TABLE 1.3 (Cont'd)

HYDROLOGICAL STUDIES WITHIN THE NOTTAWASAGA RIVER BASIN

Watercourse/Basin	Author/Title	Flows 5-Yr E	5-Yr F	10-Yr E	10-Yr F	25-Yr E	25-Yr F	50-Yr E	50-Yr F	100-Yr E	100-Yr F	Regional E	Regional F
Truax Creek (sub-catchments 600-603)	Cumming-Cockburn; A Floodplain Delineation Study for Truax Creek; 1985												x
Besley Drain Town of Shelburne	Marland Engineering Ltd.; Floodline Mapping for Besley Drain, Town of Shelburne												x
Pine River	The Lathem Group Ltd.; Flood Proofing Investigations, Angus Plaza, 1982									x	x		
Pine River	Crysler and Lathem Ltd.; Floodplain Study of Pine River near Angus, 1979												x
Willow Creek	Cumming-Cockburn & Associated Ltd.; Flood and Fill Line Mapping, Willow Creek, 1982	x		x		x		x		x		x	
Willow Creek	Cumming-Cockburn & Associates Ltd.; Hydrological Analysis, Willow Creek, 1982	x		x		x		x		x		x	

TABLE 1.3 (Cont'd)

HYDROLOGICAL STUDIES WITHIN THE NOTTAWASAGA RIVER BASIN

Watercourse/Basin	Author/Title	5-Yr E	5-Yr F	10-Yr E	10-Yr F	25-Yr E	25-Yr F	50-Yr E	50-Yr F	100-Yr E	100-Yr F	Regional E	Regional F
		Flows											
Lamont Creek (Town of Stayner)	Ainley and Associated Ltd.; Floodline Mapping Study, Lamont Creek, 1973												x
Lamont Creek	Cumming-Cockburn and Associates; King St. Flood Study; Town of Stayner, 1985	x		x		x		x		x		x	
* Black Ash Creek	Ainley and Associates Ltd.; Black Ash Creek Flood Control Study in the Town of Collingwood, 1983									x	x	x	x
Sturgeon Creek	Cumming-Cockburn and Associates; Beaver Brook Estates, Flood-plain Mapping Study, Sturgeon Creek									x	x		
Sturgeon Creek	Henderson, Paddon and Associates Ltd.; Mr. and Mrs. W. Plalte, Report on Hydrology and Hydraulics of Sturgeon Creek, 1985					x				x		x	
Upper Innisfil Creek	M.M. Dillon Limited; Fill Line and Floodplain Mapping Study; Innisfil Township, 1977												x

1.3.3 Sources of Information

A general description of the water resources of the Nottawasaga River together with an insight to the flood potential was obtained from watershed reports listed in the bibliography of this report. Records of streamflow and climatologic data for stations located within and adjacent to the Authority were provided by the Water Survey of Canada, the Ontario Ministry of the Environment and the Atmospheric Environment Service respectively.

Details of the physiographic characteristics of the study area that were required for the definition of the hydrologic model were assembled from a number of sources:

General

- The Physiography of Southern Ontario, Ontario Ministry of Natural Resources, 1984

Topographic Detail

- 1:50,000 national topographic information series maps
- 1:10,000 Ontario base maps (1984)
- flood plain maps (map coverage indicated in Figure 1.1)

Drainage Patterns

- 1:10,000 aerial photographs (1978)
- 1:30,000 Ontario base map aerial photographs (1983)

Soils

- Canada Department of Agriculture soil surveys of Simcoe and Dufferin Counties

Land use within the study area was identified to the degree required for hydrologic runoff computations. The definition of future urban land use was obtained from municipal plans and zoning by-laws (Table 1.4) while the real extent of current urban usage was interpreted from 1:30,000 aerial photographs. Agricultural cropping patterns and rural land cover was assembled from the Ontario Ministry of Agriculture and Food's agriculture land use systems series (1984). This information was considered valid for both the present and the future with the latter being applicable to those lands not affected by urban growth.

TABLE 1.4

FUTURE LAND USE: DATA SOURCES

	Municipality	Land Use Plan
Dufferin County	Township of Amaranth	1986 Official Plan
	Township of Melancthon	1986 Amendment #4 to Official Plan
	Township of Mono	1974 Official Plan, June 1986 Zoning By-law
	Township of Mulmur	1973 Official Plan; Amendment #5
Simcoe County	Township of Adjala	1986 Consolidated Official Plan
	Township of Essa	1985 Official Plan
	Township of Flos	1981 Amendment #7 to Official Plan
	Township of Innisfil	1981 Official Plan
	Township of Techumseth	1983 Amendment #4 to Official Plan
	Township of West Gwillimbury	1973 Official Plan, Amendment #3
	Township of Tosorontio	1972 Official Plan
	Township of Sunnidale	1985 Official Plan
	Township of Nottawasaga	1972 Official Plan
	Township of Vespra	1982 Official Plan
	Township of Medonte	1978 Official Plan
Grey County	Township of Collingwood	Official Plan of the Beaver Valley Planning Area
	Township of Osprey	1978 Official Plan of the Beaver Valley Planning Area
Cities, Towns and Villages	Town of Alliston	1975 Official Plan, Amendment #8
	Town of Collingwood	1986 Official Plan
	Town of Stayner	1980 Official Plan
	Town of Wasaga Beach	1984 Amendment #4 to Official Plan
	Village of Beeton	1980 Official Plan
	Village of Cookstown	1970 Official Plan
	Village of Creemore	1985 Amendment #2 to Official Plan
	Village of Tottenham	1984 Official Plan
	City of Barrie	1983 Official Plan

2.0 FIELD PROGRAMMES

2.1 Reconnaissance Surveys

At the onset of the Hydrologic Study, discussions were held with Authority staff in order to identify those drainage boundaries of the Nottawasaga basin which have not been well defined through topographic mapping. These headwater areas were examined on the 1:30,000 areal photographs to obtain a better appreciation of local drainage patterns and subsequently visited in the field during a reconnaissance survey. Final drainage boundaries depicted on Figure 1.1 reflect the height of land at these locations and the tributary drainage area of the Nottawasaga River system. Those sites requiring boundary definition during the study are summarized in Table 2.1.

In order to avoid discrepancies in drainage boundaries which may lead to errors in drainage planning, reference was made to annexation plan background studies for the City of Barrie (Ref. 26). Headwater areas of Bear Creek were defined in this manner.

2.2 Surveys of Waterway Cross-sections

2.2.1 Upper Nottawasaga River and Georgian Bay Tributaries

2.2.1.1 Selection of Cross-section Locations

During the field programme, surveys of waterway and floodplain cross-sections were completed for the Upper Nottawasaga River Basin and tributaries which discharge to the Lower Nottawasaga River and Georgian Bay. This information together with flow roughness estimates were required for hydrologic routing purposes when computing Basin flows with the digital model (QUALHYMO). Prior to implementing the field programme, the Nottawasaga watershed and catchments draining directly to Georgian Bay were discretized into sub-catchments representing uniform hydrologic characteristics (Figure

TABLE 2.1

DRAINAGE BOUNDARIES ESTABLISHED BY FIELD RECONNAISSANCE

HEADWATERS OF RIVER SYSTEM	DRAINAGE BASIN REFERENCE NO.	LOCATION
	(Figure 1-1)	
Beeton Creek	200	South of Tottenham
Nottawasaga River	100, 102, 104	North of Orangeville
Boyne River	400	West of Shelburne
Pine River	500	North-West of Shelburne
Mad River	800, 801	West of Singhampton
Willow Creek	713	Craig Swamp
Willow Creek	707, 708, 709	South of Little Lake in City of Barrie
Bear Creek	600	City of Barrie
Innisfil Creek	300	North-East of Cookstown

2.1). Major watercourses which receive runoff from these sub-catchments and convey flows to Georgian Bay represent runoff from these sub-catchments and the Basin. Routing of flows through this network is required in order to accurately simulate peak flow attenuation processes and flow travel time. Stream and floodplain cross-sections form a basic input to the flow routing computations; therefore, field surveys of selected stream geometries were conducted to obtain representative conveyance sections.

The location of stream sections to be field surveyed was determined by initial inspection of available topographic maps and aerial photographs followed by a reconnaissance survey of the streams from road crossings. Stream reaches with relatively uniform cross-section and floodplain vegetation were delineated. It was determined that 30 field surveyed cross-sections would satisfy the foregoing hydrologic routing requirements. Location of sections is documented on Figure 2.1.

2.2.1.2 Field Surveys

Field surveys of waterway cross-sections within the subject stream reaches were carried out by a two-man crew (Messrs. L. Alexander and R. Malcolm) between July 7 and 11, 1986. Due to the low streamflows which were experienced at that time, it was possible to survey the stream bed bathymetry by fording the streams and measuring with a level, rod and tape. Elevations were recorded during this process with a level (Wild Nak 0 Serial No. 475095) which was located on the river bank quite close to the cross-section while horizontal distances were measured from an arbitrary reference point at some location within the section. No datum was established for the levels since the subsequent hydrologic routing did not require a geodetic reference. Waterway slopes were obtained from 1:50,000 NTIS maps.

The lateral extent of the surveyed cross-sections was established on a site-specific basis but primarily depended on the geometry of the cross-section and the difficulty of carrying a survey line through dense undergrowth. At each location, photographs were taken for documentation and for future reference when establishing the hydraulic roughness.

2.2.1.3 Presentation of Data

Survey information was documented for the Authority in the following format:

i) field survey book;

ii) the location of each cross-section together with the stream reach to which the section is applicable for routing purposes (Figure 2.1)

iii) waterway and floodplain cross-sections in a digital form. A hard copy is provided in Appendix B.

iv) cross-sectional plots for each section together with the Manning's 'n' used for the bed and overbank portions

v) photographs which document the vegetation and general setting of each section

Items i), iv) and v) were supplied to the Authority under separate cover.

2.2.1.4 Supplementary Information

During the subsequent hydrologic analysis of the Basins, it was found that the flow routing routines in the QUALHYMO model exceeded the flow travel time table at a few cross-sections under more extreme flooding conditions. This occurrence usually arose in stream reaches with wide flood plains in which the lateral inundation surpassed the distance that had been surveyed from the active waterway. The routing sections obtained in the field were supplemented with 1:10,000 OBM mapping in order to provide a fully defined section which will contain the flood discharge. Information on each section used in the hydrologic analysis can be obtained from the input files for the QUALHYMO model which was provided to the Authority as part of project documentation.

2.2.2 Minesing Swamp and Lower Nottawasaga River

2.2.2.1 Field Surveys

Surveys of the Nottawasaga River waterway cross-sections traversing the Minesing Swamp were carried out on July 15 to 17 and October 18, 1986. During July, the reach between Highway No. 90 and the confluence with the Willow Creek was completed while the lower portion of the Nottawasaga River within the swamp and Willow Creek were surveyed on October 18.

Reference water levels (geodetic datum) for the Nottawasaga River were recorded on each day of the July survey at the Highway No. 90 bridge in Angus, a Bailey bridge approximately 4.5 kilometres downstream, and at Edenvale near the outlet of the Minesing Swamp. Water elevations for the stream profile at intermediate locations within the swamp were estimated for each day of the survey by linear interpolation. Fourteen surveyed cross-sections (Fig. 2.2) of the Nottawasaga River were completed for the reach above the confluence with the Willow Creek. Section locations were first established from 1:50,000 topographic maps and modified as required during the field survey in order to provide representative cross-sections. Surveys were carried out using a survey tape and a sounding rod or chain for the waterway section and survey level (Wild Nak O serieal no. 475094) within the overbank section. Cross-sections were extended at least 50 metres from the edge of the stream. Due to the difficult access to the swamp and the numerous log jams encountered along the waterway, a canoe was used during the survey (Messrs. P. Donahue and C. Thomas) for transport.

During the bathymetric survey (October 15 to 18, 1986; Messrs. C. Thomas and G. Hebbert) of the Lower Nottawasaga River from the outlet at Nottawasaga Bay to the confluence with the Willow Creek and the foregoing Creek within the Minesing Swamp (Fig. 2.2), reference water levels were established on temporary staff gauges at the Wasaga Beach and Edenvale bridges and the crossings upstream and downstream of Jack's Lake. Nearby benchmarks were surveyed at the former two locations while a topographic elevation of the bridge decks was obtained at the Jack's Lake crossing. The elevations of the water profile at intermediate locations were interpreted linearly with chainage between these reference levels on the days of survey.

Thirty-three cross-sections (Fig. 2.2) were surveyed on the Lower Nottawasaga River below the Willow Creek confluence with a chart recording echo sounder (Furuno Model No. FE-600). Streambank surveys were carried out below Jack's Lake but were not possible above this point due to high waters which accompanied flood conditions. The topography of the floodplain was obtained from 1:10,000 Ontario base maps at these sections for modelling purposes. Doran Lake was sounded with a rod and chain due to the shallow water depths.

In the absence of as-built plans for the bridge-crossings at Jack's Lake and Doran Lake, field surveys of details required for hydraulic modelling were completed on October 28, 1986.

2.2.2.2 Presentation of Data

Survey information was documented for the Authority in the following format:

i) field survey book

ii) the location of each cross-section (Fig. 2.2)

iii) waterway and flood plain cross-sections in a digital form

iv) cross-sectional plots for each section

v) bridge dimensions and pictures

This information was forwarded to the Authority under separate cover.

2.3 Flow Monitoring

2.3.1 Upper Nottawasaga River Basin

2.3.1.1 General

There are several streamflow gauging stations within the Nottawasaga Valley Conservation Authority and the records at these hydrometric stations are useful for the calibration/validation of hydrologic models. However, some catchment areas within the NVCA have runoff characteristics that merit special attention when estimating the flood potential. Two such areas are the Innisfil Creek catchment area and the watercourses draining directly into Georgian Bay. The former catchment area has extensive municipal drains and the latter watercourses have steep channel gradients due to their proximity to the Niagara Escarpment.

In order to obtain high flow events for calibration/validation purposes, temporary manual flow gauging stations were established at a suitable location on Innisfil Creek and on Pretty River. The Pretty River was selected as being representative of the watercourses draining into Georgian Bay.

A temporary flow gauging station was also established on the upper Nottawasaga River during the study. Although a recording streamflow gauge exists at Baxter, it was felt that an additional upstream flow station on the Nottawasaga River near Alliston would provide streamflow data on a smaller catchment area for modelling purposes.

2.3.1.2 Field Monitoring Network

To obtain calibration/validation data for Innisfil Creek, Pretty River and Upper Nottawasaga River, continuous rainfall and streamflow data are required for high flow events. Based on modelling requirements, desirable flow monitoring locations for the above-noted catchment areas were initially identified from available mapping and areal photography. Similarly, two potential recording rainfall sites were identified to supplement the areal distribution provided by the existing recording rainfall network. One site was identified in the Cookstown area and the other in the Collingwood area.

Following the initial identification of potential sites, a field reconnaissance was undertaken to select appropriate sites for streamflow monitoring and rainfall observations. The following criteria was used for the selection of the streamflow sites:

- no backwater effect
- uniform channel section with non-erodible bed
- structure across the watercourse to conduct metering in safety
- easily accessible

Based on the above considerations, the following sites were selected for flow metering:

i) Innisfil Creek at the first culvert upstream of Highway 27, in the Cookstown area

ii) Pretty River at Highway 26 bridge, Collingwood

iii) Nottawasaga River at the second bridge downstream of Highway 50, south of Alliston

The locations of the above flow monitoring stations are shown in Figure 1.1. On June 25, 1986, staff gauges of three metre length were mounted on the downstream side of the concrete abutments at these locations to avoid backwater effects.

The following criteria was used for the site selection of the rainfall gauges:

- no vertical obstructions nearby to obstruct rainfall catch
- protection from potential vandalism
- availability of interested observer(s) to read the gauge(s)
- accessibility to hydro power

Two sites which met the foregoing criteria were located at 54 King St. N., Cookstown and 119 Minnesota St., Collingwood with the assistance of the Authority (Figure 2.1).

At each of the rainfall sites, a recording Tipping Bucket rain gauge was installed. Each recorder was connected to a hydro line and housed in a garage. A manual gauge was also installed near each Tipping Bucket rain gauge to compare the rainfall observations.

2.3.1.3 Training of Field Staff

The efficient and timely response required to monitor high flow events on small catchments dictates that field crews must be mobilized quickly. The assistance of the engineering firm, Reid and Associates Limited with offices in Barrie, was obtained to provide field crews on short notice to monitor high flow events.

In order to ensure that flow monitoring procedures were carried out to accepted standards, the Water Survey of Canada (WSC) personnel trained the field crews through class instruction and flow monitoring exercises at the Innisfil gauging station.

The rainfall observers were also instructed on the procedure to follow in reading the gauges and who to contact in case of a malfunction. The manual gauges were read twice daily at about 7:00 a.m. and 7:00 p.m.

2.3.1.4 Flow Monitoring Communication System

Although Reid and Associates were required to conduct the field monitoring, MacLaren Plansearch retained the responsiblity to advise the field crews of potential high flow events.

General weather reports were obtained by radio from the weather broadcast channel maintained by the Atmospheric Environment Service. However, for more specific information, arrangements were made to contact the Toronto Weather Office. Contact was initiated with the weather office to consult with the weather forecasters, obtain forecasted and observed rainfall amounts, and to obtain the path and aerial distribution of storms by the use of the weather radar.

The automated flow gauges on the Nottawasaga River at Baxter and the Pine River at Everett were also polled regularly by telephone. The information obtained from these flow gauges together with the recorded rainfall data provided an assessment of the soil moisture conditions within the NVCA. This information was useful in the assessment runoff from future rainfall amounts.

2.3.1.5 Flow Monitoring

The initial duration of the flow monitoring program was from July 2 to August 1, 1986. However, due to lack of high flow events during the above period, the flow monitoring program was extended until August 15, 1986.

Most of the rainfall events that occurred during the monitoring period were generated by thunderstorms. Unfortunately, thunderstorms are usually local in nature and their exact occurrence is difficult to forecast. This aspect made flow monitoring very difficult, because the exact rainfall amounts and the aerial distribution were often difficult to predict.

Although most of the rainfall amounts near the flow monitoring stations were generally small, one rainfall event did occur at Collingwood which provided significant rainfall. The event occurred early in the morning on July 26, 1986 and produced about 74 mm within a couple of hours. However,the thunderstorm was localized and was not brought to the attention of MacLaren Plansearch personnel by the weather office. Consequently, no flow monitoring of the Pretty River was undertaken. For the above event, the following rainfall amounts were recorded: Alliston, 20.6 mm; Cookstown, 23.6 mm; and Camp Borden, 22.0 mm. From the polling of the automated gauges on Pine River and Nottawasaga River at Baxter, the peaks generated from the above rainfall were small since fairly dry soil moisture conditions existed prior to this event.

Another major thunderstorm event occurred in the Cookstown area on August 15, 1986. The thunderstorm was part of the system that produced record rainfall in the Toronto area. Within the study area it produced the following rainfall amounts: Cookstown, 25 mm; Collingwood, 6 mm; Alliston, 11.8 mm; and Barrie, 0.0 mm. At Sharon, east of the NVCA, it produced 57.3 mm in less than one hour.

The Innisfil Creek catchment produced significant runoff from the above rainfall due to the wet antecedent soil moisture conditions. The water level at the gauging station rose about 0.75 metre. The field crew started to monitor the event starting about 21:00 hours on August 15 and finished about 16:00 hours on August 16. Since little warning was received regarding the severity of the thunderstorm and its path, there was some delay in mobilizing the field staff. Consequently, the rising limb of the flow hydrograph was not observed. The recorded hydrograph and rainfall are shown in Figure 3.5.

Daily rainfall totals recorded over the July 2 to August 15, 1986 observation period at the Collingwood and Cookstown manual gauges are presented in Table 2.2. Strip charts are also available. The continuous rainfall data was abstracted only for the August 15, 1986 event at Cookstown for the calibration of the Innisfil Creek hydrologic model.

2.3.2 Minesing Swamp and Lower Nottawasaga River

A flow and water level monitoring program was undertaken in conjunction with staff of the Conservation Authority and the Water Survey of Canada during the height of the spring freshet in 1987. The observed data was subsequently to be used for the calibration of hydraulic routing procedures on the Lower Nottawasaga River system.

Hourly stream flow information is available from permanent Water Survey of Canada gauging stations on the Nottawasaga River at Baxter, the Pine River at Everett, the Mad River near Glencairn, and the Willow River at Midhurst (Appendix L). Unfortunately, the spring data for the Pine River near Everett was not to be abstracted by the Ontario Ministry of the Environment for the Water Survey of Canada until December 1987 and was not available for the study. Further definition of inflows and discharges from the Minesing Swamp was provided by temporary stations which were established on the Nottawasaga River at the Highway No. 90 bridge in Angus and the Highway No. 26 bridge in Edenvale. River stage readings were taken within the lower Nottawasaga River at Edenvale and Wasaga Beach (Figure 1.1).

Overall coordination and organization of the field observations program was carried out by MacLaren Plansearch Inc.. Discharges emanating from the upper Nottawasaga River basin were remotely monitored by the consultant by accessing the Authority's telemark at the Baxter hydrometric station (Water Survey of Canada). At the same time, the Atmospheric Environment Service was contacted for forecasts of temperature (5 day) and rainfall (24 hours to 48 hours). Snowpack estimates for the watershed were available from snow-

TABLE 2.2

DAILY RAINFALL TOTAL RECORDED AT COLLINGWOOD AND AT COOKSTOWN

Date (1986)	Collingwood (mm)	Cookstown (mm)
July 2	-	2
3	-	-
4	5	Trace
5	1	1
6	-	-
7	-	-
8	-	-
9	-	Trace
10	-	-
11	-	-
12	Trace	Trace
13	19	8
14	Trace	-
15	-	-
16	-	-
17	9	7
18	2	11
19	-	2
20	-	-
21	-	-
22	-	-
23	-	-
24	-	-
25	-	-
26	74	23
27	-	-
28	2	-
29	Trace	-
30	1	-
Aug. 1	6	10
2	-	-
3	-	Trace
4	-	-
5	-	-
6	Trace	-
7	6	10
8	15	N/A
9	16	11
10	Trace	Trace
11	-	-
12	-	-
13	-	-
14	Trace	-
15	6	39

courses maintained by the Conservation Authority. When meteorological forecasts together with rising flows on the upper Nottawasaga River indicated the possibility of a significant spring flow event, a joint decision was made by the Authority and the consultant whether to assign a Water Survey of Canada field crew to the Nottawasaga River basin for flow monitoring duties. Flow monitoring was initiated by the consultant through a request for assistance which was directed to the Water Survey's office in Guelph.

Flow observations made by the Water Survey of Canada crew on the downstream side of the bridges at Highway No. 90 in Angus and Highway No. 26 at Edenvale between April 4 and 15, 1987 are presented on Table 2.3. Suspension measurements from the bridges were undertaken with Price current metres used to measure the velocity at the various metering panels. Discharges at Angus on intermediate days were synthesized during the subsequent dynamic routing investigations from continuous flow records which were available from the permanent stations on the Nottawasaga River at Baxter.

Water stages which were recorded on the lower Nottawasaga River by Authority staff over the freshet period are summarized in Table 2.4. The consultant had installed staff gauges at the Edenvale and Wasaga Beach bridges during the fall of 1986 in preparation for the spring monitoring program. In view of problems in observing levels at the old Highway No. 92 bridge in Wasaga Beach and concerns about the influence of lake elevations at this site, the Authority established a temporary staff gauge further upstream at the Schoonertown bridge and recorded water surface elevations throughout the high water period. These gauges were surveyed into the geodetic datum (G.S.C.) in order to relate observed water levels to computed flow profiles.

TABLE 2.3

WATER SURVEY OF CANADA FLOW OBSERVAIONS

Date	Location	River	Width (m)	Area (m^2)	M. Vel. (m/s)	M.G.H. (m)	Discharge (m^3/s)
Mar 08/87	Angus[1]	Nottawasaga	44.0	111	0.533	1.250	59.2
Apr 04/87	Angus	Nottawasaga	48.0	133	0.672	1.35	89.6
Apr 05/87	Angus	Nottawasaga	50.0	160	0.765	--	122.0
Apr 09/87	Angus	Nottawasaga	45.0	106	0.569	0.981	60.1
Apr 10/87	Angus	Nottawasaga	43.0	95.0	0.535	0.738	50.8
Apr 15/87	Angus	Nottawasaga	42.0	58.4	0.480	--	28.0
Apr 06/87	Edenvale[2]	Nottawasaga	85.5	219.0	0.310	--	67.9
Apr 09/87	Edenvale	Nottawasaga	80.0	247.0	0.514	3.180	127.0
Apr 10/87	Edenvale	Nottawasaga	80.0	254.0	0.508	3.13	125.0
Apr 15/87	Edenvale	Nottawasaga	80.0	199.0	0.485	2.500	96.5

(1) Dwoper Model Cross-section No. 1; Chainage 45,900 m

(2) Dwoper Model Cross-section No. 12; Chainage 29,910 m