PALMERSTON URBAN HYDROLOGY STUDY
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SYNOPSIS

In 1982, four urban catchments in the Darwin/Palmerston area were selected for an urban hydrology study to update current design aids for urban drainage systems in the Darwin region.

This report briefly describes each of the four gauging station catchments and the establishing of the respective gauging stations and associated pluviographs.

Gauging station design and documentation errors are noted.

Comment is made on the instrumentation and on the operation of the gauging stations over the 1983/84 wet season. Other factors relevant to the catchments are also noted.

Conclusions and recommendations on each of the Study catchments are included.
WATER DIVISION PROJECT NO. 3039
PALMERSTON URBAN HYDROLOGY STUDY

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1. INTRODUCTION

This study was initiated in 1982, following discussions between officers from Water Division and Roads Division of the Department of Transport and Works, and Palmerston Development Authority (PDA).

The study objective was to establish an urban gauging station network of four gauging stations and eight pluviographs in the Darwin region. The network was to provide the data necessary to enable assessment of present urban drainage design methods, assess their suitability and develop an empirical base of design parameters.

Four catchments covering a range of sizes, stormwater systems and stages of development were selected for the study. The catchments chosen were:

1. Palmerston - a 1.42 square kilometre catchment comprising the suburb of Gray at Palmerston which is currently being developed.
2. Corneys Creek - a 1.44 square kilometre catchment of mainly undeveloped rural land in the rural residential fringe of Darwin.
3. Karama - a 0.51 square kilometre catchment in a recently developed Darwin suburb.
4. Moil - a 0.36 square kilometre catchment in a well established Darwin suburb.

The locations are indicated on Figure 1.

Palmerston Development Authority (PDA) commissioned consulting engineers Gutteridge Haskins and Davey Pty Ltd (Reference 1) in July 1982, to design and document the four project gauging stations required and to prepare a report detailing each catchment. A contract was let in June 1983 jointly funded by PDA and Roads Division for construction of the stations. Contractual delays resulted in only two stations being completed prior to the 1983/84 wet season.

Water Division's role as in the past is to undertake the necessary field activities for the study and to carry out basic data processing. With the completion of this report further work will be carried out as part of the Division's Project No 1005 (Hydrographic Operations) and No 1006 (Hydrographic Data Processing). Detailed analysis of the data and derivation of regional parameters is to be commissioned to specialist consultants after five years operation, in 1989. The study is to be reviewed after two years operation.
LOCATION OF CATCHMENTS

Fig. 1
2. PALMERSTON CATCHMENT

2.1 General

2.1.1 The Palmerston gauging station (GS 815233) is located on the open floodway adjacent to the culvert on Temple Terrace at McArthur Park and has a catchment area of 1.42 km² within the developing suburb of Gray.

2.1.2 Rainfall is recorded at the gauging station site (R815233A) and within the upper catchment on Chung Wah Terrace (R815233B).

2.1.3 Catchment runoff is via three open floodway channels which form into a single channel at the gauging station. The floodways incorporate a 750 N.B. drainage pipe under the centre of each channel to take low and early stormwater flows. The drainage pipeline has 'Special Letterbox Pits' at intervals along the pipe to allow pipe surcharge and surface water re-entry to occur.

2.1.4 Construction of the gauging station, to an operational stage, was reached in October 1983. The gauging station consists of the following:

(a) a flat V-weir and retaining walls;
(b) a recorder float well and inlets;
(c) an instrument shelter and floor slab;
(d) a connecting conduit for instrument cables etc. to Special Letterbox Pit 1A.

2.1.5 Variations to design/specifications found necessary to implement during construction were:

(a) tie-in of weir slab to retaining walls;
(b) tie-in of retaining end walls to culvert walls;
(c) install larger equipment conduit to pit 1A;
(d) replace reinforcing shown incorrectly on drawings;
(e) add a nib wall on the floor slab of the instrument shelter.

2.2 Instrumentation

2.2.1 A Leupold and Stevens Duplex, graphical trace float recorder was installed October 1983 on the float-well of the gauging station to record flow in the open channel, and rainfall. Full record was obtained to the end of the wet season.
2.2.2
A Marsh McBirney VM/FM Flow Meter intended for pipe flow measurement at Special Letterbox Pit 1A was installed in October 1983. This instrument did not have the operating range to meet design flow rates of the pipe system and was operated for a brief period only.

2.2.3
A Sherlock DP15 pressure sensing unit with Leupold & Stevens recorder was tried from late December 1983 in a further endeavour to monitor pipe flow. This also met with little initial success but operated satisfactorily towards the end of the wet season.

2.2.4
Pipe flow velocity was briefly measured at two locations in the vicinity of Special Letterbox Pit 1A by a fixed recording (velocity) current meter.

2.2.5
Rainfall in the upper catchment was recorded from early January 1984 to the end of the wet season.

2.3 Field Observations

2.3.1
As could be expected, pipe full flow occurs in each of the three floodway pipes prior to commencement of substantial channel flow. Pipe surcharge frequently occurs at the start of flow events at Special Letterbox Pits 1A, 2A and 3A (other pits not observed). Surcharge duration at Special Pit 2A is usually much longer than the surcharge duration at Special Pits 1A and 3A. This results in the situation of Special Pit 2A surcharging and simultaneous re-entry occurring at Special Pit 1A.

2.3.2
Pipe flow is not maintained at pipe full stage for the duration of surface flows. Surface water re-entry at Special Pit 1A generally commences prior to the flow peak occurring in the channel.

2.3.3
Pipe flow velocity under conditions of full to near full pipe flow in the vicinity of Special Pit 1A, increases 70% from a point 1.5 metres upstream to a point 2 metres downstream. The downstream measurement (of 3.4 m/s) indicates a full pipe discharge of 1.5 m³/s.

2.3.4
Pipe flow observed at a quarter to half full pipe at Special Pit 1A is quite turbulent.
2.3.5
A discrepancy exists between channel flow peaks as recorded on the float well recorder and that recorded via the pressure unit with orifice located within Special Pit 1A. The pressure unit record should not be used except for the measurement of pipe flow stage.

2.3.6
Some deposition of sediment occurs around the Special Letterbox Pit as a result of the surcharge influencing the surface flow regime in the vicinity.

2.3.7
The gauging station design and instrumentation is satisfactory for the measurement of surface channel flow. The weir design calibration curve has not been verified by gauging measurements.

2.3.8
Because of the flat shape of the floodway channel, surface flow in general is not diverted towards the re-entry pits, except by the gauging station weir at Special Pit 1A.

2.4 Processing of Field Data

2.4.1
Streamflow chart records obtained during the 1983/84 wet season are currently being edited and coded for processing.

2.4.2
Rainfall data will be manually extracted from the charts for 24 hour rainfall totals only. Digital processing is expected to be available in 1986.

2.5 Problems Identified

2.5.1
The extended duration of surcharge at Special Letterbox Pit 2A indicates a possible system design error with the pipe junction at Special Letterbox Pit 2A.

2.5.2
Surface water entry through the Special Letterbox Pits is restricted by the pit covers.

2.5.3
Channel bed disturbance is occurring at the edge of the control weir apron, due to the increased velocities over the weir crest.
2.5.4
Sediment deposition and vegetation could build up in the channel bed downstream of the road culvert. This could reduce the culvert capacity and affect the flow characteristics upstream, including change in rating of the gauging station and higher flood levels.

2.5.5
Measurement of pipe flow is not possible with the instrument purchased for the task. Long term availability of the replacement pressure sensing unit and recorder from Water Division is uncertain.

2.6 Conclusions

2.6.1
It is feasible to obtain the required field data, from the gauging station site and upper catchment pluviograph location.

2.6.2
Pipe flow methods of measurement are limited and currently depend on the availability of a pressure sensing unit and recorder from Water Division.

2.7 Recommendations

2.7.1 Design
Modify the design of the drainage pipe 750 N.B.T. at Special Letterbox Pit 2A to reduce turbulence within the pit and improve the regime of pipe flow downstream of the junction.

Replacement of the Special Letterbox Pit covers with a mesh grill set to ground level. A trial modification as suggested has been done on Pit 1A and appears to allow a significantly greater volume of water to enter the pipe.

Concreting of the channel bed section between the control weir apron and the road culvert. This would overcome disturbance to the channel bed and assist in streamlining the flow through the culverts.

Maintain the floodway channel downstream of the road culvert, to ensure sediment or vegetation build-up is removed, prior to each wet season.

Obtain suitable instrumentation for pipe flow measurement. Recommended instrument is a Sherlock DP pressure sensing unit and strip chart recorder at an estimated cost of $4800.

Following completion of the recommended modifications to the drainage system, flow characteristics at the gauging station should not be further altered.

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2.7.2 Operation
Water quality of stormwater runoff from the catchment should be determined for pH, conductivity, turbidity and temperature. The recorders to be operating over the 'wet' season (approx December to April) on a time scale of 9.6 inches per day (allowing a five minute chart resolution) and visited at least weekly.
Dry season operation to be on a 1.2 or 2.4 inch per day time scale and monthly visits to ensure immediate availability and serviceability of the equipment.

2.7.3 Catchment Monitoring
In conjunction with the annual aerial photo coverage of the catchment, as requested of Lands Department for October/November. The Regional Supervising Hydrographer should report on the degree of development within the catchment, changes observed, and general conditions, with comment on ground coverage etc. eg lawns, parks and trees.
3. CORNEYS CREEK CATCHMENT

3.1 General

3.1.1 The gauging station on Corneys Creek (GS 815 234) is situated approximately 90 metres upstream of a gravel track which turns off eastwards from the southern end of Virginia Road. Corneys Creek gauging station has a catchment area of 1.44 km² mostly on vacant Crown Land. The creek is a tributary of the Elizabeth River. The catchment is mainly undeveloped rural land in the rural residential fringe of Darwin. This catchment was selected as a control catchment for the purpose of assessing change in storm runoff characteristics in the developing urban catchments also being monitored.

3.1.2 Rainfall is measured at the gauging station site (R815 234A) and (during 1983/84) near the upper catchment boundary (R815 234B).

3.1.3 Construction of the gauging station was completed in September 1983 and consists of the following:

- a flat V-weir and retaining walls (similar to but on a smaller scale than Palmerston);
- a recorder float well and inlets;
- an instrument shelter and floor slab.

3.1.4 Variations to design/specifications made during construction of the station were:

(a) instrument shelter and internal float well ladder turned 90° to avoid inspection problems during overbank flow;

(b) tie-in of weir slab to retaining walls;

(c) gravelling on top of banks, in lieu of top soil and grassing;

(d) stabilising of the banks upstream and downstream of the weir retaining walls by rock pitching;

(e) subsequent sealing of the upstream weep-holes in the retaining walls to stop drainage of the stilling pool.

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3.2 Instrumentation

3.2.1
A Leupold & Stevens A71 graphical trace recorder was installed in October 1983 on the float well to record stream flow. Full record was obtained to the end of the wet season.

3.2.2
A separate installation for rainfall measurement in the lower catchment was necessary to avoid removing large trees in the vicinity of the gauging station. A pluviometer shelter with a Leupold & Stevens recorder was installed some 50 m from the gauging station and operated satisfactorily throughout the wet.

3.2.3
Upper catchment rainfall was similarly recorded with the pluviometer located on private land near to the catchment boundary.

3.3 Field Observations

3.3.1
The streamflow and rainfall records of the 1983/84 wet season are not of the highest quality due to infrequent maintenance visits.

3.3.2
The streamflow record indicates that full capacity of the control weir was reached or exceeded on four occasions during the wet season. Three discharge measurements were made during the season and all indicate a marked deviation from the design rating of the weir. The highest measurement of Q 1.738 m$^3$/s is approx. 69% of design Q for the same stage. The control weir is constructed to the design specifications.

3.4 Processing of Field Data

3.4.1
Similar comments apply as for Palmerston 2.4.

3.5 Problems Identified

3.5.1
Reference 3.3. (Field Observations) visiting frequency of 3 to 4 weeks is insufficient to ensure quality record.

3.5.2
The control weir does not perform to design specifications.
3.5.3
Location of the upper catchment pluviometer is not at the optimum site for determining the behaviour of catchment runoff.

3.6 Conclusions

3.6.1
The performance of the gauging station in its present form is not suitable to meet the aims of the study for this catchment.

3.7 Recommendation

3.7.1
The recorders to be operating over the 'wet' season (approx December to April) on a time scale of 9.6 inches per day (allowing a five minute chart resolution) and visited at least weekly. Dry season operation to be on a 1.2 or 2.4 inch per day time scale and monthly visits to ensure immediate availability and serviceability of the equipment.

3.7.2
Conduct survey work and investigate as necessary to determine the cause of drowning of the control weir. Dependent on results remove or modify obstructions to the channel flow that are affecting the design performance of the weir structure.

3.7.3
Relocate the pluviometer within the upper catchment area.

3.7.4
An annual report on the catchment should be prepared as for Palmerston (Ch 2.7.3).

3.7.5
Water quality parameters as for Palmerston (Ch 2.7.2) should be determined during the wet season.
4. KARAMA CATCHMENT

4.1 General

4.1.1 The Karama gauging station (GS 815 232) is located on a stormwater outfall drain on the northern side of Vanderlin Drive opposite Lot 4395. Karama is a recently developed suburb and contributes the catchment area of 0.51 km² to the gauging station.

4.1.2 Rainfall is measured at the gauging station site (R815 232A) and within the upper catchment at the Karama Public School (R815 232B).

4.1.3 Construction of the gauging station to an operational stage was reached in late January 1984. The gauging station consists of:

- a 3.6 m Parshall Flume;
- a recorder, float well and inlets;
- an instrument shelter and floor slab.

4.1.4 Additional works required during construction of the station:

(a) tie-in of the flume walls to the flume floor slab;
(b) benching of the wing walls of the flume to the natural rock bank.

4.2 Instrumentation

4.2.1 An Leupold & Stevens Duplex recorder was installed on the float-well, in February 1984, for the measurement of flow through the flume, and rainfall. Reasonable record was obtained to the end of the wet season. The recorder was removed in June 1984 following a break-in to the shelter and damage to the instrument.

4.2.2 A pluviometer in the upper catchment was installed in March 1984. Operation was satisfactory for the limited period to the end of the wet season.
4.3 Field Observations

All comments on field observations relate to a significant rainfall event over the catchment on the morning of Saturday 14 January 1984.

4.3.1 The pipe network in the catchment was generally surcharged and excess water diverted to overland flow. In some locations, water issued from the entry pits with sufficient force to lift the pit lids, some were cracked. Most of these situations occurred where 'T' junctions of similar size pipes exist.

4.3.2 Not all surcharge flow was contained within the road easement or walkway flow paths. Some of the overland flow constituted a nuisance to residents in the area as it caused local flooding. The local flooding was accompanied by significant erosion of soil and subsequent deposition of this material in areas of ponding.

4.3.3 The west bound lane of Vanderlin Drive was completely covered by surcharge flow from behind Lot 5186 Town of Sanderson to the western edge of the catchment for several minutes during the peak runoff period. It is thought likely that some of the surcharged flow in Vanderlin Drive flowed out of the catchment to the west of the channel and measuring flume.

4.4 Processing of Field Data

4.4.1 Processing of the limited amount of flow data recorded for the 1983/84 wet season is scheduled for completion by January 1985.

4.4.2 Rainfall record as available will be manually extracted from the charts for 24 hour rainfall totals only.

4.5 Conclusions

The gauging station as constructed is suitable for the measurement of flows contained within the outfall drain.

4.6 Recommendations

4.6.1 The recorders to be operating over the 'wet' season (approx December to April.) on a time scale of 9.6 inches per day (allowing a five minute chart resolution) and visited at least weekly. Dry season operation to be on a 1.2 or 2.4 inch per day time scale and monthly visits to ensure immediate availability and serviceability of the equipment.
4.6.2
An annual report on the catchment should be prepared as for Palmerston (Ch 2.7.3).

4.6.3
Water quality parameters as for Palmerston (Ch 2.7.2) should be determined during the wet season.
5. Moil Catchment

5.1 General

5.1.1 The Moil catchment is in a well established Darwin suburb with a catchment area of 0.36 km². The gauging station (GS 815 231) is on a re-aligned outfall drain off McMillans Road and approximately opposite to the Marrara Hotel.

5.1.2 It is proposed to record rainfall at the gauging station site (R815 231A) and within the upper catchment (R815 231B).

5.1.3 The gauging station construction was not completed before the end of the 1983/84 wet season and no records were obtained. The gauging station consists of the following:

- a 3 m Parshall Flume;
- a recorder float-well and inlets;
- an instrument shelter and floor slab.

5.2 Instrumentation

5.2.1 The installation of instruments is proposed for the 1984/85 wet season and will consist of the following:

(a) a Leupold & Stevens Duplex float recorder at the gauging station to record all flow within the drain and rainfall;

(b) a pluviometer in the mid to upper catchment at a location still to be confirmed.

5.3 Conclusions

5.3.1 The gauging station, as constructed, is suitable for the measurement of flow within the outfall drain.

5.4 Recommendations

5.4.1 The recorders to be operating over the 'wet' season (approx December to April.) on a time scale of 9.6 inches per day (allowing a five minute chart resolution) and visited at least weekly. Dry season operation to be on a 1.2 or 2.4 inch per day time scale and monthly visits to ensure immediate availability and serviceability of the equipment.

5.4.2 The water quality of stormwater runoff should be determined as for Palmerston (Ch 2.7.2).

5.4.3 An annual report on the catchment should be prepared, as for Palmerston (Ch 2.7.3).
6. REFERENCES

1. Gutteridge Haskins & Davey Pty Ltd
   Palmerston Urban Drainage Study

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