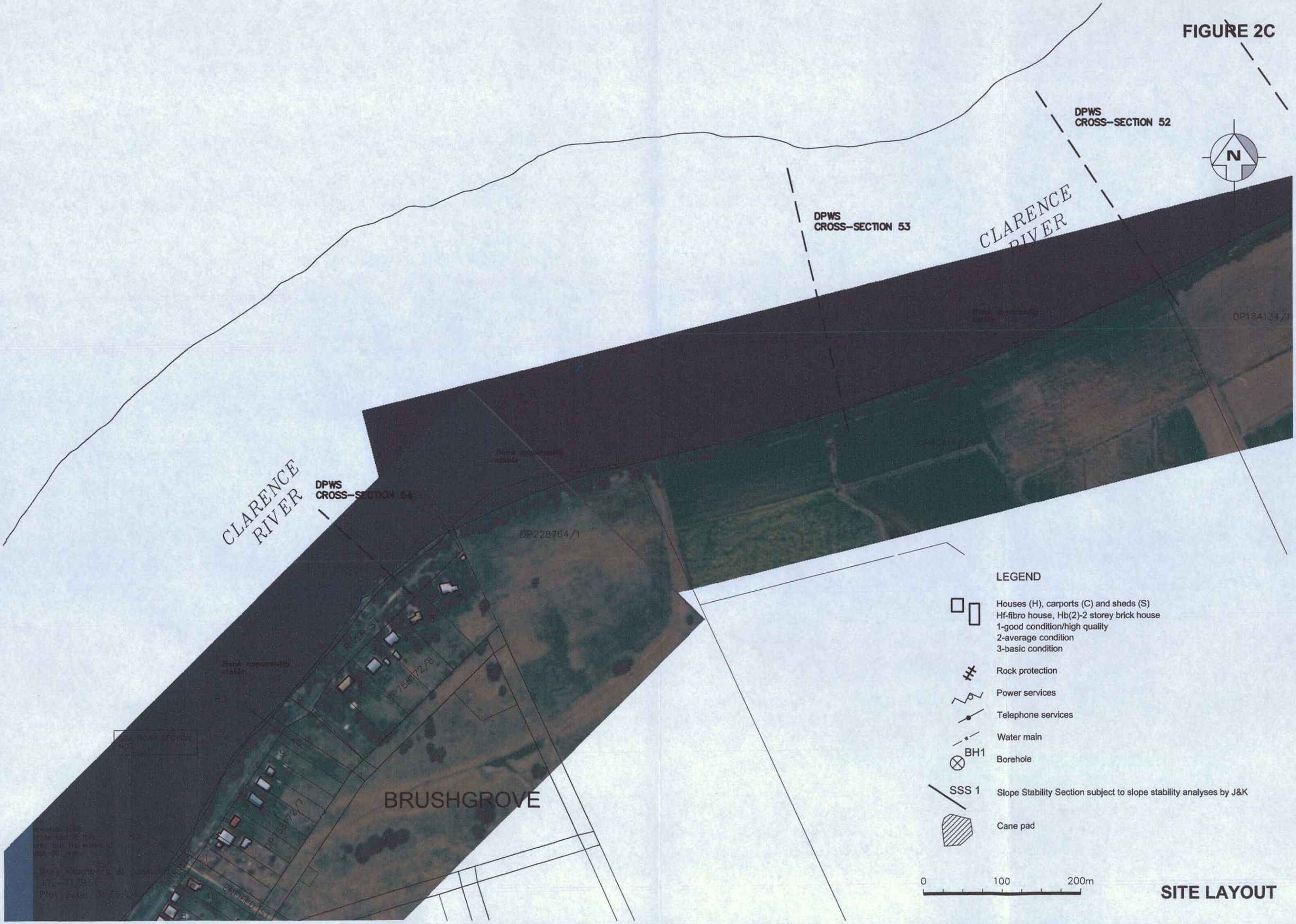
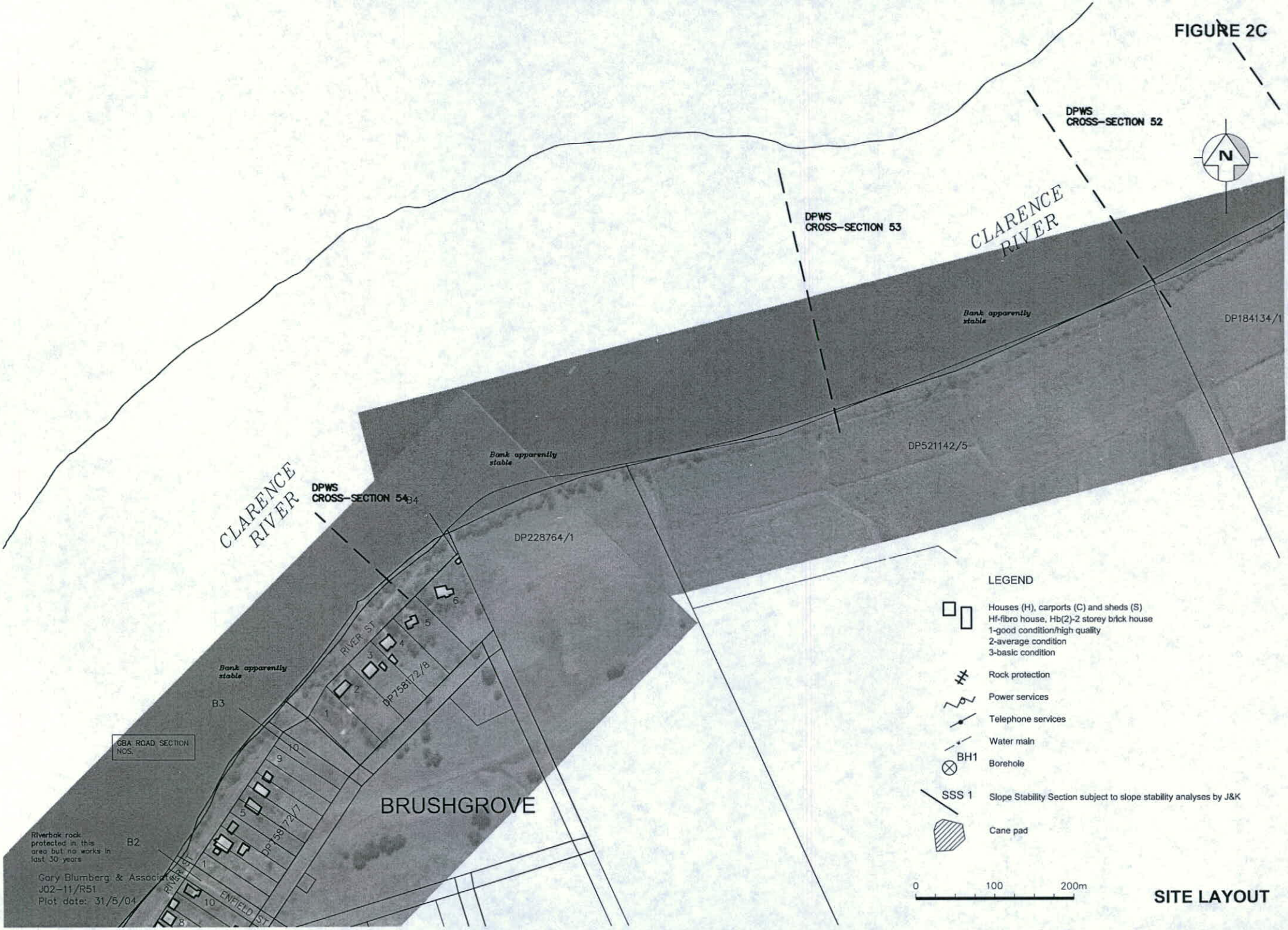
J02-11/R51
Plot date: 31/5/04

FIGURE 2C



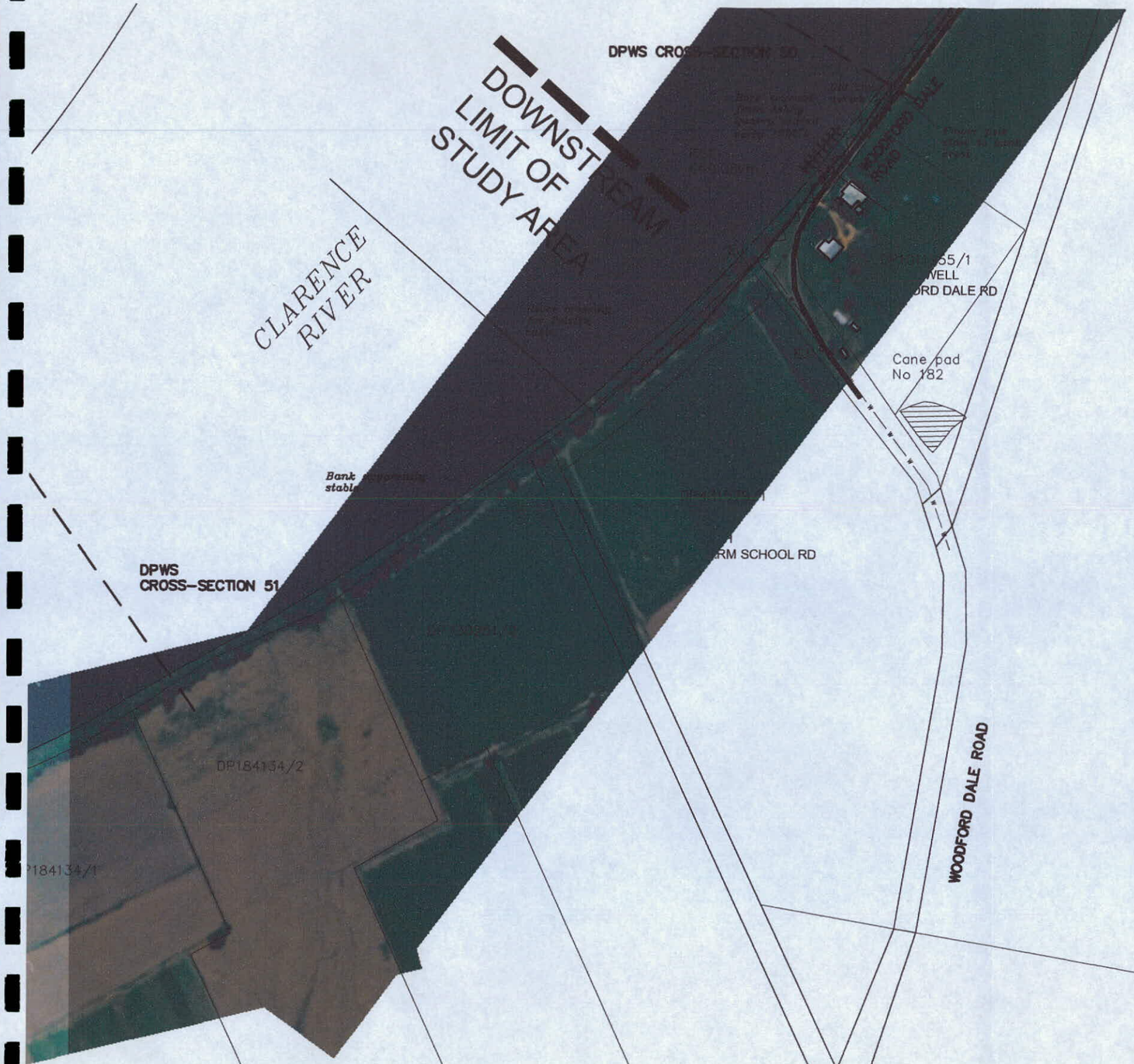
SITE LAYOUT

FIGURE 2C



SITE LAYOUT

FIGURE 2D



N

LEGEND

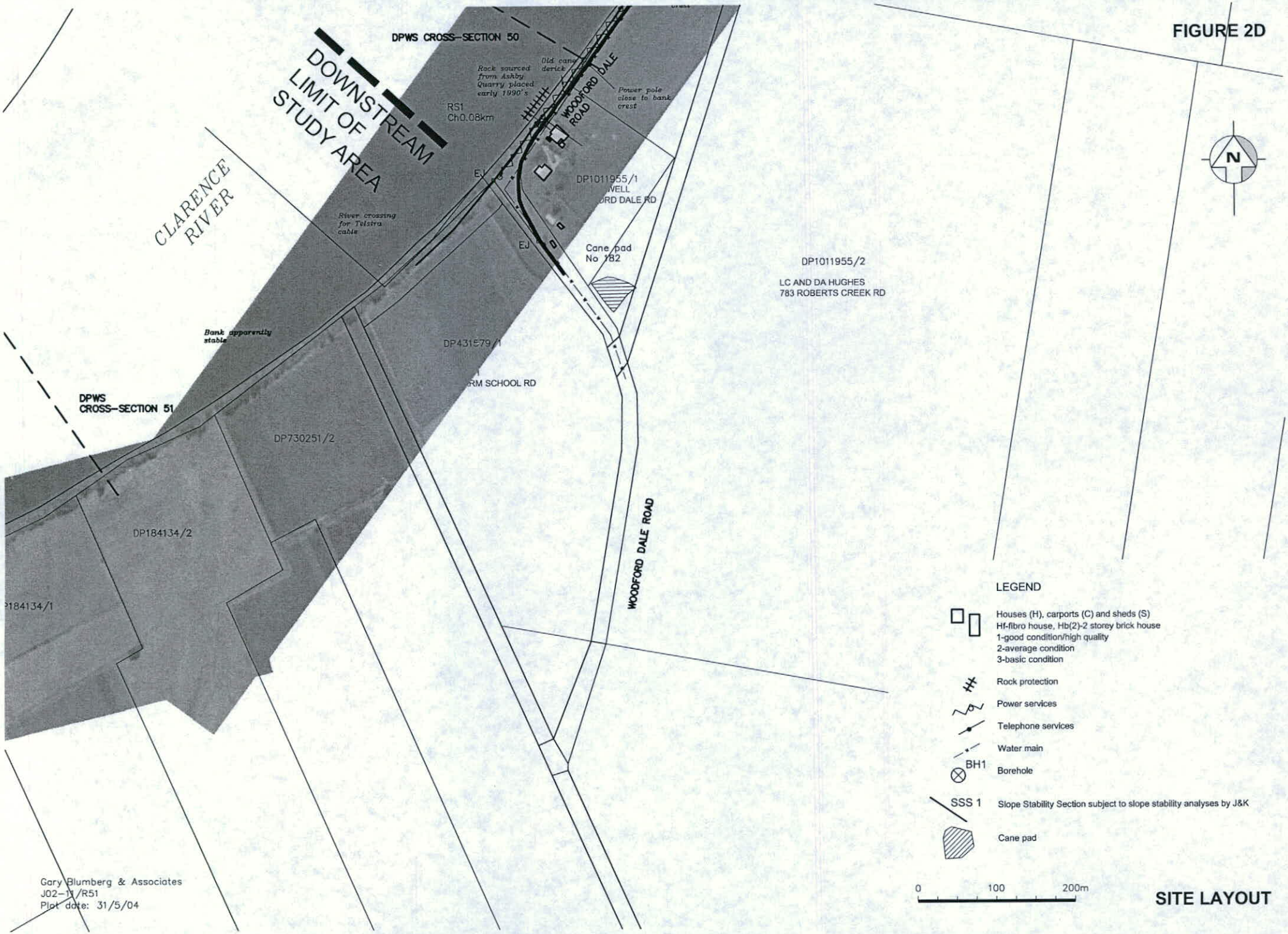
- Houses (H), carports (C) and sheds (S)
  Hf-fibro house, Hb(2)-2 storey brick house
  1-good condition/high quality
  2-average condition
  3-basic condition
- Rock protection
- Power services
- Telephone services
- Water main
- BH1 — Borehole
- SSS 1 — Slope Stability Section subject to slope stability analyses by J&K
- Cane pad

0 100 200m

Gary Blumberg & Associates
J02-11/R51
Plot date: 31/5/04

SITE LAYOUT

FIGURE 2D



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J02-11/R51
Plot date: 31/5/04

SITE LAYOUT

FIGURE 2E

HEILAMAN ISLAND

CLARENCE RIVER

RS9
Ch1.4

Rocked 3–4 yrs ago, 200–300 m3 over say 100 m of bank

GBA ROAD SECTION NOS. AND CHAINAGE FROM BANK CORNER OF WOODFORD DALE ROAD

RS7
Ch1.20

All slip... past. ... old ... pla...

DPWS CROSS–SECTION 48

DPWS CROSS–SECTION 50

SECTION 50

GBA ROAD SECTION NOS. AND CHAINAGE FROM BANK CORNER OF WOODFORD DALE ROAD

WOODFORD DALE ROAD

SSS 1

DP751392/7

OVERBANK FLOW HERE IN FLOODS

RB AND JE BARNIER
NO WI STREET ADDRESS

CLARKS LANE

...LARK
...ORD DALE RD

DP1022583/619

DP203585

...RD

DP209385/2

RA AND AM CLARK
563 WOODFORD DALE RD

DP751392/6

NC SELLARS
575 WOODFORD DALE RD

Cane pad
No 190

Cane pad
No 191

DP751392/5

CJ MCFARLANE
619 WOODFORD DALE RD

DP878482/12

CJ MCFARLANE
619 WOODFORD DALE RD

N

LEGEND

- Houses (H), carports (C) and sheds (S)
  Hf-fibro house, Hb(2)-2 storey brick house
  1-good condition/high quality
  2-average condition
  3-basic condition
- Rock protection
- Power services
- Telephone services
- Water main
- BH1 — Borehole
- SSS 1 — Slope Stability Section subject to slope stability analyses by J&K
- Cane pad

0 100 200m

SITE LAYOUT

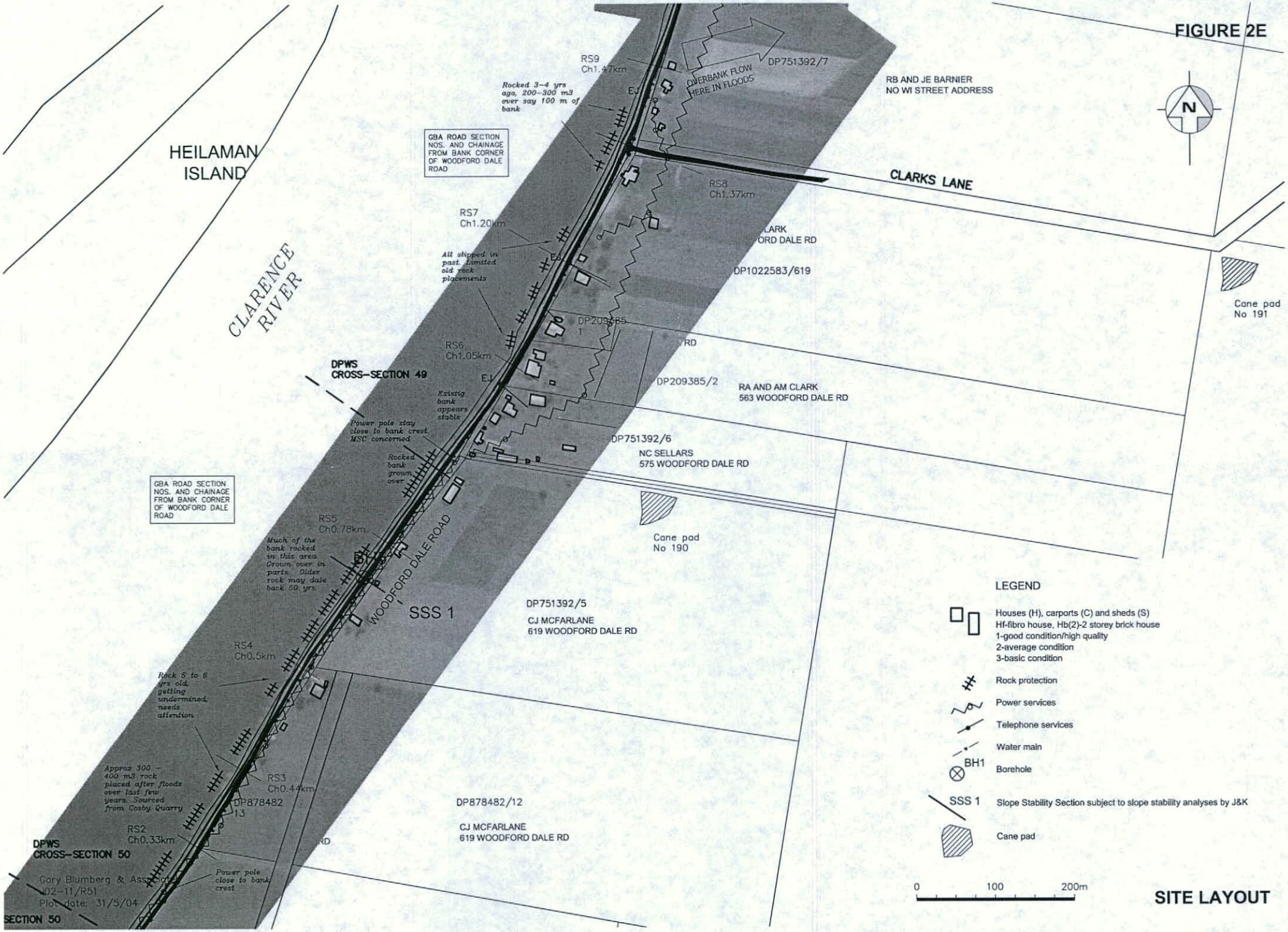
FIGURE 2E
HEILAMAN ISLAND
CLARENCE RIVER
RS9 Ch1.47km
Rocked 3-4 yrs ago, 200-300 m3 over say 100 m of bank
OVERBANK FLOW HERE IN FLOODS
DP751392/7
RB AND JE BARNIER
NO WI STREET ADDRESS
GBA ROAD SECTION NOS. AND CHAINAGE FROM BANK CORNER OF WOODFORD DALE ROAD
CLARKS LANE
RS8 Ch1.37km
RS7 Ch1.20km
All slipped in past. Limited old rock placements
DP1022583/619
Cane pad No 191
DP209385/1
RS6 Ch1.05km
DPWS CROSS-SECTION 49
DP209385/2
RA AND AM CLARK
563 WOODFORD DALE RD
Existig bank appears stable
Power pole stay close to bank crest. MSC concerned
DP751392/6
NC SELLARS
575 WOODFORD DALE RD
Rocked bank grown over
GBA ROAD SECTION NOS. AND CHAINAGE FROM BANK CORNER OF WOODFORD DALE ROAD
RS5 Ch0.78km
Much of the bank rocked in this area. Grown over in parts. Older rock may dale back 50 yrs.
Cane pad No 190
WOODFORD DALE ROAD
SSS 1
DP751392/5
CJ MCFARLANE
619 WOODFORD DALE RD
RS4 Ch0.5km
Rock 5 to 6 yrs old, getting undermined, needs attention
Approx 300 - 400 m3 rock placed after floods over last few years. Sourced from Cosby Quarry
RS3 Ch0.44km
DP878482/13
DP878482/12
CJ MCFARLANE
619 WOODFORD DALE RD
RS2 Ch0.33km
DPWS CROSS-SECTION 50
Power pole close to bank crest
Gary Blumberg & Ass
02-11/R51
Plot date: 31/5/04
SECTION 50
LEGEND
Houses (H), carports (C) and sheds (S)
Hf-fibro house, Hb(2)-2 storey brick house
1-good condition/high quality
2-average condition
3-basic condition
Rock protection
Power services
Telephone services
Water main
BH1
Borehole
SSS 1
Slope Stability Section subject to slope stability analyses by J&K
Cane pad
0
100
200m
SITE LAYOUT

FIGURE 2F

GBA ROAD SECTION NOS. AND CHAINAGE FROM BANK CORNER OF WOODFORD DALE ROAD

DPWS
CROSS-SECTION 47

DPWS
CROSS-SECTION 48

CLARENCE RIVER

RS11A
Ch1.92km

RS11
Ch1.86km

DP751392/11
BC AND CJ DAVIES
NO WI STREET ADDRESS

DP820661/3
PC AND PA RICHARDSON
475 WOODFORD DALE RD

DP820661/4
SG BLANCH
503 WOODFORD DALE RD

SSS 2

N

LEGEND

- Houses (H), carports (C) and sheds (S)
  Hf-fibro house, Hb(2)-2 storey brick house
  1-good condition/high quality
  2-average condition
  3-basic condition
- Rock protection
- Power services
- Telephone services
- Water main
- BH1 Borehole
- SSS 1 Slope Stability Section subject to slope stability analyses by J&K
- Cane pad

0 100 200m

SITE LAYOUT

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J02-11/R51
Plot date: 31/5/04

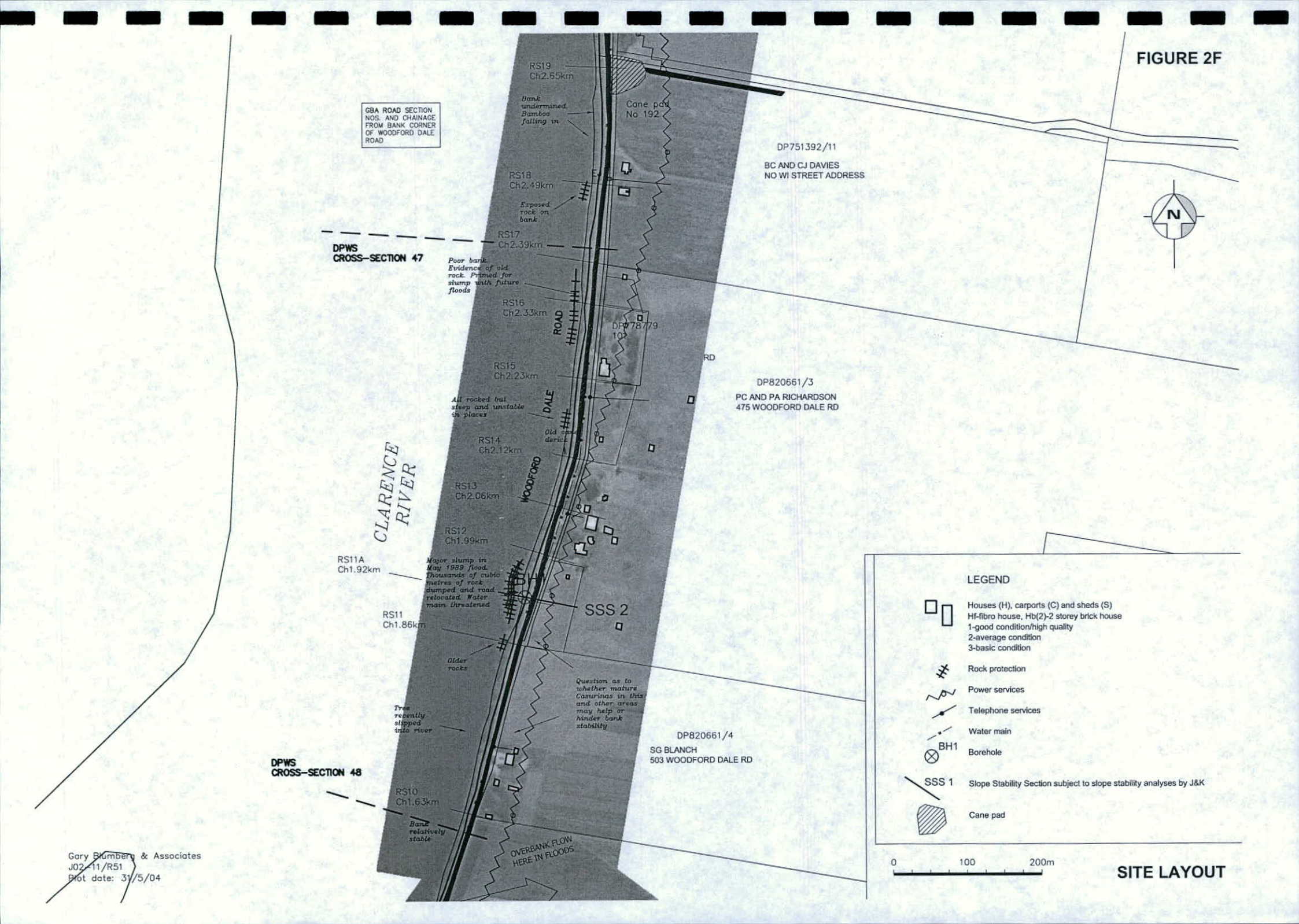
FIGURE 2F
GBA ROAD SECTION NOS. AND CHAINAGE FROM BANK CORNER OF WOODFORD DALE ROAD
RS19 Ch2.65km
Bank undermined. Bamboo falling in
Cane pad No 192
DP751392/11
BC AND CJ DAVIES
NO WI STREET ADDRESS
RS18 Ch2.49km
Exposed rock on bank
N
DPWS CROSS-SECTION 47
RS17 Ch2.39km
Poor bank. Evidence of old rock. Primed for slump with future floods
RS16 Ch2.33km
ROAD
DP778779
10
RD
RS15 Ch2.23km
DP820661/3
PC AND PA RICHARDSON
475 WOODFORD DALE RD
All rocked but steep and unstable in places
DALE
Old cane derick
RS14 Ch2.12km
CLARENCE RIVER
WOODFORD
RS13 Ch2.06km
RS12 Ch1.99km
RS11A Ch1.92km
Major slump in May 1989 flood. Thousands of cubic metres of rock dumped and road relocated. Water main threatened
SSS 2
RS11 Ch1.86km
Older rocks
Question as to whether mature Casurinas in this and other areas may help or hinder bank stability
Tree recently slipped into river
DP820661/4
SG BLANCH
503 WOODFORD DALE RD
DPWS CROSS-SECTION 48
RS10 Ch1.63km
Bank relatively stable
OVERBANK FLOW HERE IN FLOODS
LEGEND
Houses (H), carports (C) and sheds (S)
Hf-fibro house, Hb(2)-2 storey brick house
1-good condition/high quality
2-average condition
3-basic condition
Rock protection
Power services
Telephone services
Water main
BH1
Borehole
SSS 1
Slope Stability Section subject to slope stability analyses by J&K
Cane pad
0
100
200m
SITE LAYOUT
Gary Blumberg & Associates
J02-11/R51
Plot date: 31/5/04

FIGURE 2G

NJ AND ML KIRBY
301 WOODFORD DALE RD

DP421144/2

KIRBYS LANE

GBA ROAD SECTION NOS. AND CHAINAGE FROM BANK CORNER OF WOODFORD DALE ROAD

DP751392/15

WOODFORD DALE ROAD

RS23
Ch3.28km

Existing bank stable to here

CLARENCE RIVER

DPWS
CROSS-SECTION 46

DP751392/14

Old school building

DP751392/13

Flood drain

DP751392/12
SR MCSWAN
401 WOODFORD DALE RD

LEGEND

- Houses (H), carports (C) and sheds (S)
  Hf-fibro house, Hb(2)-2 storey brick house
  1-good condition/high quality
  2-average condition
  3-basic condition
- Rock protection
- Power services
- Telephone services
- Water main
- BH1 Borehole
- SSS 1 Slope Stability Section subject to slope stability analyses by J&K
- Cane pad

0 100 200m

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J02-11/R51
Plot date: 31/5/04

SITE LAYOUT

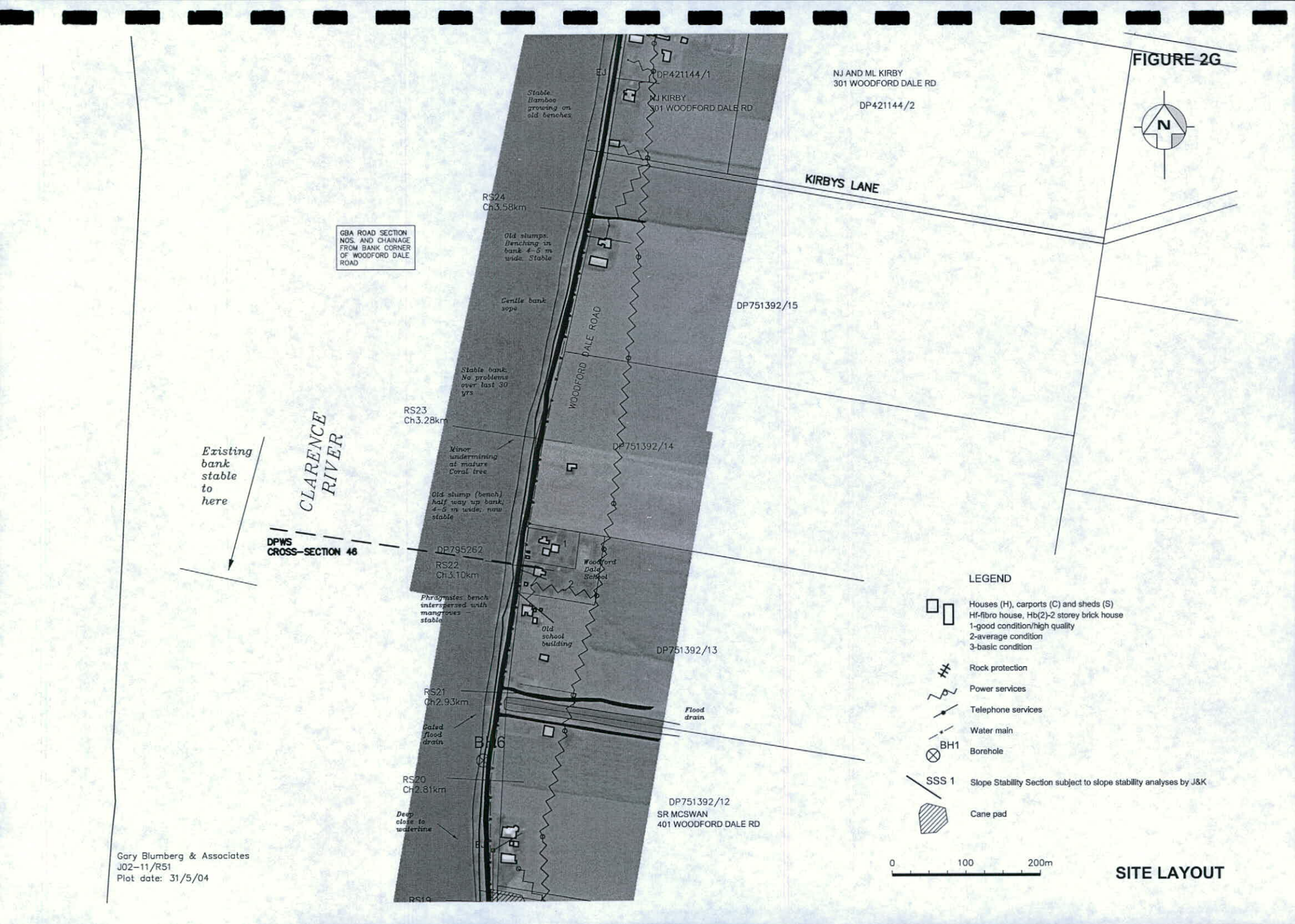
FIGURE 2G
NJ AND ML KIRBY
301 WOODFORD DALE RD
DP421144/2
DP421144/1
NJ KIRBY
301 WOODFORD DALE RD
KIRBYS LANE
N
GBA ROAD SECTION NOS. AND CHAINAGE FROM BANK CORNER OF WOODFORD DALE ROAD
RS24
Ch3.58km
Stable Bamboo growing on old benches
Old slumps. Benching in bank 4-5 m wide. Stable
Gentle bank slope
DP751392/15
WOODFORD DALE ROAD
Stable bank. No problems over last 30 yrs
RS23
Ch3.28km
Minor undermining at mature Coral tree
DP751392/14
Old slump (bench) half way up bank, 4-5 m wide, now stable
Existing bank stable to here
CLARENCE RIVER
DPWS CROSS-SECTION 46
DP795262
RS22
Ch3.10km
Woodford Dale School
Phragmites bench interspersed with mangroves stable
Old school building
DP751392/13
RS21
Ch2.93km
Flood drain
Gated flood drain
BH6
RS20
Ch2.81km
Deep close to waterline
DP751392/12
SR MCSWAN
401 WOODFORD DALE RD
RS19
LEGEND
Houses (H), carports (C) and sheds (S)
Hf-fibro house, Hb(2)-2 storey brick house
1-good condition/high quality
2-average condition
3-basic condition
Rock protection
Power services
Telephone services
Water main
BH1
Borehole
SSS 1
Slope Stability Section subject to slope stability analyses by J&K
Cane pad
0
100
200m
SITE LAYOUT
Gary Blumberg & Associates
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FIGURE 2H

RS31
Ch4.80km

RS30
Ch4.68km

Steep, no Casurinas, but wide strip between road and crest

RS29A
Ch4.60

DPWS
CROSS-SECTION 44

RS29
Ch4.53km

Existing bank stable to here

CLARENCE RIVER

RS28
Ch4.35

GBA ROAD SECTION NOS. AND CHAINAG FROM BANK CORNE OF WOODFORD DA ROAD

RS
Ch

DPWS
CROSS-SECTION 45

RS
Ch

RS
Ch

BH2

DP751392/77
(MSC 7/02)

MUNROS LANE

MUNROS LANE

E/J

751392/18

P751392/17

UNRO
WOODFORD DALE RD

NJ AND ML KIRBY

N

LEGEND

Houses (H), carports (C) and sheds (S)
Hf-fibro house, Hb(2)-2 storey brick house
1-good condition/high quality
2-average condition
3-basic condition

Rock protection

Power services

Telephone services

Water main

BH1 Borehole

SSS 1 Slope Stability Section subject to slope stability analyses by J&K

Cane pad

0 100 200m

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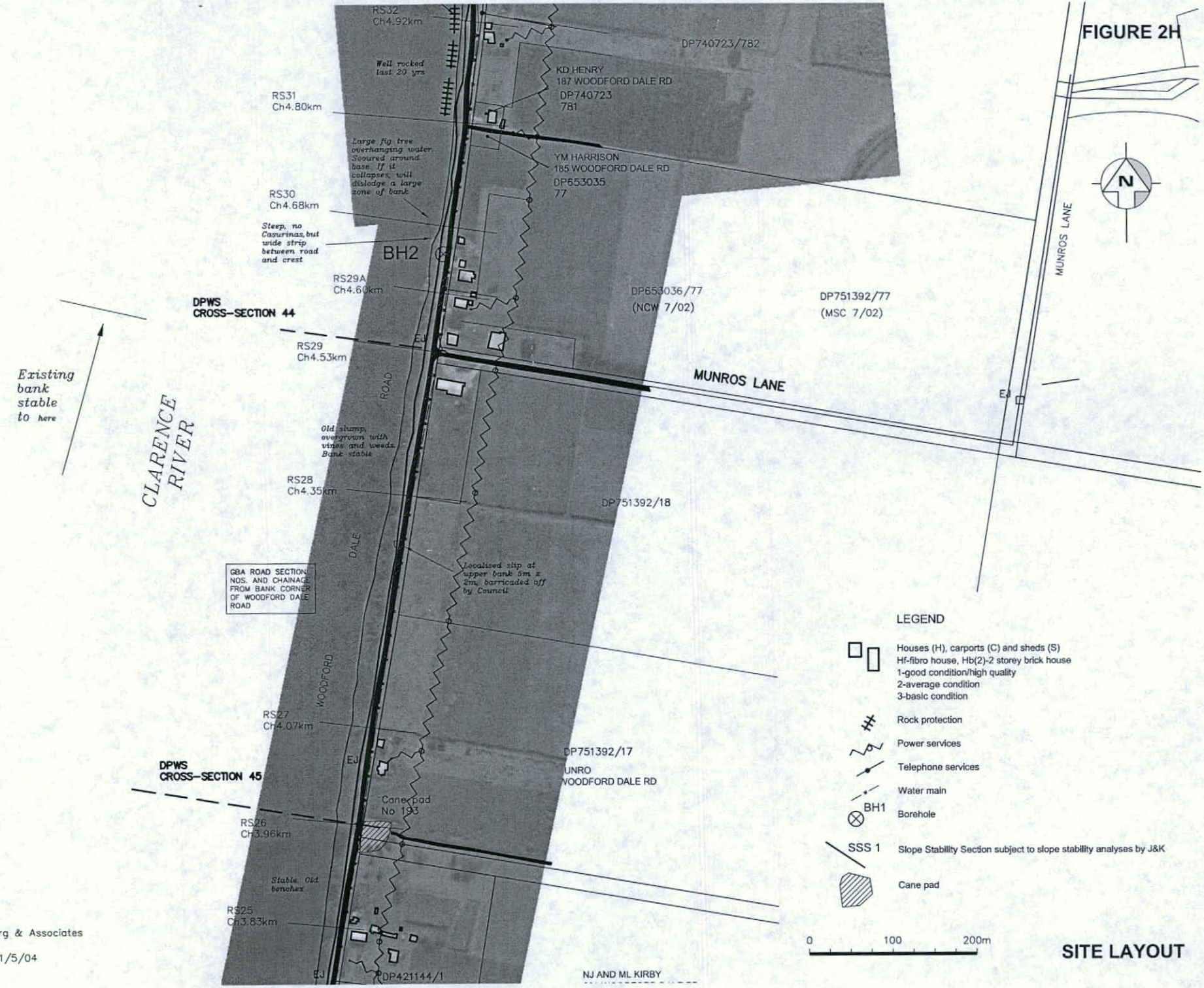
SITE LAYOUT

FIGURE 2H



SITE LAYOUT

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FIGURE 2I

CLARENCE RIVER

1997 intertidal shoal (DLWC survey)

40m rock placement opposite Hough... slope 1:1.25–... above WL, ø=... 5–8m width ... bench below ... covered

DPWS CROSS–SECTION 43

Munro Island grown substantially over last 40 yrs. In mid 1960's, island only visible at low tide, mainly at up and downstream ends

1974 submerged shoal from airphoto

GBA ROAD SECTION NOS. AND CHAINAGE FROM BANK CORNER OF WOODFORD DALE ROAD

1967 extent of apparent shoal from airphoto

1997 intertidal shoal (DLWC survey)

3

N

LEGEND

- Houses (H), carports (C) and sheds (S)
  Hf-fibro house, Hb(2)-2 storey brick house
  1-good condition/high quality
  2-average condition
  3-basic condition
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- Power services
- Telephone services
- Water main
- BH1 — Borehole
- SSS 1 — Slope Stability Section subject to slope stability analyses by J&K
- Cane pad

0 100 200m

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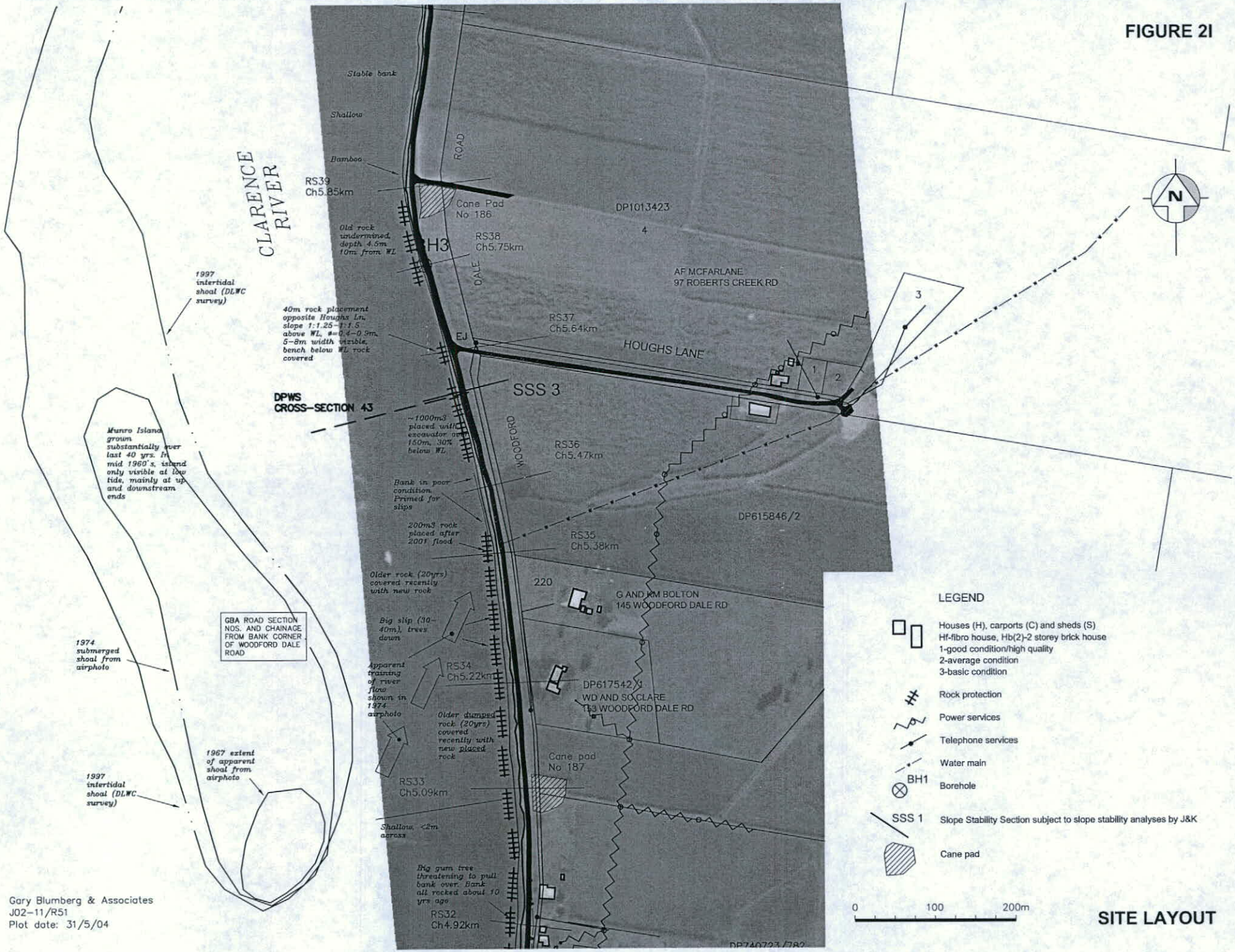
SITE LAYOUT

FIGURE 2I



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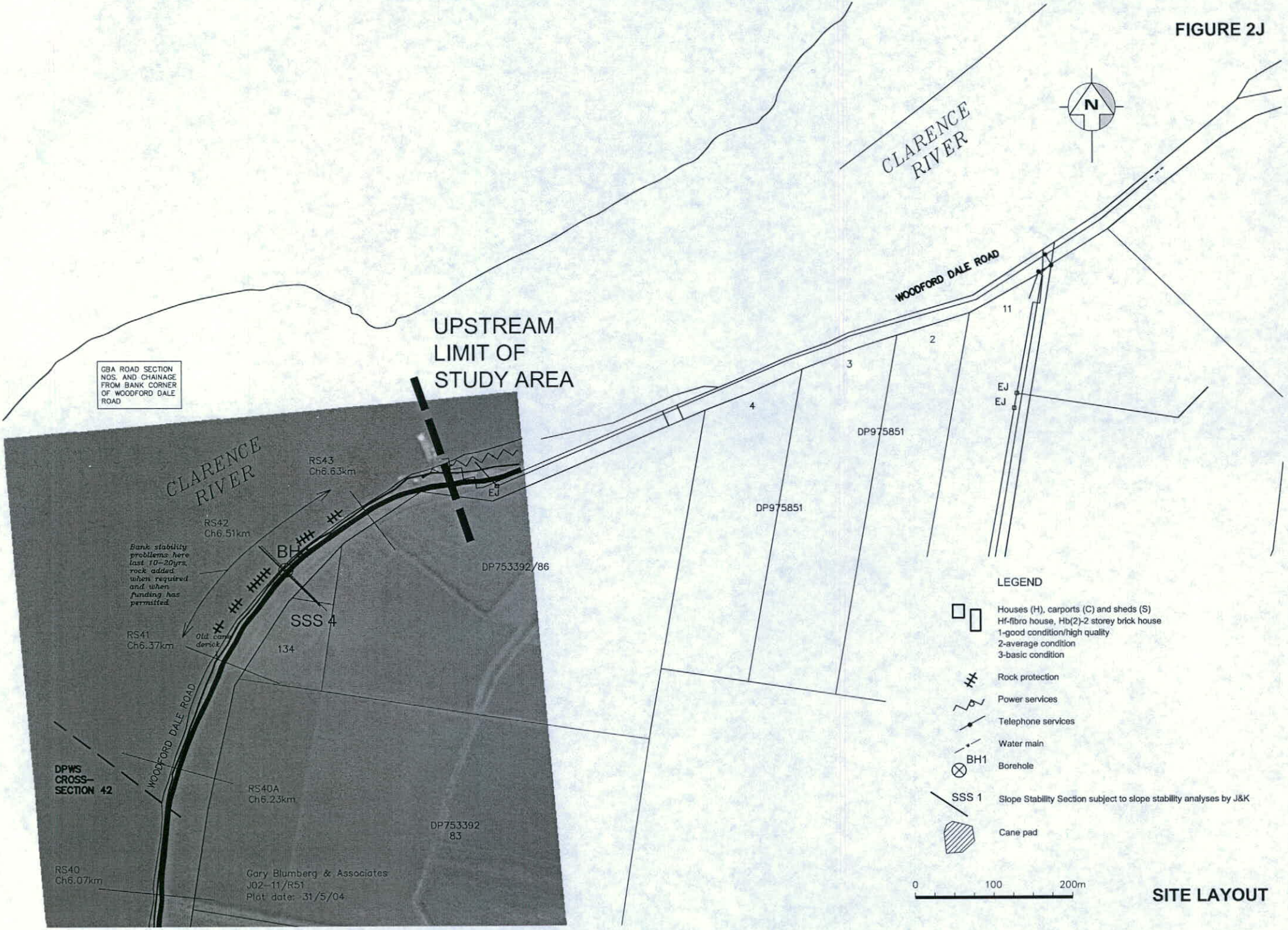
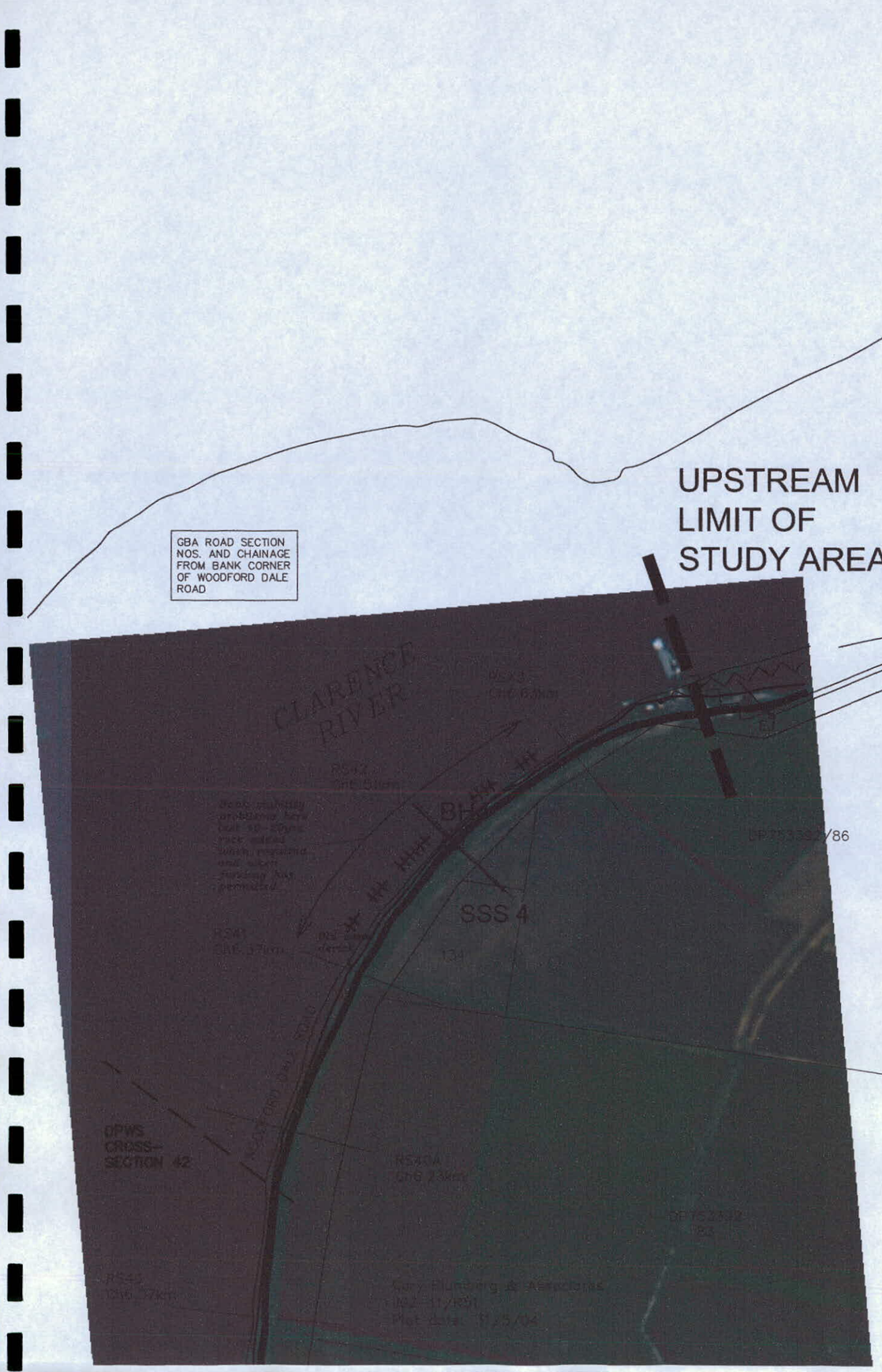
SITE LAYOUT

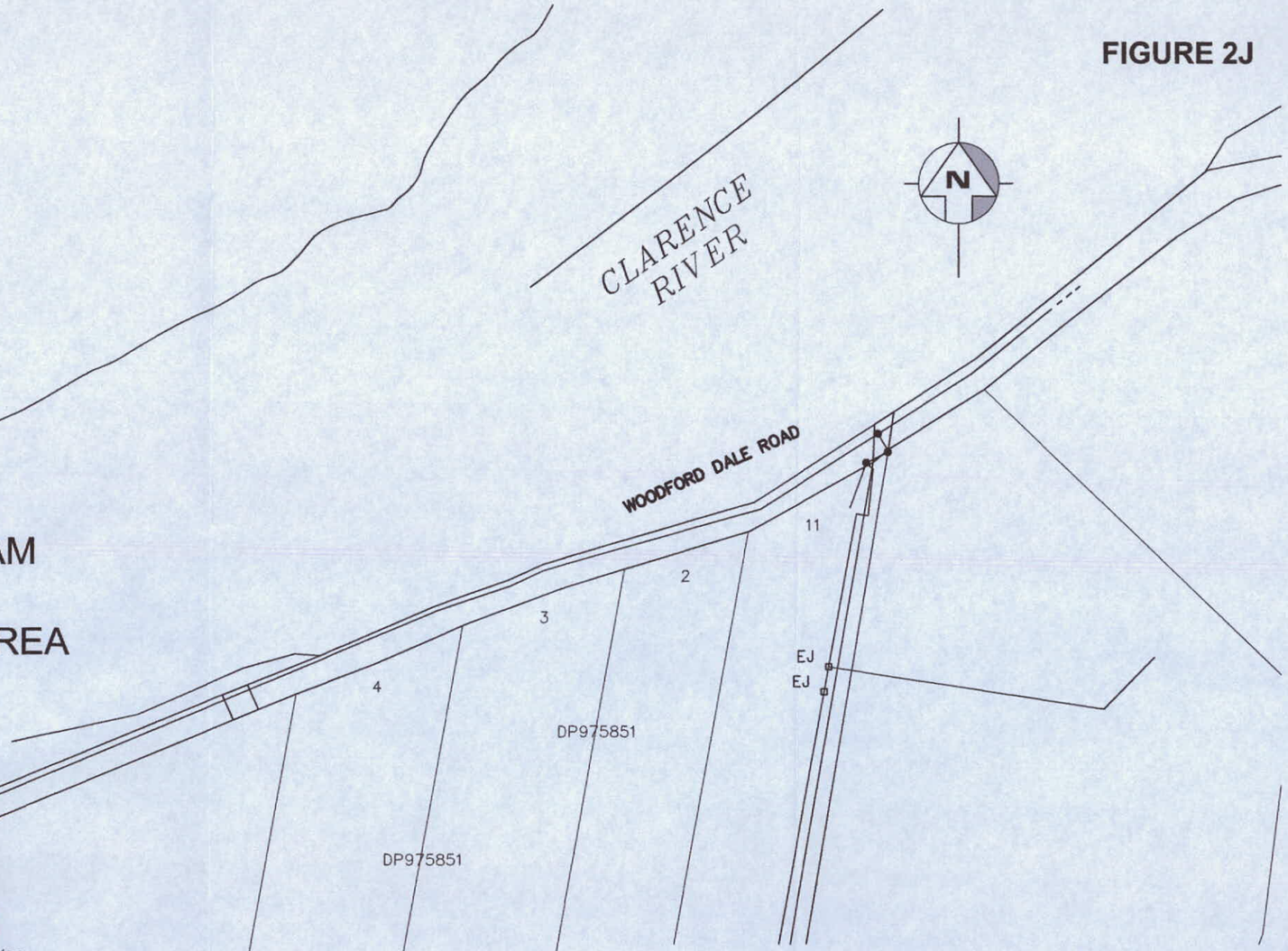
FIGURE 2J



SITE LAYOUT

FIGURE 2J





LEGEND

- Houses (H), carports (C) and sheds (S)
  Hf-fibro house, Hb(2)-2 storey brick house
  1-good condition/high quality
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- Rock protection
- Power services
- Telephone services
- Water main
- BH1 — Borehole
- SSS 1 — Slope Stability Section subject to slope stability analyses by J&K
- Cane pad

0 100 200m

SITE LAYOUT

FIGURE 3

Notes

1. Source of base: CMA 1:25,000 topographic maps

LEGEND

- Extent of riverbank precinct
- New rock placement
- Existing dwellings
- New watermain
- New services route
- New driveways
- Upgraded lane

PR 5
PR 4
PR 3
PR 2
HOUGHS LANE
2A-SC
EXTEND DREWS LANE
DWELLING
2B-SC
2A-SC
2-SC
2B-SC
CLARKS LANE
2B-SC
USE EXISTING ROAD RESERVE HERE
COMMON ALIGNMENT OF ALLOTMENT BOUNDARIES
CLARENCE RIVER
Hielaman Island
Munro Island
THE ELBOW
Duckpond Creek
Woodford Island
Robert's Creek
Elbow Creek
MUNROS LANE
DREWS LANE
BLUFF POINT FERRY
WOODFORD DALE ROAD
ELBOW CREEK ROAD
GOLF LINKS ROAD

PRELIMINARY COST ESTIMATE	
2A-SC	$0.41 MILLION
2B-SC	$0.53 MILLION

0 500 m
SCALE

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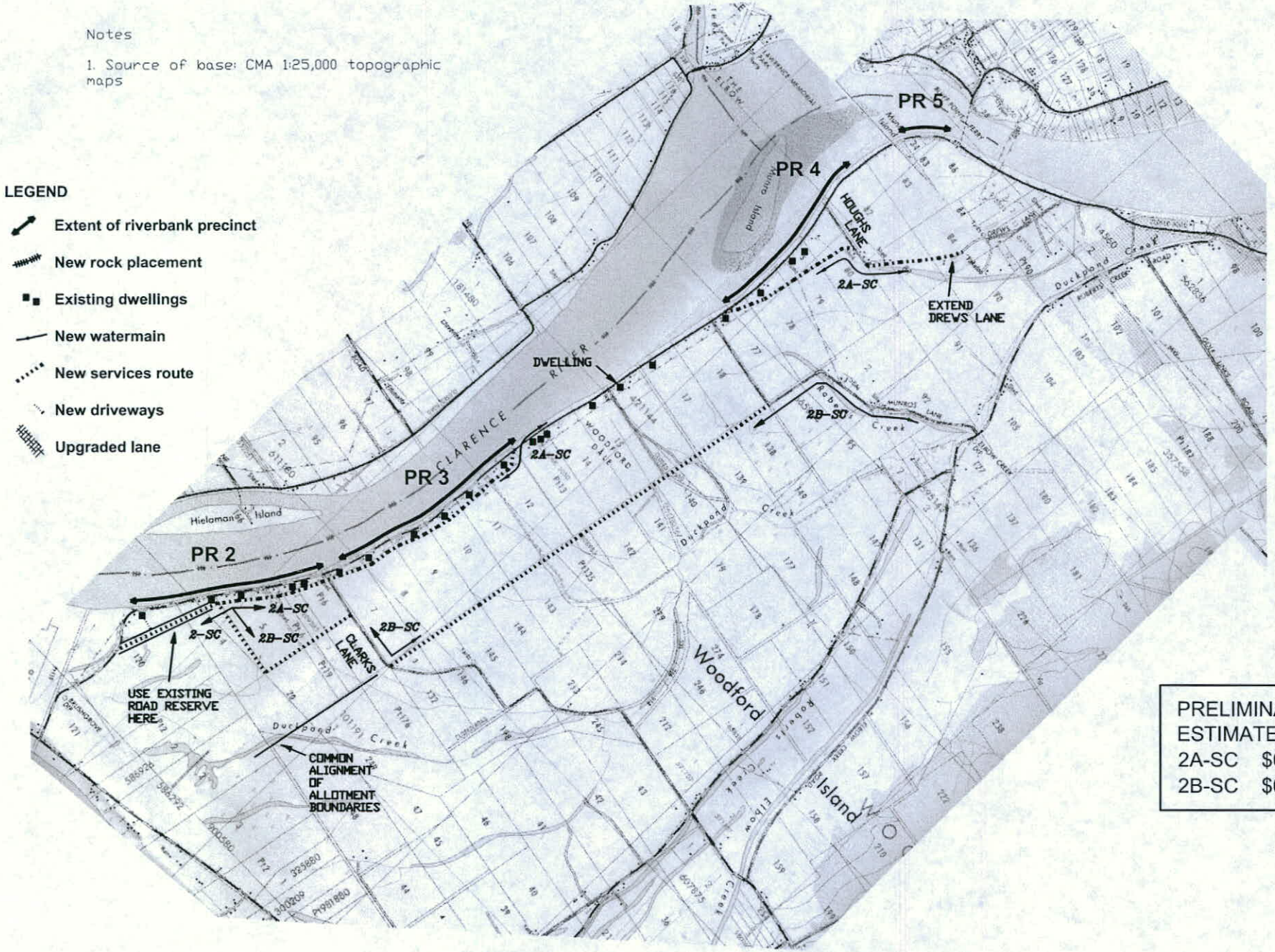
SERVICES CONTINGENCY PROPOSAL

FIGURE 3

Notes

1. Source of base: CMA 1:25,000 topographic maps



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SERVICES CONTINGENCY PROPOSAL

APPENDIX A

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