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MAINTENANCE PLAN FOR THE LAM NAM OON IRRIGATION SYSTEM IN NORTHEAST THAILAND

WATER MANAGEMENT SYNTHESIS PROJECT

WMS REPORT 13

MAINTENANCE PLAN FOR THE LAM NAM OON IRRIGATION SYSTEM IN NORTHEAST THAILAND

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With Thai translation by Sanae Sangsuk

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WATER MANAGEMENT SYNTHESIS PROJECT

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PREFACE

My greatest concern with writing this report, "Maintenance Plan for the Lam Nam Oon Irrigation System in Northeast Thailand," is that the focus is upon problems, rather than attributes, so that this report may appear too critical, or negative. This definitely was not my intent! Unfortunately, this irrigation project has received too much criticism in the past.

In completing this three-month assignment, I have become very impressed with this particular project. First of all, the physical combination of water supply, water control facilities, and amount of land to be served demonstrates good planning. But, the most exciting aspect of this project is the interdepartmental government agency infrastructure that has been developed in recent years. There is a high degree of cooperation under the Lam Nam Oon Integrated Rural Development Project among the Royal Irrigation Department, Community Development Department, Department of Agriculture, Department of Fisheries, etc. The leadership and a number of the staff in these departments are highly competent and energetic.

The Lam Nam Oon Irrigation Project has most of the required attributes for becoming a highly successful irrigation project. The major difficulty is that the farmers are not experienced in irrigated agriculture. Herein lies the greatest challenge for the next 10-20 years.

Gaylord V. Skogerboe

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Many people have supported this particular field activity. Most of all, I have to thank Khun Vichai Snguanpaiboon, Project Field Director for the Lam Nam Oon Integrated Rural Development Project, who provided many support services, such as a vehicle and driver, maps, documents, photography, offices, drafting, typing, etc. Even more importantly, he spent the necessary time with me in discussing issues. So many of the field and office staff provided support to this effort that I dare not begin to mention names for fear of offending someone by not having listed their name.

I greatly appreciate the time and insights provided by Khun Nukhul Thongtawee, Director, O&M Division, Royal Irrigation Department, Bangkok, who is both experienced and well read about irrigated agriculture. Also, the Deputy Director, Khun Sunthorn Rungrongtaanin, was very helpful in providing both information and advice.

The Louis Berger International Team stationed at Lam Nam Oon -- Mr. James Dalton, Mr. William Bell and Mr. Anthony Zola -- were extremely helpful in my developing an understanding of the irrigation system, as well as providing support whenever necessary. Mr. Gian N. Kathpalia, Asian Development Bank consultant to the Nong Wai Irrigation Project near Khon Kaen, spent numerous hours with me discussing O&M in the Northeast, and certainly some of his concepts are contained in this report.

This assignment resulted from a chance meeting in Burma last summer with the U.S. Aid/Bangkok Project Officer, Ms. Sara Schwartz, who also made every effort to support this activity. The U.S. Aid Assistant Project Officer, Khun Kamol Chantanumate, was extremely helpful by introducing me to the Northeast and to Thai culture, and his advice helped me immeasurably.

Finally, I need to pay special tribute to those who worked with me in the field and were instrumental in completing this assignment on time. My greatest teacher was Khun Sanae Sangsuk, who not only served as translator, but also actively participated in the field work and was forthright and honest in advising me. Khun Suphakiet Olansatien, an Irrigation Engineer stationed at the Royal Irrigation Department Regional Office in Ubol, was assigned as a counterpart to be trained in the maintenance of irrigation systems, and I certainly hope he benefited from the experience for he is capable of conducting similar investigations for other irrigation projects in the Northeast. One of the joys of this field experience was having the driver, Khun Sawai Kanchieng, also take a keen interest in learning how to identify maintenance problems and work alongside the rest of us.

I am very grateful to all my teachers of Thai culture and irrigation in the Northeast. My thanks to all of you for such an educational and enjoyable experience.

Gaylord V. Skogerboe

SECTION I

SUMMARY OF MAINTENANCE PLANS

There are two types of maintenance discussed in this report--"catch-up" and preventive. The term "catch-up" implies a deterioration of the irrigation system beyond what would be corrected under a preventive maintenance program; thus, the need to undertake and complete a catch-up maintenance program in order to correct present deficiencies so that an effective preventive maintenance program can be implemented to avoid future deterioration of the irrigation facilities.

Catch-up maintenance is needed for the Lam Nam Oon irrigation system because a lack of manpower, equipment, and budget is resulting in a deterioration of the system. The proposed short-term and medium-term plans will satisfy the requirements for completing the catch-up maintenance, which then allows the long-term plan to provide mostly for preventive maintenance. The short-term plan would be accomplished during Fiscal Year 1983 (FY 83), the medium-term plan during Fiscal Years 1984, 1985, 1986 and 1987, and the long-term plan would begin in FY 88.

Three methods are proposed for accomplishing the catch-up maintenance needs: (a) emergency; (b) contract; and (c) force account. Emergency maintenance consists of constructing deep open drains on both sides of the Left Main Canal between stations 12+500 and 16+000 (3.5 km) and then replacing and repairing damaged concrete lining panels. Contract maintenance consists of providing surface and subsurface drainage at specified locations along the Right Main Canal and the Left Main Canal. The remaining catch-up maintenance needs would be done by force account using the manpower, equipment, and budget made available to the Operation and Maintenance (O&M) Division at Lam Nam Oon.

The short-term plan (FY 83) consists of:

1. Completing emergency maintenance;
2. Completing field surveys and initiating the designs for contract maintenance; and
3. Doing the following force account maintenance activities:
   a. Complete as many of the Critical Maintenance Needs (Appendix A) as possible; and
   b. Obtain approvals within the Royal Irrigation Department for the proposed maintenance equipment list, call for bids, and award bid.

The medium-term plan (Fiscal Years 1984, 1985, 1986, and 1987) consists

1. Completing the bidding documents for the proposed contract maintenance in FY 84, undertake construction in FY 85, and complete construction before the 1986 monsoon season;
2. Having the proposed maintenance equipment available at Lam Nam Oon during FY 84.
3. Filling the requested O&M new positions during Fiscal Years 1984, 1985, and 1986;
4. Providing additional budget to the O&M Division at Lam Nam Oon for the force account catch-up maintenance;
5. Completing by force account all of the Critical Maintenance Needs listed in Appendix A before the 1984 monsoon season;
6. Removing sediment from all irrigation channels; and
7. Completing all of the catch-up maintenance needs listed in Appendix B.

The long-term maintenance plan, which would begin in FY 88, consists of:

1. Completing all of the required surface and subsurface drainage facilities for the laterals and sublaterals;
2. Eliminating at least 90 percent of all sediment sources along the irrigation channels;
3. Completing the sealing of all concrete lining panel joints with asphalt;
4. Periodically replacing worn-out maintenance equipment;
5. Continually providing funds for the purchase of maintenance materials; and
6. Adhering to a strict program of preventive maintenance.

In accordance with the time schedule for the short-term, medium-term, and long-term plans, the additional (new) funding required in Baht to accomplish catch-up maintenance would be as follows:

Table 1. Summary of costs for the catch-up maintenance plan for the Lam Nam Oon irrigation system. (All costs are in Baht (฿) where 23 ฿ = $1 U.S.A.)

Maintenance Method	Short-Term Plan	Medium-Term Plan by Fiscal Year			
	1983	1984	1985	1986	1987
Emergency Maintenance	9,500,000	-	-	-	-
Contract Maintenance	-	-	9,500,000	9,500,000	-
Force Account Maintenance	-	998,271	1,400,000	1,800,000	2,000,000
FISCAL YEAR TOTALS, Baht	9,500,000	998,271	10,900,000	11,300,000	2,000,000

For the long-term plan, there will be a need to provide about Baht 1,000,000 each year for the purchase of maintenance materials, while another Baht 1,000,000 should be provided each year for the replacement of worn-out equipment. These are estimated costs for the year 1982; these figures need to be corrected each year for inflation.

SECTION II

INTRODUCTION

GENERAL DESCRIPTION OF IRRIGATION SYSTEM

The Lam Nam Oon (Lam is the Thai word for river) is the major tributary of the Lam Nam Songkam, a major drainage area north of the Phu Phan mountain range located on the Korat Plateau in Northeast Thailand. The Nam Oon Dam is located roughly 60 km west of the provincial capital city of Sakon Nakhon and 120 km east of the city of Udon Thani as shown in Figure 1.

The Nam Oon Dam is an earthfill structure having a crest length of 3,300 m, height above the river bed of 29.5 m, and bedrock 9.5 m below the river bed. The reservoir has a total storage capacity at 185 m above mean sea level (msl) of 520 million cubic meters and a dead storage capacity at 175 m above msl of 45 million cubic meters, leaving an active reservoir capacity of 475 million cubic meters. The average annual reservoir inflow is 365 million cubic meters, with the estimated mean annual reservoir evaporation loss being 60 million cubic meters. The reservoir area at 185 m above msl is 85 square kilometers, while the watershed area is 1,100 square kilometers. The average annual rainfall is 1,400 mm, most of which occurs during the monsoon season of May-October.

The irrigated area of approximately 185,000 rai (1 rai is 40 m x 40 m, or 0.16 hectares, or 0.4 acres) is served by two major canals--the Right Main Canal and the Left Main Canal. The Right Main Canal is 45.7 km in length and serves 122,545 rai, where Table 2 shows the irrigable land and discharge capacity of each Farm Turnout (FTO) structure along the Right Main Canal (e.g., FTO 1L is the control regulator serving 121 rai, whereas R-1L is the FTO regulator for Lateral R-1L, which has many Farm Turnouts along

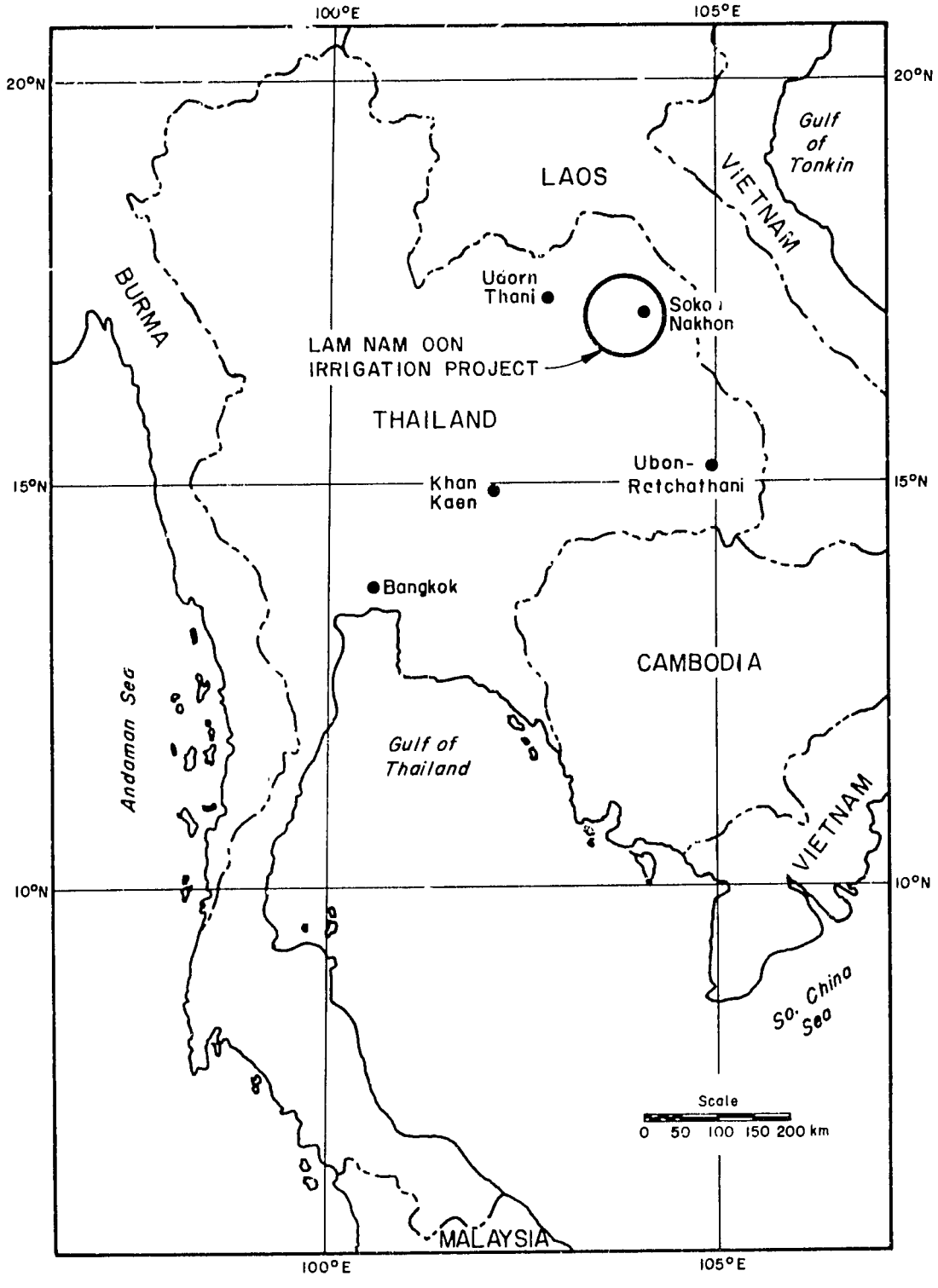


Figure 1. Location of the Lam Nam Oon Irrigation System, Sakon Nakhon Province, Northeast Thailand

its length). The Right Main Canal has a design discharge capacity of 21.8 cubic meters per second (m^3/s or cms) and an initial concrete trapezoidal cross-section having a bottom width of 5 m, side slopes of 1½ horizontal to 1 vertical, and a vertical depth of 2.85 m.

The Left Main Canal is 28 km in length and serves 63,177 rai, where Table 3 shows the irrigable land and discharge capacity of each FTO structure. The Left Main Canal has a design discharge capacity of 9.1 cms with an initial concrete trapezoidal cross section having a bottom width of 3 m, side slopes of 1½ horizontal to 1 vertical, and a vertical depth of 1.85 m.

A map showing the location of canals, laterals, and sublaterals in the Lam Nam Oon irrigation system is shown in Figure 2. Tables 4 and 5 give the length of concrete lining for each lateral and sublateral. Sandy soils are predominant throughout the Northeast, including the Lam Nam Oon project lands. Irrigation channels generally require concrete lining to prevent serious degradation, as well as to avoid excessive seepage losses.

APPROACH IN DEVELOPING MAINTENANCE PLAN

Many of the Royal Irrigation Department officers loacted at the Lam Nam Oon Irrigation Project recognize the maintenance problems in the water delivery network. Most Northeast irrigation projects have similar maintenance problems which result from the physical combination of sandy soils and monsoon rains. The damaging effects of this physical phenomenon has been observed by project personnel. The surface runoff from the roadways and berms alongside the irrigation canals and laterals results in the erosion of the sandy banks, much of which is transported into the irrigation channels. Other problems frequently cited include the lack of equipment, manpower, and budget limitations.

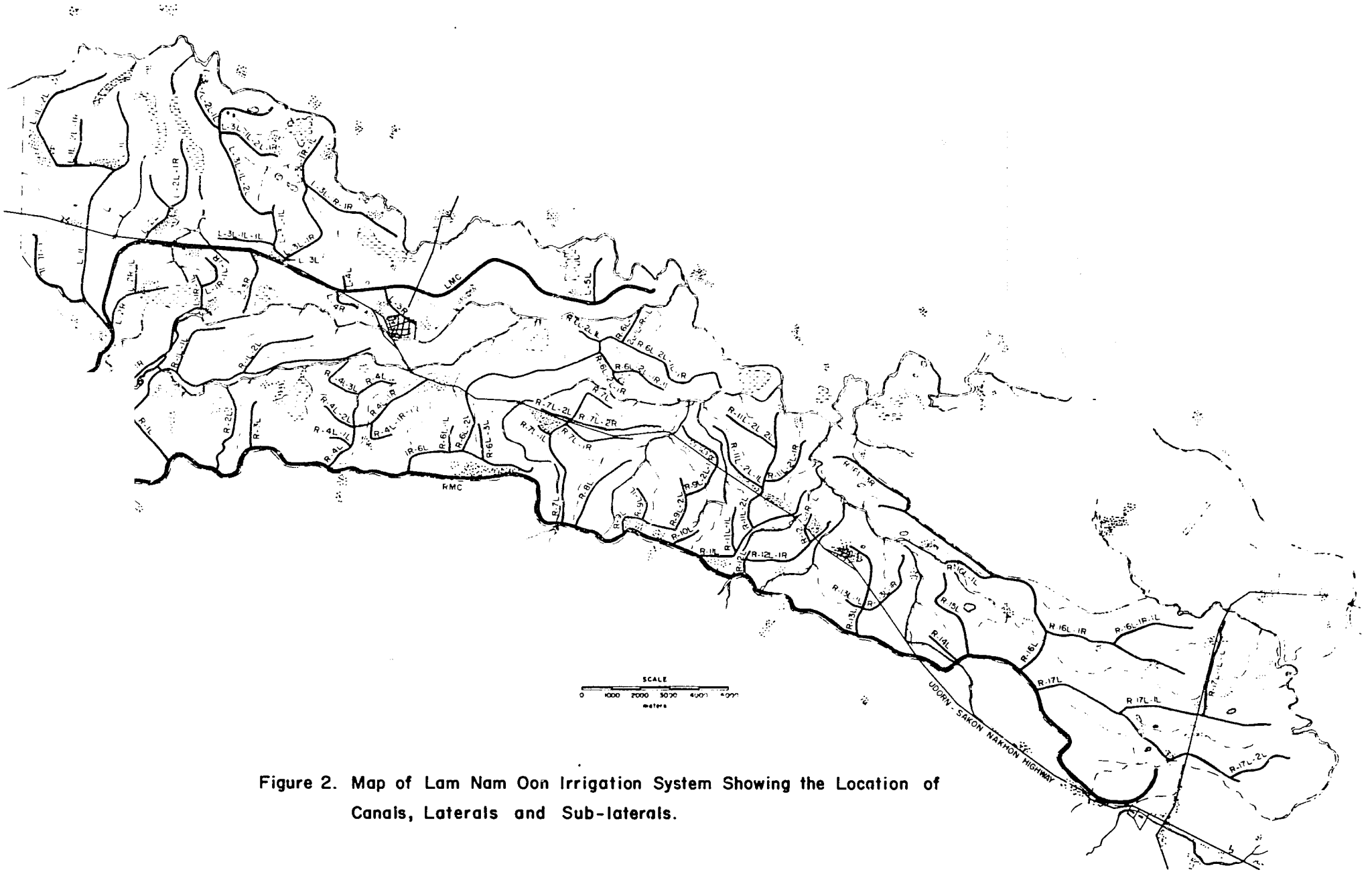


Figure 2. Map of Lam Nam Oon Irrigation System Showing the Location of Canals, Laterals and Sub-laterals.

The intent of this study was to document the required maintanance that needs to be done; estimate the costs of doing such maintenance; determine the requirements for maintenance equipment; and estimate manpower requirements and their costs. In addition, some assessment would be made of the maintenance requirements for the on-farm irrigation delivery channels, which are the responsibility of the Water Users Groups to maintain.

An initial review was conducted of the operation and maintenance (O&M) reports prepared by various consultants to the Royal Irrigation Department. Discussions were held with O&M personnel within the department, as well as other consultants. Field work primarily consisted of a detailed inventory along the full-length of every concrete-lined canal, lateral and sublateral. This investigation provided considerable insight into the physical phenomena affecting maintenance. It also allowed for a valuable working knowledge of the system inself. The costs associated with correcting the maintenance problems were developed in cooperation with O&M personnel at Lam Nam Oon Project Headquarters. This is also true of the manpower requirements needed for implementing the proposed maintenance plan. The Royal Irrigation Department and U.S. Agency for International Development (USAID) previously had developed a list of maintenance equipment needed to supplement the limited amount presently available at Lam Nam Oon.

The cumulative results of these studies were used in developing an over-all maintenance plan for the Lam Nam Oon irrigation system. To that end, short-term, medium-term, and long-term maintenance procedures are to be developed. The short-term aspects of the over-all plan will emphasize what can be accomplished with the existing manpower, equipment, and budget. The medium-term aspects will focus upon catching-up on present maintenance requirements so as not to continue falling behind each year. Finally, the

long-term aspects of the plan will develop maintenance requirements following completion of all on-farm construction (at this time only 10 percent of the irrigable area has completed on-farm facilities).

Table 2. Number, Location, Irrigable Area, and Discharge Capacity of Farm Turnouts (FTO's) Along the Right Main Canal

FTO Number	Location, meters	Irrigable area, rai	Discharge capacity, m^3/s(cms)
1L	1+850	121.0	0.048
R-1L	2+170	12,356.7	2.424
2L	3+390	114.7	0.048
3L	3+820	152.0	0.061
R-2L	4+195	664.5	0.2658
4L	4+252	143.5	0.057
5L	4+800	87.5	0.035
6L	5+350	151.0	0.060
7L	5+650	207.0	0.083
R-3L	5+760	741.2	0.2965
8L	5+800	97.5	0.039
9L	6+200	151.0	0.060
10L	6+850	122.0	0.049
11L	7+600	72.0	0.0288
12L	8+600	56.0	0.0224
R-4L	8+822	5,096.5	1.2899
13L	9+700	50.0	0.0200
14L	11+100	150.5	0.0602
15L	11+550	69.0	0.0276
R-6L	11+935	17,660.4	3.240
16L	13+000	298.8	0.1195
17L	13+600	118.7	0.04748
18L	14+960	126.0	0.0504
19L	16+800	248.5	0.0994
20L	17+400	142.0	0.0568
21L	17+950	231.5	0.0926
R-1L	18+895	6,152.2	1.456
22L	19+305	88.0	0.0352
R-8L	19+495	1,599.3	0.6397
23L	20+220	212.5	0.085
24L	21+200	118.5	0.0474

Table 2. continued

FTO Number	Location, meters	Irrigable area, rai	Discharge capacity, m^3/s(cms)
R-9L	21+515	5,183.3	1.313
25L	22+800	105.0	0.042
26L	23+350	159.0	0.0636
R-10L	23+516	284.1	0.1136
27L	23+550	192.0	0.0768
28L	24+000	218.0	0.0872
R-11L	24+470	8,663.5	1.880
29L	25+350	166.5	0.0666
30L	26+300	55.5	0.00222
R-12L	26+403	2,642.6	0.907
31L	26+550	208.0	0.0832
32L	27+550	163.0	0.0652
33L	28+396	160.0	0.064
34L	28+796	217.5	0.087
35L	29+645	178.5	0.0714
36L	29+835	207.5	0.083
37L	30+195	171.0	0.0684
38L	31+540	416.0	0.1664
39L	31+820	350.5	0.1402
R-13L	31+860	4,767.9	1.237
40L	32+400	188.8	0.0755
41L	32+940	230.8	0.0923
42L	34+030	155.0	0.0620
43L	34+500	232.5	0.0930
44L	35+660	243.3	0.0973
R-14L	35+733	642.1	0.2568
45L	35+800	284.7	0.1139
R-15L	36+123	2,474.9	0.880
46L	36+200	136.1	0.0544
47L	36+650	318.7	0.1275
48L	36+650	432.2	0.1729

Table 2. continued

FTO Number	Location, meters	Irrigable area, rai	Discharge capacity, m^3/s(cms)
49L	37+000	382.9	0.1532
50L	37+500	343.9	0.1376
51L	38+000	476.4	0.1906
R-16L	38+100	13,552.0	3.5200
52L	38+500	479.8	0.1919
53L	38+850	329.5	0.1318
R-17L	38+900	16,199.7	3.520
54L	39+250	728.8	0.2915
55L	40+500	995.3	0.3981
56L	41+400	521.5	0.2086
57L	42+000	500.0	0.200
58L	42+350	250.0	0.100
59L	43+700	565.2	0.2261
60L	44+700	652.9	0.2612
61R	45+230	493.4	0.1974
62	45+700	481.0	0.1924
	Total	114,400.9	29.5045

Table 3. Number, Location, Irrigable Area, and Discharge Capacity of Farm Turnouts (FTO's) Along the Left Main Canal

FTO Number	Location, meters	Irrigable area, rai	Discharge capacity, m^3/s(cms)
L-1R	1+420	4,440.40	1.1608
1R	1+850	286.50	0.1146
2L	2+900	87.80	0.0351
3R	3+200	319.50	0.1278
4R	3+600	217.00	0.0868
5R	3+800	52.50	0.0210
6R	4+400	183.00	0.0732
7R	4+800	489.00	0.1956
L-1L	6+000	17,492.20	3.2117
L-2R	6+000	2,369.50	0.8483
L-2L	9+724	3,619.30	1.035
L-3R	13+400	1,759.50	0.7038
8L	13+880	253.85	0.1015
L-3L	14+560	15,527.60	2.8526
9L	16+000	341.50	0.1366
10R	16+500	573.852	0.2151
L-4R	16+600	510.500	0.2040
11L	16+860	341.00	0.1364
L-4L	16+975	560.00	0.1839
12L	17+290	352.00	0.1408
13L	17+650	271.150	0.1085
14R	17+675	367.00	0.1468
15R	17+960	358.00	0.1432
L-5R	18+400	1,244.50	0.4978
16R	18+650	275.50	0.1162
17L	19+400	585.50	0.2324
18L	19+980	383.50	0.1534
19R	20+036	459.50	0.1838
20L+20R	20+200	242.50	0.0970
21R	20+500	139.00	0.0556
22L	21+500	507.50	0.2030

Table 3. continued

FTO Number	Location, meters	Irrigable area, rai	Discharge capacity, m^3/s(cms)
23R	21+700	229.00	0.0916
24R	22+200	435.00	0.1740
25L	22+200	679.00	0.2716
26R	22+800	77.00	0.030
27L	22+800	307.50	0.1230
28L	22+950	305.00	0.1220
29L	23+260	277.00	0.1108
30R	23+260	249.00	0.0996
31L	23+950	309.50	0.1238
32R	24+100	540.00	0.2160
33L	24+520	537.00	0.2148
34R	24+520	509.00	0.2036
35L	25+500	342.50	0.1370
36R	25+500	167.50	0.0670
37L	25+920	307.50	0.1230
38R	25+980	351.00	0.1404
L-5L	26+800	1,029.20	0.4117
39L	26+900	312.00	0.1248
40R	26+900	413.00	0.1652
41R	27+550	200.0	0.0800
42R	28+000	180.0	0.0720
43L	28+000	175.0	0.0700
44	28+040	161.50	0.0646
	Total	63,153.352	16.7373

Table 4. Length of Concrete-Lined Laterals and Sub-Laterals Served by the Right Main Canal

Canal	Lateral	Sub-Lateral	Length, km	Year Constructed
RMC			45.700	1975-1979
	R-1L		11.415	1975
		R-1L-1L	2.500	1975
		R-1L-2L	2.800	1975
	TOTAL FOR LATERAL R-1L		16.715	
	R-2L		3.515	1976
	R-3L		1.600	1976
	R-4L		4.600	1977
		R-4L-1L	0.800	1977
		R-4L-2L	1.120	1977
		R-4L-3L	2.020	1977
		R-4L-1L	3.200	1977
		R-4L-1R-1R	1.150	1978
	TOTAL FOR LATERAL R-4L		12.890	
	R-6L		4.900	1976
		R-6L-1L	0.900	1976
		R-6L-2L	7.790	1976-1979
		R-6L-3L	1.300	1976
		R-6L-2L-1L	1.120	1979
		R-6L-2L-1L-1R	5.400	1979
		R-6L-2L-1L-1R-1L	1.550	1979
		R-6L-2L-1R	1.200	1979
		R-6L-2L-1R-1L	1.810	1979
	TOTAL FOR LATERAL R-6L		25.970	

Table 4. continued

Canal	Lateral	Sub-Lateral	Length, km	Year Constructed
	R-7L		6.120	1976-1978
		R-7L-1L	0.620	1976
		R-7L-1R	2.500	1976
		R-7L-2L	1.020	1976-1978
		R-7L-2R	3.420	1976-1978
	TOTAL FOR LATERAL R-7L		13.680	
	R-8L		3.050	1977
	R-9L		2.655	1977-1978
		R-9L-1L	1.180	1977
		R-9L-2L	2.160	1977-1978
		R-9L-2L-1R	3.450	1979
	TOTAL FOR LATERAL R-9L		9.445	
	R-10L		1.100	1977
	R-11L		4.800	1978
		R-11L-1L	1.500	1978
		R-11L-2L	4.500	1977-1978
		R-11L-2L-1R	2.300	1977-1978
		R-11L-2L-1L	2.900	1979
		R-11L-2L-2L	2.100	1979
	TOTAL FOR LATERAL R-11L		18.100	
	R-12L		0.800	1979
		R-12L-1R	3.700	1979
		R-12L-1R-1L	1.230	1979
	TOTAL FOR LATERAL R-12L		5.730	
	R-13L		3.720	1979
		R-13L-1L	0.760	1979
		R-13L-1R	3.050	1979
	TOTAL FOR LATERAL R-13L		7.530	

Table 4. continued

Canal	Lateral	Sub-Lateral	Length, km	Year Constructed
	R-14L		1.300	1979
	R-15L		3.700	1979
	R-16L		9.500	1980
		R-16L-1L	2.068	1980
		R-16L-1R	5.000	1980
		R-16L-1R-1L	2.943	1980
		R-16L-3R	3.430	1980
	TOTAL FOR LATERAL R-16L		22.941	
	R-17L		8.370	1980
		R-17L-1L	5.580	1980
		R-17L-1L-1L	3.670	1980
		R-17L-2L	2.460	1980
	TOTAL FOR LATERAL R-17L		20.080	
		GRAND TOTAL	213.046	

Table 5. Length of Concrete-Lined Laterals and Sub-Laterals Served by the Left Main Canal

Canal	Lateral	Sub-Lateral	Length, km	Year Constructed
LMC			28.040	1973-1975
	L-1L		9.310	1973-1977
		L-1L-1L	3.400	1973
		L-1L-2L	6.500	1978
		L-1L-2L-1R	1.500	1978
	TOTAL FOR LATERAL L-1L		20.710	
	L-1R		6.624	1973
		L-1R-1L	1.170	1974
		L-1R-1L-1R	1.569	1974
	TOTAL FOR LATERAL L-1R		9.363	
	L-2L		3.500	1974
		L-2L-1R	2.880	1974
	TOTAL FOR LATERAL L-2L		6.380	
	L-3L		0.835	1978
		L-3L-1R	3.173	1978
		L-3L-1R-1R	3.500	1979
		L-3L-1R-1L	1.920	1978
		L-3L-1L	2.020	1978
		L-3L-1L-1L	1.900	1978
		L-3L-1L-2L	6.320	1979
		L-3L-1L-2L-1R	2.155	1979
		L-3L-1L-2L-1L	2.000	1979
	TOTAL FOR LATERAL L-3L		23.823	

Table 5. continued

Canal	Lateral	Sub-Lateral	Length, km	Year Constructed
	L-4L		0.530	1974
	L-5L		1.600	1975
	L-2R		3.010	1973
		L-2R-1L	1.250	1973
	TOTAL FOR LATERAL L-2R		4.260	
	L-3R		2.500	1974
	L-4R		1.500	1974
	L-5R		1.650	1974
		GRAND TOTAL	100.356	

SECTION III

PHYSICAL PHENOMENA AFFECTING REQUIRED MAINTENANCE

A general description of the physical phenomena occurring in the Lam Nam Oon irrigation system needs to be presented in order to understand the relationship between the field maintenance inventory and the proposed solutions contained in the form of maintenance needs, including activities, costs, and manpower. There are four distinct areas of concern. The most serious problem is the formation of cavities behind the concrete lining panels which eventually leads to the actual failure of the panels themselves. Second, sedimentation is a serious problem in some channels, but not others. The theoretical approach to this problem is to prevent the sediment from ever entering the irrigation channels. Third, aquatic growth is a difficult problem especially as the present level of technology generally allows for such growth to be removed only by hand or mechanically. The fourth, and final, area of concern is a problem unique to Thailand--the extensive use of the irrigation system for fishing. Fishing practices have resulted in considerable maintenance being required, and in some cases extensive damages have occurred.

To provide further insight into solutions to the various maintenance problems, the role of drainage is discussed. To complete the general picture about maintenance needs in the system, the impact of various structures upon maintanance requirements is presented.

PHYSICAL PHENOMENA

Cavities

The most serious long-term damage to the concrete-lined irrigation channels is the formation of cavities behind the wall panels such as shown

in Figures 3 and 4. The systematic physical process of cavity formation followed by eventual failure of the concrete panel(s) results from the combination of lining panel joints, sandy soils, and monsoon rains, with many other contributing factors.

Generally, the concrete lining panels are three meters in length. Alternate panels are formed with wood strips and then poured in-place. Later, the wood strips are removed and the open space three meters in length is completely filled with concrete. A triangular-shaped piece of wood is used shortly after pouring to etch a joint about 1-2 cm deep. However, upon drying, there is frequently an open joint between the concrete panels that is 2-5 mm wide. These open joint openings are the result of concrete shrinkage. The wider joint openings are most likely caused by the more rapid drying of the poured concrete due to inadequate curing, with the thickness of the lining as a possible contributing factor.

The process of cavity formation most commonly begins with seepage through the joint into the irrigation channel. This seepage also carries some sediment into the channel, which results in a small cavity near the joint. Since the easiest path of the seepage water is vertically along the joint, once this process begins it does not take too long for the cavity to progress upwards until there is an actual opening at the top of the lining wall panel. Then, as surface runoff during the monsoon rains starts running down into the open cavity, it enlarges even more.

During this process of cavity enlargement, the concrete panel begins to deteriorate. First of all, very small amounts of concrete on the sides of the joint opening begin to break off, most commonly just above the floor level, but sometimes much higher. Next, hairline cracks will likely occur, first near the joint but perhaps later across the full width or height of

Figure 3. Medium-Sized Cavity behind Left Side of the Right Main Canal

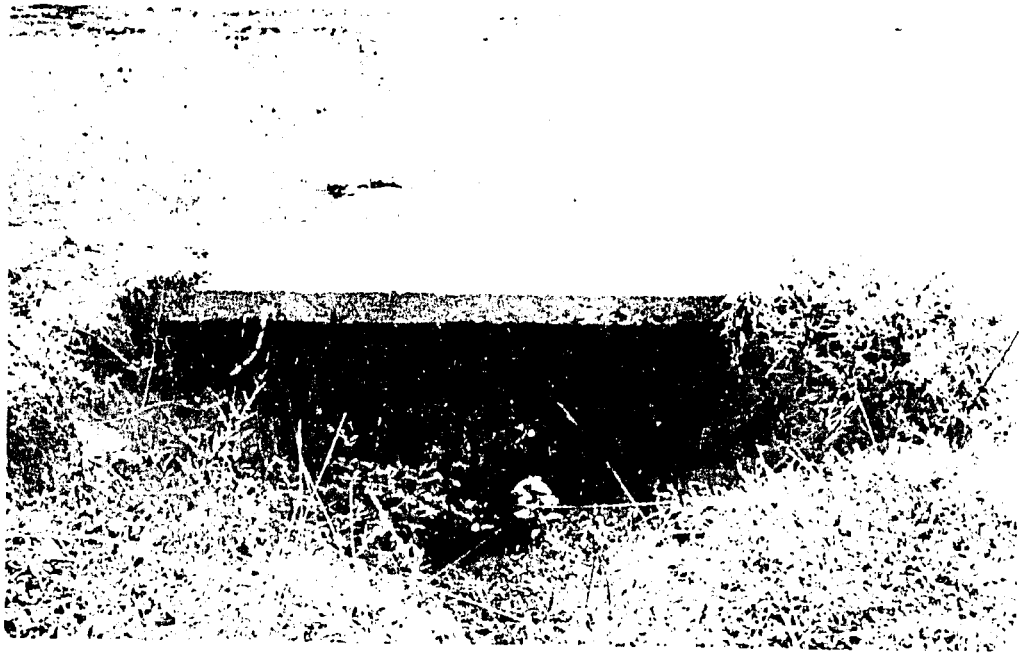


Figure 4. Huge Cavity behind Concrete Panel along the Right Main Canal

the panel. Soon, a small chunk of concrete adjacent to the joint will break off, thereby leaving a small hole in the lining (Figure 5). This small hole further aggravates the problem by allowing the cavity underneath to further enlarge, so that larger chunks of concrete eventually break off (Figure 6). At this point, water in the irrigation channel is also eroding the underlying soil. The filling and emptying of the irrigation channel, which occurs frequently, further aggravates this process of soil erosion. The eventual outcome of this physical phenomena is the failure of the concrete lining panel. This process is accelerated if surface runoff from the roadway or berm is allowed to flow towards the irrigation channel. If the cavity has formed an opening to the top of the lining, then some of the surface runoff will flow into the cavity, thereby increasing the seepage flow and sediment transport through the joint. Thus, the cavity becomes enlarged even more rapidly. If the soil surface is depressed below the top of a panel, then the surface runoff will pond behind the panel and is likely to move along the interface between the soil and concrete, eventually reaching a joint as an outlet.

Concrete-lined irrigation channels located in cut areas are highly susceptible to cavity formation and eventual failure of the lining panels (Figure 7). (In contrast, concrete lining in fill areas, such as shown in Figure 8, is usually in excellent condition unless the fill was not properly compacted as shown in Figure 9.) The cut banks are easily eroded and eventually: (a) surface runoff containing high sediment concentrations are being transported into the irrigation channel; and (b) the soil is saturated to a height higher than the top of the panels. This results in seepage flow over the panels in some cases, as well as definitely increasing the seepage rate and sediment transport through the joints. In addition, seepage

Figure 5. Right Main Canal in Cut Area with Right Berm Surface Erosion into Canal and Many Holes in Lining

Figure 6. Concrete Lining Panel with Large Hole in Cut Area along the Right Main Canal

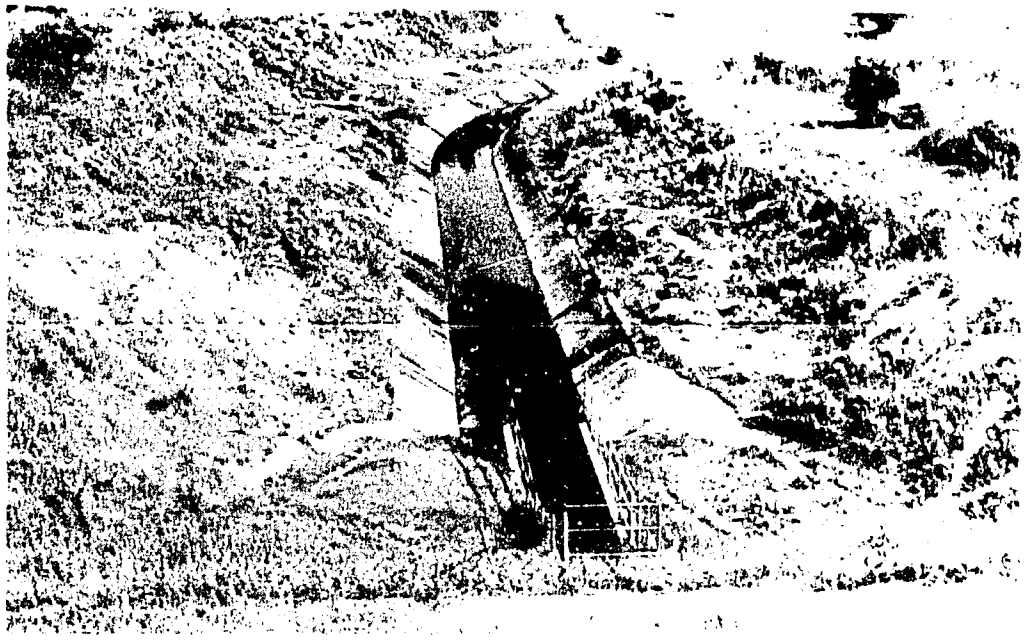


Figure 7. Cut Area at the Nam Oon Dam Outlet Works for the Left Main Canal

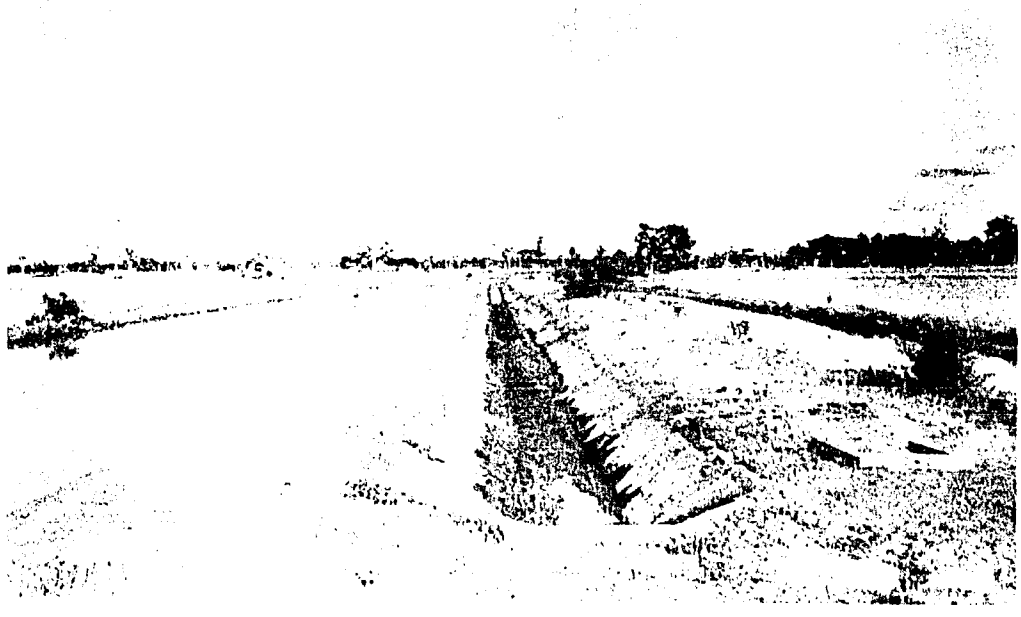


Figure 8. Concrete Lining in Lateral L-2R is in Excellent Condition because Adjacent Land is Below the Lateral Invert Elevation

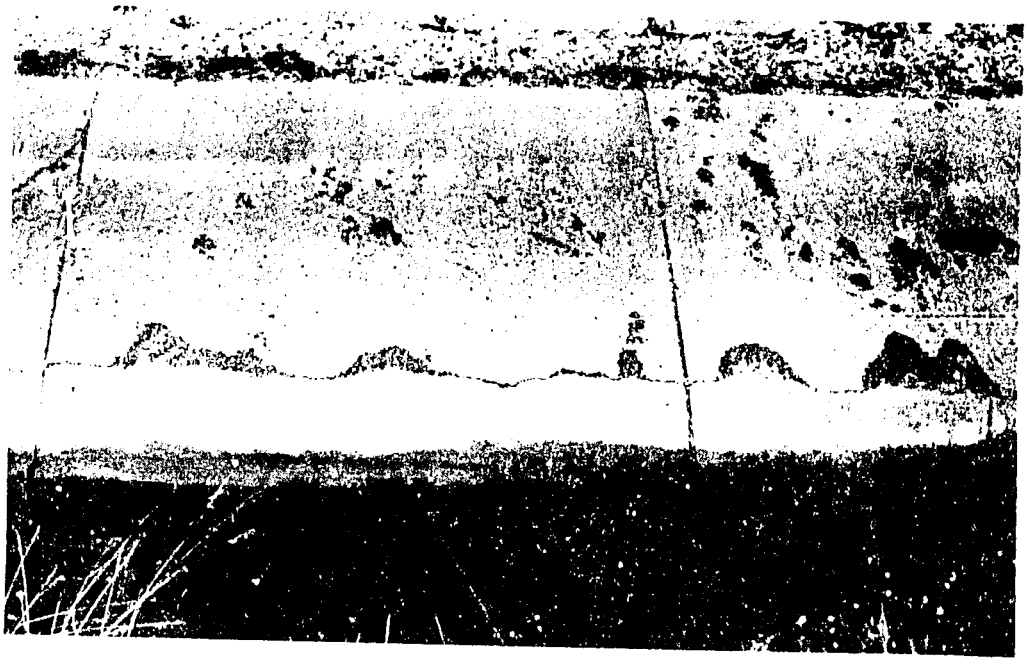


Figure 9. Cracked Right Concrete Lining Panels Due to Right Berm Soil Settlement at Station 1+600, Lateral L-1L

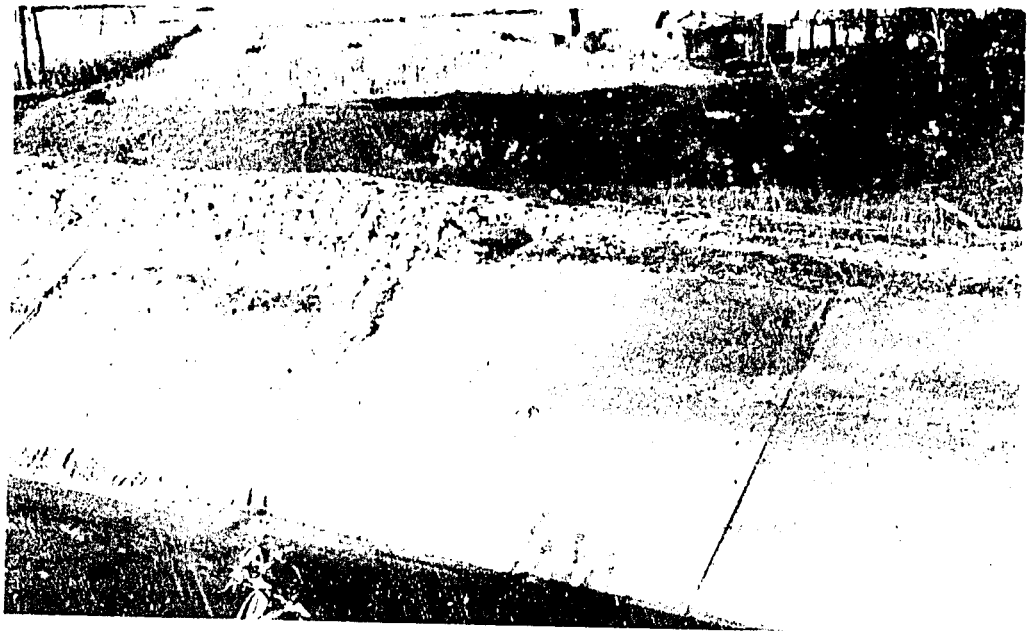


Figure 10. Sediment Removed from Lateral L-1L is Placed on Edge of Right Berm where Monsoon Rains will Wash Sediment Back into the Irrigation Channel

continues to occur for many more days after a rainfall event or canal closure because of the large volume of stored soil-water.

Preventive maintenance consists of:

1. Grading of roadway and berm so that surface runoff flows away from the irrigation channel; and
2. Constructing open drains on both sides of the irrigation channel sufficiently deep to provide both surface and subsurface drainage.

If a cavity already has formed, then the maintenance remedies become:

1. Fill the cavity with grout (mortar);
2. Seal the joint with asphalt;
3. Grade and shape roadway bank or berm bank adjacent to lining panels; and
4. Sod (vegetate) the roadway bank or berm bank adjacent to the lining panels.

Sedimentation

There is a tremendous variation in the amount of sedimentation that occurs in the canals and laterals. This sediment comes from surface drainage inflows into the irrigation channel (Figures 11 and 12)--some of which are planned, such as at concrete surface drainage inlet structures, while most is the result of:

1. Roadway and berm erosion;
2. Erosion from cut banks;
3. Erosion resulting from farmers and fishermen (includes men, women, boys and girls) tampering with the control gates, thereby resulting in overtopping of the concrete lining panels and serious erosion and even failure of the panels;

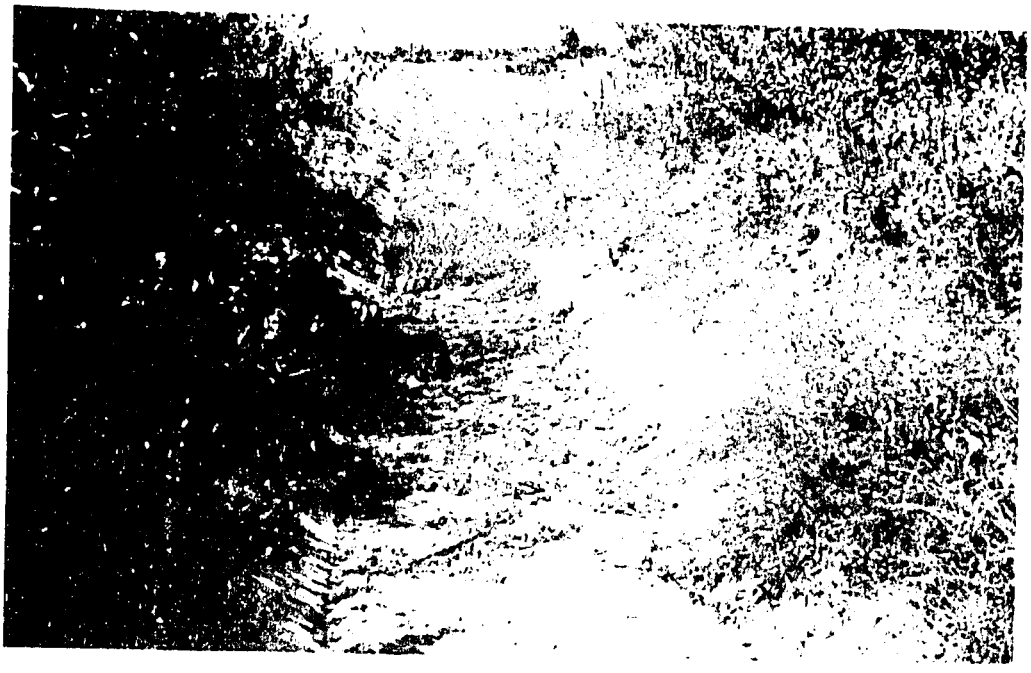


Figure 11. Sublateral R-4L-2L Half Full of Sediment Downstream from Station 0+450

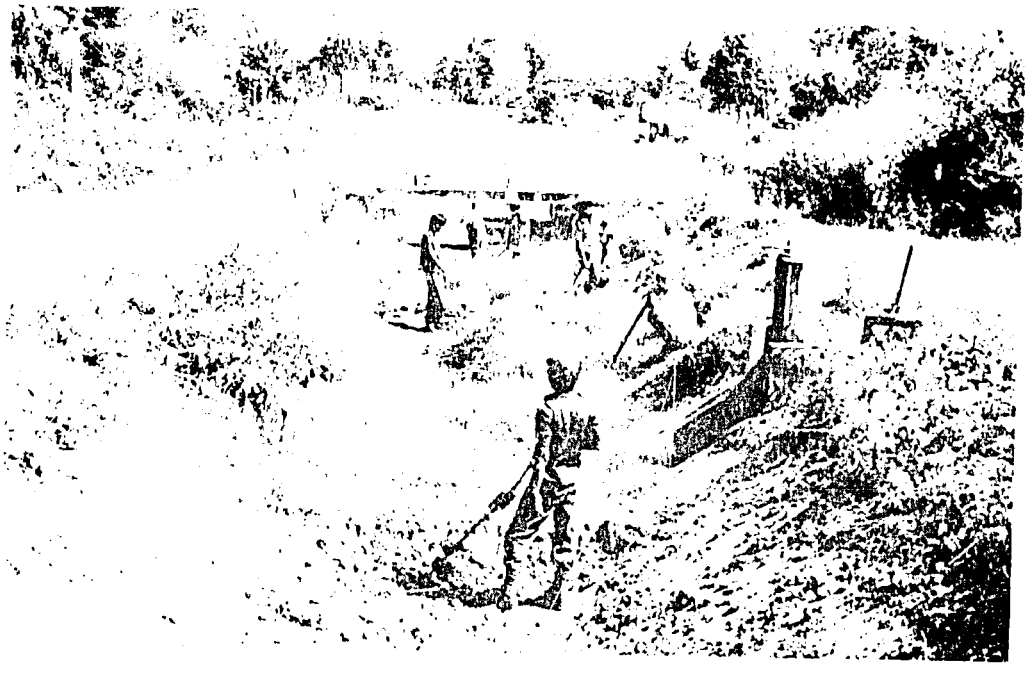


Figure 12. Removing Sediment from Lateral R-4L at Station 3+680

4. Overflow from adjoining earthen irrigation channels or ponds into the concrete-lined channel; and
5. Animals crossing the concrete-lined laterals, with subsequent erosion resulting in the animal pathways.

The basic philosophical approach towards sedimentation should be the elimination of all sources of sediment, so that no sediment enters the irrigation channels. However, the complete elimination of all sediment sources is nearly impossible, although it is quite possible to eliminate the majority of it, that is, some 90 percent. (Certainly, the situation illustrated in Figure 10 could easily be eliminated.)

Roadway and berm erosion can be greatly reduced by lowering the roadway to only 15 cm above the top of the concrete lining panels, then sodding the bank adjoining the panels, and grading the roadway so that surface runoff flows away from the irrigation channel. The berm should be cut down to the level of the top of the panels, and then graded so that surface runoff flows away from the irrigation channel.

Erosion from cut banks can be prevented from entering the irrigation channel by constructing a large open drain at the base of the cut bank. This open drain will require frequent maintenance; otherwise, it will soon fill with sediment. Consequently, the cut bank should be sodded to minimize erosion. Also, at the top of the cut bank, surface runoff should be diverted so that the flow over the cut bank is minimized.

The most difficult erosion problems to correct have occurred as the result of gate tampering by farmers and fishermen creating subsequent disasterous events. Unfortunately, the precedent has already been set that allows farmers to operate the Constant Head Orifice turnout structures to regulate their irrigation water deliveries. Attempts have been made to

improve the locks on the Constant Head Orifice gates, but they have not been particularly successful. A combination of better locks, public education, and sanctions appears to be in order to overcome this problem.

Overflow erosion from adjoining earthen irrigation channels and ponds can be avoided by investigating each location and constructing the necessary control structures. In some cases, a higher berm between the two channels is needed. This could result in more surface drainage and erosion from the berm, a situation which can be alleviated by proper grading, shaping, and sodding of the berm. In some cases, the problem results from adjoining buffalo wallows, which can be prevented by providing other nearby sites for buffalo wallows and informing farmers about the damage their animals can cause.

Erosion resulting from animal crossings could be eliminated for the most part by installing a concrete bridge, but taking care to provide adequate measures to prevent surface erosion near the abutments. In some cases, farmers may need to be encouraged to use a nearby bridge for an animal crossing.

Aquatic and Vegetative Growth

One of the most persistent maintenance problems, besides sedimentation, is aquatic growth. This is a frustrating problem because once the aquatic growth has been removed from a channel, it will return to the same level within a month or two. The amount of aquatic growth that commonly occurs results in considerable reduction of the discharge capacity of the irrigation channel. This is also the case for vegetative growth that has its roots in the sediment lying in the channel bottom.

Vegetative growth can be largely eliminated by removing the sediment in the irrigation channels and by employing corrective measures to prevent

sediment from entering the channel in the future. Any remaining vegetative growth would be found in broken joints and in holes in the lining panels; therefore, asphalt sealing of the joints and repair of the holes should eliminate this possibility.

Unfortunately, eliminating aquatic growth is an extremely difficult task. One alternative is to use chemicals; a procedure which should be attempted on an experimental basis. This approach will be attempted in the near future at an irrigation project near Khon Kaen and should be observed by O&M personnel from Lam Nam Oon. Presently, the only sure technique for removing aquatic growth is by hand or improvised mechanical tools. There is no known commercial machine for removing aquatic growth, but undoubtedly, some irrigated areas in the world have developed a machine for their own use. A floating platform with power-driven cutters would appear to be a possible approach.

Fishing

A surprising maintenance problem is the result of fishing, an activity that is seemingly undertaken by everyone living within the boundaries of the Lam Nam Oon Irrigation Project. Considerable damage has resulted from fishing activities, but at the same time, fishing is a major benefit of this irrigation system. The reservoir, canals, laterals, and adjoining earthen channels and ponds are extensively fished. The argument can be made that in order to be a good designer of irrigation systems in Thailand, an extensive knowldge of fishing practices is definitely needed.

The most serious problem resulting from fishing activities is the opening and closing of gates. This practice not only interferes with the operation of the system, but also has caused considerable damage on a few occasions. Many of the prefabricated concrete walkway panels installed on

the Constant Head Orifice turnout structures have been removed by fishermen for damming of the irrigation channel to trap fish. Nowadays, the Royal Irrigation Department neither installs these walkway panels on Constant Head Orifice structures, nor replaces them on the existing structures. Riprap placed at the end of Constant Head Orifice outlet structures for erosion control is commonly removed to build temporary dams in the downstream earthen channel in order to trap fish in the outlet structure and in downstream channels. In addition, riprap is removed from the compacted backfills surrounding USBR Stilling Basin VI structures in order to pond the stilling basin. As a consequence, rubble masonry is being recommended rather than riprap alone. In other cases, soil is removed from the irrigation channel bank to form an earthen dam, allowing rainfall runoff to quickly erode more soil from the disturbed area into the channel.

ROLE OF DRAINAGE

Surface Drainage

The primary purpose in providing surface drainage is to prevent surface runoff from entering the irrigation channel because of: (a) the sediment load being conveyed by the surface runoff; and (b) the potential for cavity enlargement or formation. A second purpose in providing surface drainage is to prevent the ponding of water alongside the irrigation channel. Most of this ponded water will eventually percolate into the soil, thereby raising the underlying groundwater table, which in turn increases the seepage rate and sediment transport through the joints. Consequently, the emphasis of a surface drainage system should be the rapid conveyance of surface runoff to a drain culvert or natural drainage channel.

Subsurface Drainage

When concrete-lined irrigation channels are constructed in cut areas, the soil-water pressures behind the concrete panels can increase significantly, particularly during the monsoon season. This condition results in higher seepage rates, and consequently, greater sediment transport through the lining joints. Also, these increased hydraulic pressures can cause side panels to fail by sliding, or floor panels to fail by increased hydraulic uplift pressures.

Cut areas, in particular, require that the design of the irrigation channel include effective subsurface drainage. This can be usually accomplished by excavating open drains alongside the roadway and berm provided they are sufficiently deep. Preferably, the invert elevation of the open drain should correspond with the invert elevation of the irrigation channel, or be even lower.

Subsurface drainage is provided naturally when the irrigation channel is located in a fill area so that the adjacent land alongside the roadway and berm is below the water surface level in the irrigation channel. Preferably, the adjacent land will be at, or below, the invert elevation of the irrigation channel.

IMPACT OF STRUCTURES

Constant Head Orifice Outlet Structures

Constant Head Orifice outlet structures are usually in good structural condition if the adjacent land is above the invert elevation of the irrigation channel. If the drop in water surface elevation between the Constant Head Orifice outlet structure and the downstream earthen channel is 10 cm or more, then the outlet structure will likely fail because of soil erosion immediately downstream from the outlet structure as shown in Figures 13, 14,

Figure 13. Failed Constant Head Orifice Outlet Structure along Lateral R-7L-2R Because of One Meter Drop

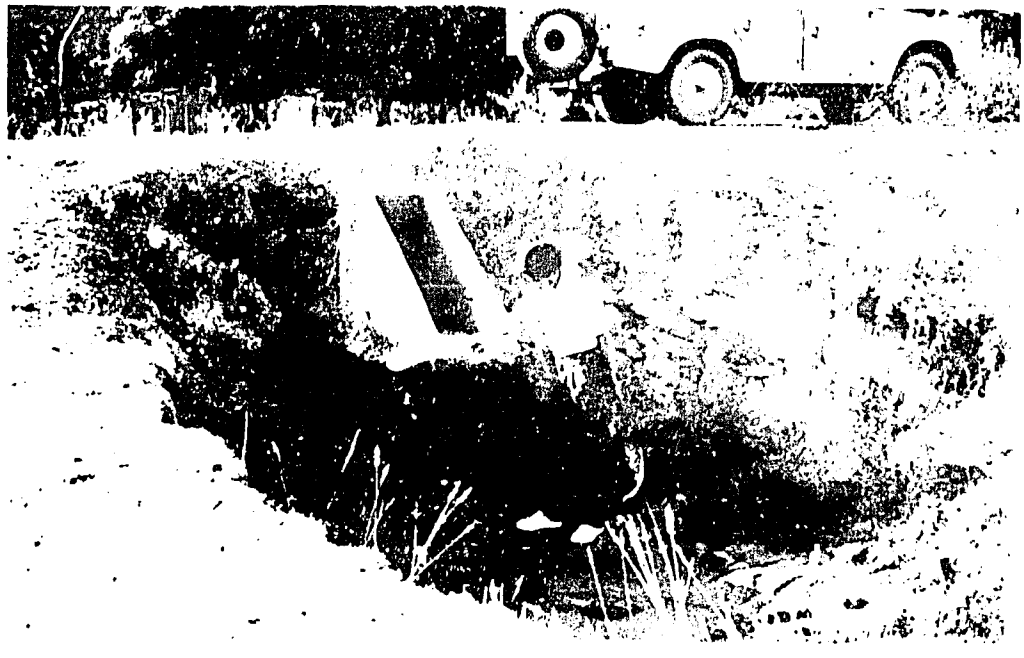


Figure 14. Failed Constant Head Orifice Outlet Structure and Pipe Outlet Structure is Undermined and Will Soon Fail

and 15. This erosion soon undermines the end panels, which crack, then break, and eventually fall into the scour hole. If the drop in water surface elevation is sufficiently great, then the entire outlet structure will fail soon. In some cases, even the concrete pipe sections between the Constant Head Orifice and the outlet structure have failed.

For small drops in water surface elevation, say 10-30 cm, rubble masonry can be placed at the end of the outlet structure along the walls, and even more importantly, in the downstream channel floor in such a manner as to dissipate the excess hydraulic energy. This serves as a good temporary measure until the on-farm facilities are constructed which will solve the problem on a more permanent basis. When the drop in water surface elevation is more than 30 cm, then a rubble masonry or concrete chute should be constructed, along with a lined stilling basin for dissipating the hydraulic energy such as shown in Figures 16, 17, and 18.

Drop Structures

Drop structures usually consist of: (a) an inlet structure that may, or may not, have a gate for controlling the upstream water level; (b) a concrete pipeline between the inlet and outlet structures; and (c) a USBR Stilling Basin VI and an outlet transition structure.

Sometimes, cavities form near the headwall of the inlet structure and in the embankment overlying the concrete pipeline. These cavities can result from: (a) surface drainage into depressions; or (b) leaking concrete pipe joints.

Quite frequently, a hole has formed in the joint between the end of the outlet transition structure and the beginning of the downstream irrigation channel section as shown in Figure 19. This primarily occurs because the outlet is structurally stronger than the irrigation channel concrete lining

Figure 15. Failed Constant Head Orifice Outlet Structure because of Too Much Drop

Figure 16. Constant Head Orifice Outlet Structure in Excellent Condition

Figure 17. Constant Head Orifice Pipe Outlet Structure with Downstream Channel Concrete-Lined to Prevent Structure Failure

Figure 18. Constant Head Orifice Outlet Structure with Concrete-Lined Chute to Prevent Failure of the Outlet Structure

panels; the large hydraulic pressures, resulting from the high nearby roadway and berm, are most easily relieved at this particular joint. This problem can be partially relieved by: (a) lowering the roadway ahead of the inlet structure so that the roadway will not be so high above the outlet structure; (b) placing an open drain alongside the roadway and berm that is sufficiently deep to provide subsurface drainage, as well as surface drainage; and (c) installing more small-diameter weep holes in the outlet transition structure.

Bridges

Generally, concrete bridges are in very good structural condition. The only structural problem usually found is the breaking of railings as a result of large trucks having to make sharp turns.

Oftentimes, cavities have formed behind the concrete lining panels underneath the bridge because of surface runoff near the abutments as shown in Figures 20, 21 and 22. To prevent such cavities from forming underneath bridges, rubble masonry should be placed between the top of the concrete lining panels and the bridge abutments. If the bridge settles, then the rubble masonry will crack, and the cracks can be filled with asphalt or mortar.

Other Structures

In general, the concrete structures are in excellent structural condition. The quality of the construction work is impressive. The only difficulties have been the grading and shaping of the soil surface surrounding the structure and behind adjoining concrete lining panels. Only in a few instances have these cavities endangered the structure (an exception

Figure 19. Small Hole in Lining Joint is Commonly Found at End of USBR Stilling Basin VI Outlet Transition Structure

Figure 20. Large Cavity at Bridge Abutment

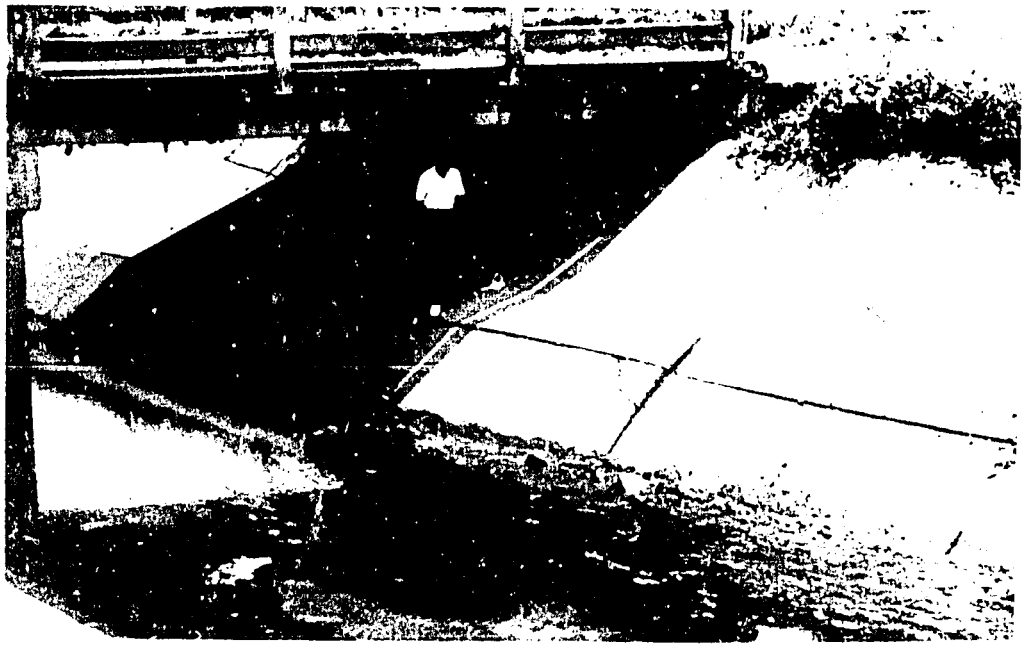


Figure 21. Bulging Lining Panels Underneath Bridge that will Fail during the Next Monsoon Season

Figure 22. Broken Concrete Lining Panels Underneath Bridge

would be the Constant Head Orifice outlet structures) but frequently they have resulted in cracked, broken, or failed concrete lining panels. The remedy for this situation is to fill the cavities with mortar and then properly shape the surrounding soil surface.

Culvert Drains

In general, the culvert drains are another example of excellent concrete construction. In some cases, more compacted backfill should have been placed behind the headwalls of the inlet and outlet structure. The maintenance problem associated with drain culverts is the removal of sediment and shrubbery in the outlet and inlet structures. These drain culverts are very important as outlets for open drains alongside the roadway or berm, even though they were primarily installed to convey the flow in natural channels underneath the irrigation channel.

Roads

In general, the roads are in good condition; however, there are a few locations that definitely need attention. The major problem with roads is that they are not always graded so that surface runoff flows away from the irrigation channel. On bends, where superelevation has been purposely constructed to facilitate vehicle traffic, there are two possible solutions for right turning bends (in the downstream direction) which result in surface runoff into the irrigation channel:

1. Place a curb of concrete or asphalt on the inside of the bend near the irrigation channel and convey the water from the curb to the irrigation channel in a concrete-lined chute; or
2. Remove the superelevation and grade the roadway so surface runoff will be conveyed away from the irrigation channel, then place a sign warning motorists to reduce the speed of their vehicle.

The second major problem with roads is bank erosion on the bank opposite to the irrigation channel. This erosion can be the result of:

1. The cross-slope grading of the roadway being too steep so that surface runoff has a relatively high velocity;
2. The bank slope being too steep; or
3. The bank height being too high.

For the situation in (1), the problem can be easily corrected by using compacted backfill in the eroded area and then decreasing the cross-slope grade. For the situation cited in (2) or (3), the only plausible solution appears to be the placement of a curb at the edge of the bank. The curb would then collect the surface runoff and convey it down the bank in a concrete-lined or rubble masonry chute.

Another important problem with roads is that they are often constructed too high above the top of the concrete-lined irrigation channels. This situation results in more surface runoff moving at a higher velocity into the irrigation channel, thereby resulting in more sediment entering the irrigation channel. Also, this condition will result in higher soil-water pressures behind the concrete lining panels, which will cause more cracked, broken, and failed panels. The best remedy is to lower the road elevation to a level about 15 cm above the top of the concrete lining panels. Although the ideal solution would be to place the roadway at the same elevation as the top of the lining panels, there are two advantages in placing it 15 cm higher. First, vehicles will be prevented from riding on the edge of the panels and inflicting damage. Secondly, the grader will avoid catching the machine's blade on the top of the panels, a problem which has occurred, thereby causing their displacement and subsequently, possible failure.

SECTION IV

INVENTORY OF REQUIRED MAINTENANCE

After completing the maintenance inventory for the concrete-lined channels, the intent was to evaluate what maintenance should be done by the Royal Irrigation Department's operation and maintenance personnel at Lam Nam Oon, and whether by force account, or by contract. This has been done. However, after evaluating the rapidly deteriorating situation on the Left Main Canal between stations 12+500 and 16+000, it was decided that emergency action is required. Consequently, the following section discusses this particular emergency situation.

Appendix A contains a list of those conditions requiring attention before the next monsoon season: Appendix B is the detailed maintenance inventory. An argument could be made that all of the required maintenance be completed before the next monsoon season, but as this is impossible, Appendix A lists the most critical needs. It does not, however, include those emergency maintenance measures which must be of immediate and important concern.

EMERGENCY MAINTENANCE

There are numerous wall panels that have failed in the Left Main Canal between station 12+500 (12.5 km from the beginning of the Left Main Canal) and station 16+000 as shown in Figures 23 and 24. This condition is the result of inadequate surface and subsurface drainage. The concrete lining panels are below the ground surface elevation of the surrounding land. This condition results in:

1. Surface runoff flowing into the Left Main Canal between stations 12+500 and 16+000; and

Figure 23. Broken Concrete Lining Panels along the Left Main Canal between Stations 12+500 and 16+000

Figure 24. Failed Concrete Lining Panels along the Left Main Canal between Stations 12+500 and 16+000

2. Groundwater is seeping over the top of the panels at many locations in this reach. This shows that the water table levels are above the top of the concrete panels, thereby resulting in higher seepage rates and sediment transportation through the joints which, in turn, results in larger cavities being formed behind the panels.

Evidence of the seriousness of this situation is that: (a) 108 wall panels have already failed in this reach and need to be replaced; (b) another 76 wall panels will likely fail by the end of the 1983 monsoon season and need immediate repair; and (c) another 32 wall panels need repair in order to avoid failure within the next two years. This condition can be expected to rapidly deteriorate even further because the panels that have already failed automatically endanger adjoining panels because of more rapid cavity enlargement.

The solution to this problem is not simply the replacement of failed panels and repair of broken and cracked panels. This task should only be done after deep open drains have been constructed on both sides of the Left Main Canal for a distance of 3.5 km (between stations 12+500 and 16+000). These deep open drains would provide both surface and subsurface drainage for the Left Main Canal in this reach as shown in Figure 25. After constructing these drains, then the right and left berms (there is no road along the Left Main Canal from approximately station 9+000 to station 16+000) should be cut down to 15 cm above the top of the concrete wall panels. Then, the wall panels could be replaced or repaired, all cavities filled, and the joints sealed with asphalt.

Note: An important lesson to be learned from this situation is the critical importance of adding surface and subsurface drainage to the design

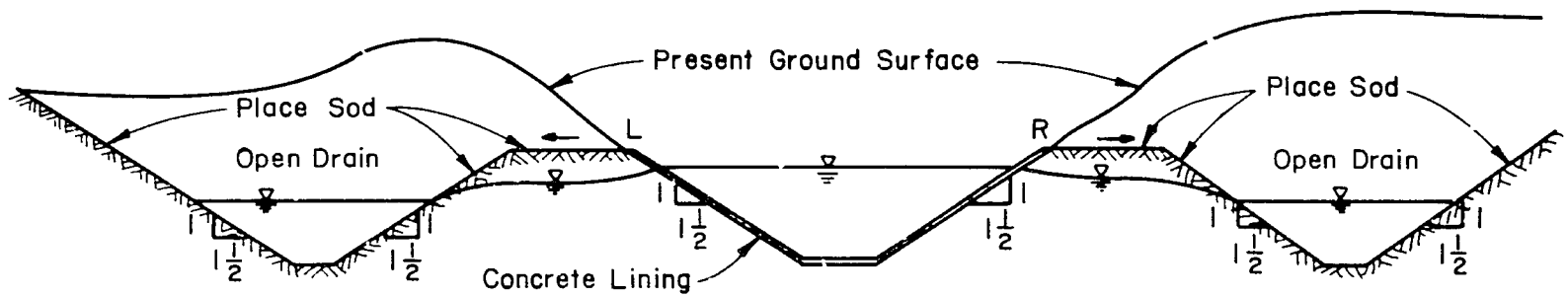


Figure 25. Typical Cross Section of Deep Open Drains for Providing Surface and Subsurface Drainage along the Left Main Canal (LMC) between Stations 12+500 and 16+000

criteria for irrigation channels in the Northeast, or wherever the physical combination of sandy soils and monsoon rains exist.

For Example: If surface and subsurface drainage had been a part of the design criteria for the Left Main Canal, then the design would have likely consisted of a single pump lift plant at station 12+500, rather than the presently existing pumping plants at station 16+000 and station 0+211 on Lateral L-3L. With a single pumping plant at 12+500, the invert of the Left Main Canal between stations 12+500 and 16+000 would be above the adjacent ground surface; therefore, surface and subsurface drainage would be excellent without having to construct any open drains. On Lateral L-3L, which diverts water at station LMC 14+570, an inverted siphon would have to be constructed at station 0+065 to convey the water under the highway, but this solution would have alleviated the present maintenance problems between stations 0+100 to 0+180, also the result of inadequate surface and subsurface drainage.

CONTRACT MAINTENANCE

There is a necessity to provide a combination of surface and subsurface drainage in the upper reaches of both the Left Main Canal and Right Main Canal. In addition, there are many other locations along the Right Main Canal where deep open drains are needed to provide both surface and subsurface drainage. This will be a large construction job requiring detailed design. As a consequence, it is proposed that this particular maintenance requirement be accomplished on a contract basis.

Right Main Canal

The greatest difficulty in providing surface and subsurface drainage along the Right Main Canal is the first three kilometers (station 0+000 to station 3+000). The right berm will require extensive excavation to

eliminate the right bank, as well as excavating a deep open drain. The real problem, however, will be the left roadway where the asphalt road has been constructed high above the top of the concrete lining wall panels. Because of the high cost involved, it is not proposed that the asphalt road be lowered. Instead, a deep open drain could be constructed to the left of the asphalt road as shown in Figure 26. In addition, it is proposed that the two surface drains along the base of the dam, which presently discharge surface runoff and sediment into the Right Main Canal, be altered so that this surface runoff is discharged into natural channels downstream.

The location of the right berm and left roadway open drains is listed in Table 6. About 6.7 kilometers of left roadway deep open drains are needed, while proper drainage along the right berm requires 15.6 kilometers of deep open drains. Fortunately, numerous drain culverts have been constructed along the Right Main Canal, so the principal requirement is for excavation work. However, there may be a need to install some concrete erosion control structures in the vicinity of the open drain outlets. If these drain culverts had not been already constructed, then the cost of providing right berm drainage would be significantly higher.

Left Main Canal

The location of left road open drains and right berm open drains required along the Left Main Canal is listed in Table 7 with the exception of the emergency maintenance open drains required along both sides of the Left Main Canal between stations 12+500 to 16+000. Along the right berm, 3.3 kilometers of deep open drains are required. The greatest difficulty will be both the design and construction of the left roadway drain from stations 0+000 to 1+300. Because the asphalt road is so high above the top of the wall panels, and as there is limited space, a special design is

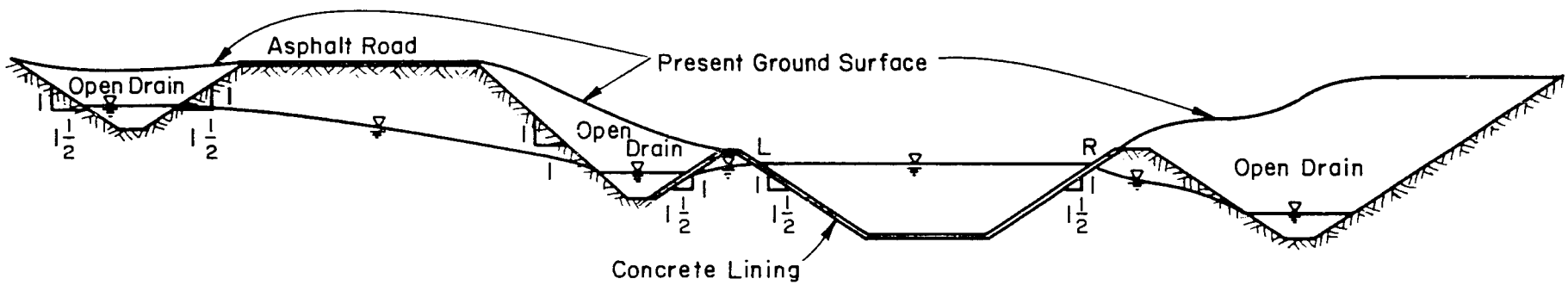


Figure 26. Typical Cross Section of Open Drains for Providing Surface and Subsurface Drainage along the Right Main Canal

Table 6. Location and length of open drains required along Right Main Canal for surface and subsurface drainage.

Beginning Station	Ending Station	Length, meters	Left Road Open Drain	Right Berm Open Drain
0+000	3+000	3,000	3,000	3,000
4+030	4+200	170	170	--
4+030	4+250	220	--	220
4+600	4+800	200	--	200
6+200	6+900	700	700	700
7+600	8+400	800	800	800
10+066	11+050	924	--	984
11+600	12+450	850	850	850
13+200	13+500	300	300	300
13+980	15+000	1,020	--	1,020
17+200	17+775	575	--	575
17+900	12+200	300	--	300
12+900	19+900	1,000	--	1,000
21+350	22+500	1,150	--	1,150
21+500	22+350	850	850	--
22+600	22+800	200	--	200
23+350	23+600	250	--	250
23+750	25+250	1,500	--	1,500
27+500	28+080	580*	--	300
31+000	31+500	500	--	500
32+140	32+700	560	--	560
34+900	35+200	300	--	300
38+280	39+200	920	--	920
Total Length, in meters			6,670	15,629

*Only 300 meters of this length needs an open drain.

Table 7. Location and length of open drains required along Left Main Canal for surface and subsurface drainage, but excluding emergency maintenance open drains from 12+500 to 16+000.

Beginning Station	Ending Station	Length, meters	Left Road Open Drain	Right Berm Open Drain
0+000	1+300	1,300	1,300*	-
0+275	0+700	425	-	425
1+200	1+345	145	-	145
1+300	2+600	1,300	1,300	-
1+900	2+600	700	-	700
4+000	4+700	700	700	-
4+280	4+380	100	-	100
4+800	5+630	830	-	830
4+800	7+250	2,450	2,450	-
6+150	7+250	1,100	-	1,100
Total Length, in meters			5,750	3,300

*Special design (e.g., concrete channel).

required, most likely utilizing a concrete interception structure or perforated pipeline drainage, or perhaps even a combination of both as shown in Figure 27.

The right berm at the head of the Left Main Canal is bedrock and there appears to be no problem with erosion or cracked panels. In contrast, most locations for the left roadway open drains will require very careful and meticulous design and construction.

FORCE ACCOUNT MAINTENANCE

The remaining maintenance listed in Appendix B is proposed to be done by force account using operation and maintenance personnel at Lam Nam Oon, supplemented by short-term temporary laborers. The major maintenance requirements are: (a) the repair and replacement of concrete lining panels; (b) the filling of cavities with grout (mortar); and (c) providing surface

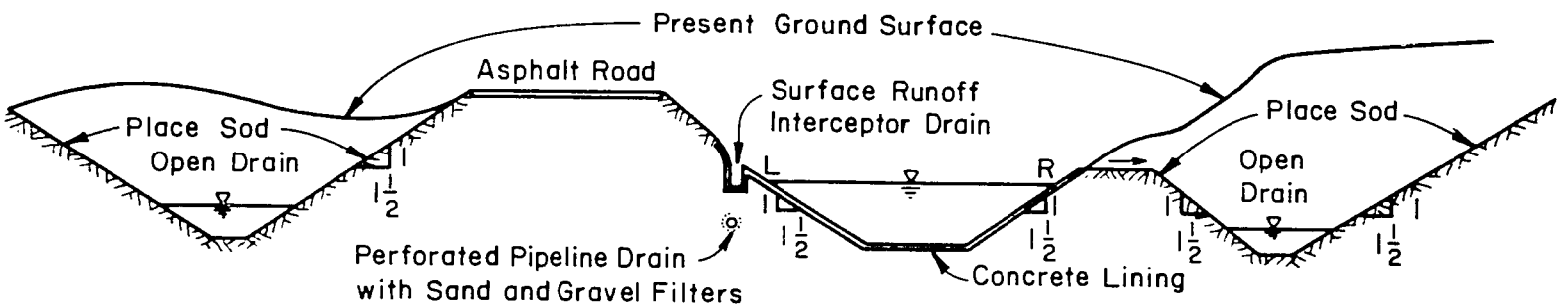


Figure 27. Typical Cross Section for Providing Surface and Subsurface Drainage in the Upper Reaches of the Left Main Canal

and subsurface drainage where necessary in order to significantly reduce the magnitude of this type of maintenance in the future. The next major activity is associated with the repair and replacement of Constant Head Orifice outlet structures, plus filling cavities, and the repair and replacement of the turnout gates and gate frames. Another major maintenance activity is the removal of sediment from the irrigation channels; more emphasis should be placed in the future on eliminating the sources of sediment.

Concrete Lining

The present damage to the concrete lining panels in the canals, laterals and sublaterals are summarized in Tables 8 and 9 for the Right Main Canal system and the Left Main Canal system, respectively. Surprisingly, the Left Main Canal has more damage than the right, even though the left is only 61 percent as long. The total of broken and failed panels is three times greater along the Left Main Canal. However, 85 percent of these panels occur between stations 12+500 and 16+000, where emergency maintenance is being recommended.

The total length of all concrete-lined laterals and sublaterals is 2.4 times greater under the Right Main Canal than the Left Main Canal. Yet, the sum of broken and failed concrete lining panels is 3.86 times greater for Right Main Canal laterals, but this ratio reduces to 3.25 when the sum of panels with holes, broken and failed are compared. Thus, the laterals and sublaterals of the Right Main Canal show roughly 60 percent more damage per km of length than for the Left Main Canal and sublaterals.

A review of the data in Tables 8 and 9 shows that certain laterals or sublaterals need particular attention on the repair and replacement of concrete lining panels, as well as the filling of cavities. Using the sum of panels with holes, broken, or failed as an index of damage, then the

Table 8. Number of Damaged Concrete Lining Panels for the Right Main Canal System

Canal	Lateral	Sub-Lateral	Concrete Lining Panels				
			Cavities	Cracked	Holes	Broken	Failed
RMC			137	98	141	64	8
	R-1L		11	9	36	3	11
		R-1L-1L	1	10	2	-	1
		R-1L-2L	1	-	2	2	4
TOTALS FOR LATERAL R-1L			13	19	40	5	16
	R-2L		1	1	4	1	1
	R-3L		-	5	-	-	-
	R-4L		8	28	10	1	5
		R-4L-1L	-	-	-	-	-
		R-4L-2L	1	-	1	-	-
		R-4L-3L	-	-	-	-	-
		R-4L-1R	81	1	12	1	9
		R-4L-1R-1R	11	-	6	-	1
TOTALS FOR LATERAL R-4L			101	29	29	2	15
	R-6L		8	1	26	3	3
		R-6L-1L	-	-	10	-	-
		R-6L-2L	82	22	30	9	30
		R-6L-3L	-	-	-	-	2
		R-6L-2L-1L	1	-	1	-	-
		R-6L-2L-1L-1R	23	4	5	-	-
		R-6L-2L-1L-2R-1L	2	-	-	2	-
		R-6L-2L-1R	-	-	-	-	-
		R-6L-2L-1R-1L	-	-	-	-	-
TOTALS FOR LATERAL R-6L			116	27	72	14	35
	R-7L		26	2	9	3	9
		R-7L-1L	-	-	-	-	-
		R-7L-1R	-	2	-	-	-
		R-7L-2L	-	1	-	-	-
		R-7L-2R	-	-	-	-	-
TOTALS FOR LATERAL R-7L			26	5	9	3	9
	R-8L		9	2	2	2	8
	R-9L		1	1	1	-	6
		R-9L-1L	-	-	-	-	-
		R-9L-2R	1	2	5	1	4
		R-9L-2L-1R	2	-	-	-	-
TOTALS FOR LATERAL R-9L			4	3	6	1	10

Table 8. continued

Canal	Lateral	Sub-Lateral	Concrete Lining Panels				
			Cavities	Cracked	Holes	Broken	Failed
	R-10L		-	-	-	-	26
	R-11L		4	1	2	-	-
		R-11L-1L	-	2	-	-	21
		R-11L-2L	5	8	2	-	22
		R-11L-2L-1R	-	1	1	-	1
		R-11L-2L-1L	5	8	-	-	-
		R-11L-2L-2L	-	-	-	-	-
TOTALS FOR LATERAL R-11L			14	20	6	-	44
	R-12L		-	-	-	-	-
		R-12L-1R	-	-	-	1	2
		R-12L-1R-1L	-	-	-	-	-
TOTALS FOR LATERAL R-12L			-	-	-	1	2
	R-13L		10	-	-	-	50
		R-13L-1L	1	-	-	-	-
		R-13L-1R	6	-	-	-	-
TOTALS FOR LATERAL R-13L			17	-	-	-	50
	R-14L		-	-	-	-	-
	R-15L		-	-	-	-	-
	R-16L		1	26	7	1	-
		R-16L-1L	-	-	2	-	-
		R-16L-1R	1	7	1	-	-
		R-16L-1R-1L	-	-	-	-	-
		R-16L-3R	-	-	2	-	-
TOTALS FOR LATERAL R-16L			2	33	12	1	-
	R-17L		-	3	3	-	-
		R-17L-1L	-	1	6	-	-
		R-17L-1L-1L	13	-	-	-	1
		R-17L-6L	2	-	-	-	-
TOTALS FOR LATERAL R-17L			15	4	9	-	1
TOTALS FOR ALL RMC LATERALS			318	148	189	30	217
TOTALS FOR RMC SYSTEM			455	246	330	94	225

Table 9. Number of Damaged Concrete Lining Panels for the Left Main Canal System

Canal	Lateral	Sub-Lateral	Concrete Lining Panels				
			Cavities	Cracked	Holes	Broken	Failed
LMC			300	161	148	101	115
	L-1L		113	168	3	6	5
		L-1L-1L	49	19	22	10	3
		L-1L-2L	12	3	7	-	-
		L-1L-2L-1R	-	-	-	-	-
TOTALS FOR LATERAL L-1L			174	190	32	16	8
	L-1R		-	7	5	-	1
		L-1R-1L	-	-	-	-	-
		L-1R-1L-1R	-	-	-	-	2
TOTALS FOR LATERAL L-1R			-	7	5	-	3
	L-2L		6	6	5	4	-
		L-2L-1R	3	3	3	-	-
TOTALS FOR LATERAL L-2L			9	9	8	4	-
	L-3L		5	8	5	5	1
		L-3L-1R	-	-	2	1	-
		L-3L-1R-1R	2	-	-	-	-
		L-3L-1R-1L	-	-	2	3	-
		L-3L-1L	2	-	7	10	11
		L-3L-1L-1L	5	-	-	-	-
		L-3L-1L-2L	11	3	4	-	-
		L-3L-1L-2L-1R	7	-	-	-	-
		L-3L-1L-2L-1L	6	-	-	-	-
TOTALS FOR LATERAL L-3L			38	11	20	19	12
	L-4L		-	-	-	-	-
	L-5L		2	8	-	-	-
	L-2R		1	2	-	-	-
		L-2R-1L	-	-	1	-	-
TOTALS FOR LATERAL L-2R			1	2	1	-	-
	L-3R		37	5	4	2	-
	L-4R		-	-	-	-	-
	L-5R		1	1	-	-	-
TOTALS FOR ALL LMC LATERALS			262	233	70	41	23
TOTALS FOR LMC SYSTEM			562	394	218	142	138

laterals and sublaterals can be prioritized for maintenance according to the degree of damage per kilometer of length. The results are shown in Table 10, where the highest priority is for Lateral R-10L, followed by Sublaterals R-11L-2L and L-3L-1L and Laterals R-13L and L-3L.

Constant Head Orifice Structures

The damage to the Constant Head Orifice structures is summarized in Tables 11 and 12 for the Right and Left Main Canal, respectively. The Constant Head Orifice Regulator for each lateral is counted as such under the lateral rather than the main canal. For example, 67 Constant Head Orifice structures are shown for the Right Main Canal, but since there are 16 laterals, there are really a total of 83 Constant Head Orifice structures. The number listed in Tables 11 and 12 includes the Tail Regulator structure at the end of each lateral and sublateral, which is designed for one gate rather than two.

As mentioned previously, the greatest maintenance problem is with the Constant Head Orifice outlet structures. About 11 percent of these outlets have failed and need to be replaced. Another 12 percent of the existing outlet structures need concrete repair, while 23 percent need rubble masonry at the end of the structure for protection against erosion.

About one-fourth of all turnout structures are missing the concrete walkway panels that are installed on top of the structure. This indicates the damage resulting from fishing activities. Most of these walkway panels were removed by fishermen in order to dam the water in the irrigation channel. However, in some cases, The Royal Irrigation Department has not installed the walkway panels because they recognized that the panels would be removed. The conclusion is that such walkways should be a permanent part of the structure rather than being prefabricated.

Table 10. Maintenance Priority for the Repair and Replacement of Concrete Lining for Various Laterals and Sub-Laterals in the Lam Nam Oon Irrigation Project

Laterals	Sub-Laterals	Length in km	No. of Panels with Holes, Broken, or Failed	D mage per km	Priority
L-1L		9.310	14	1.50	21
	L-1L-1L	3.400	35	10.29	7
L-3L		0.835	11	13.17	5
	L-3L-1L	2.020	28	13.86	3
L-3R		2.500	6	2.40	20
R-1L		11.415	50	4.38	14
	R-1L-2L	2.800	8	2.86	18
R-4L		4.600	16	3.48	16
	R-4L-1R	3.200	22	6.88	9
	R-4L-1R-1R	1.150	7	6.09	11
R-6L		4.900	32	6.53	10
	R-6L-1L	0.900	10	11.11	6
	R-6L-2L	7.790	69	8.85	8
	R-6L-2L-1L-1R-1L	1.550	2	1.29	22
R-7L		6.120	21	3.43	17
R-8L		3.050	12	3.93	15
R-9L		2.655	7	2.64	19
	R-9L-2L	2.160	10	4.63	13
R-10L		1.100	26	23.64	1
	R-11L-1L	1.500	21	14.00	2
	R-11L-2L	4.500	24	5.33	12
	R-12L-1R	3.700	3	0.81	24
R-13L		3.720	50	13.44	4
R-16L		9.500	8	0.84	23

The column, "Gate Repair", in Tables 11 and 12 also includes gates that need to be replaced, as well as gates and gate frames that need repair. About 7 percent of the gates (there are two gates in each Constant Head Orifice structure) need either repair or replacement. In some cases, a second gate has not been installed in the turnout structure.

Other Structures

The maintenance requirements for other structures, such as overflows, wasteways, culverts, etc. are usually minimal; however, there are serious problems at some of the concrete bridges over the canals, laterals and sublaterals. The details of the maintenance requirements are listed in Appendix B. The costs for this maintenance, however, will be presented in Section V.

Sediment

While doing the maintenance inventory, the depth of sediment was periodically estimated. For example, the field notes in Appendix B might list 1/3 sed or 1/5 sed or some other ratio of the estimated depth of sediment as compared with the height of the concrete lining wall panels. Then using the design drawings for each reach of canal, lateral or sublateral, the volume of sediment could be calculated. The results of these computations are listed in Tables 13 and 14.

Some reaches of Lateral R-6L (60 m) and Sublaterals R-6L-1L (220 m), R-1L-2L (330 m) and R-7L-2L (420 m) are completel full of sediment. Sublateral L-1R-1L-1R is 75-90 percent full of sediment over the full length.

A review of the slope of each reach did not disclose that this factor controlled the deposition of sediment. The gradients of the irrigation channels are quite flat, usually varying between 1:4000 and 1:8000.

Consequently, the conclusion is that most sediment entering these flat gradient irrigation channels is deposited in a relatively short distance. As a result, trying to convey large flows in half-filled irrigation channels causes the sediment (mostly sandy soils) to be dislodged and transported further downstream. Even then, the total length of sediment transport is commonly less than 1 km and frequently less than 500 m.

Table 11. Damage to Constant Head Orifice (CHO) Turnouts and Outlet Structures under the Right Main Canal System

Canal	Lateral	Sub-Lateral	Constant Head Orifice (CHO) Turnout. and Outlet Structures									
			No.	Turnouts			Outlets					
				Cavi-ties	Gate Repair	Walkway Panels Missing	Cavi-ties	Cracks	Holes or Broken	Failed	Rubble Masonry Walls	Rubble Masonry Floor
RMC			67	23	8	-	10	6	14	11	23	9
	R-1L		20	9	8	9	4	3	6	2	1	0
		R-1L-1L	6	7	3	4	-	1	-	-	1	-
		R-1L-2L	6	4	3	3	-	-	3	-	-	-
TOTALS FOR LATERAL R-1L			32	20	14	16	4	4	9	2	2	-
	R-2L		7	2	3	1	-	-	1	-	-	-
	R-3L		4	3	1	-	-	2	1	-	-	-
	R-4L		12	3	1	4	1	2	2	3	2	-
		R-4L-1L	5	-	-	2	-	-	1	-	1	-
		R-4L-2L	3	1	-	1	-	-	-	1	-	-
		R-4L-3L	9	-	-	2	3	1	2	1	1	-
		R-4L-1R	4	2	-	-	2	-	1	2	1	1
		R-4L-1R-1R	4	-	-	1	1	-	-	-	2	-
TOTALS FOR LATERAL R-4L			34	6	1	10	7	3	6	4	4	1
	R-6L		10	7	6	5	-	-	1	2	-	1
		R-6L-1L	2	-	2	-	-	-	-	-	1	-
		R-6L-2L	16	7	2	5	-	-	3	2	6	-
		R-6L-3L	3	5	5	-	-	-	-	-	1	-
		R-6L-2L-1L	7	-	-	-	-	-	-	-	3	-
		R-6L-2L-1L-1R	6	-	4	1	1	-	-	2	2	-
		R-6L-2L-1L-1R-1L	4	-	-	-	-	-	-	-	3	-
		R-6L-2L-1R	4	-	-	-	-	-	-	1	2	-
		R-6L-2L-1R-1L	8	-	-	-	-	-	1	-	2	-
TOTALS FOR LATERAL R-6L			66	21	19	11	1	-	5	7	20	1
	R-7L		13	1	1	-	2	3	2	1	3	1
		R-7L-1L	3	-	1	-	-	-	-	-	1	-
		R-7L-1R	5	1	-	-	-	-	-	-	1	-
		R-7L-2L	4	2	1	-	-	-	-	-	-	-
		R-7L-2R	6	1	1	-	3	-	1	2	2	2
TOTALS FOR LATERAL R-7L			31	5	4	-	5	3	3	3	7	3
	R-8L		8	-	-	-	1	2	1	-	1	-
	R-9L		9	-	-	2	-	-	1	-	-	-
		R-9L-1L	3	-	-	-	-	-	-	-	-	-
		R-9L-2L	9	1	1	-	1	2	1	2	1	-
		R-9L-2L-1R	7	2	1	-	8	-	-	2	3	-
TOTALS FOR LATERAL R-9L			28	3	2	2	9	2	2	4	4	-
	R-10L		2	-	1	-	-	-	-	-	-	-

Table 11. continued

Canal Lateral Sub-Lateral	Constant Head Orifice (CHO) Turnouts and Outlet Structures									
	No.	Turnouts			Outlets					
		Cavi-ties	Gate Repair	Walkway Panels Missing	Cavi-ties	Cracks	Holes or Broken	Failed	Rubble Masonry Walls	Rubble Masonry Floor
R-11L	12	1	1	-	-	-	1	4	1	-
R-11L-1L	4	-	1	-	-	-	-	1	1	-
R-11L-2L	13	-	2	-	6	-	2	5	2	1
R-11L-2L-1R	5	3	-	-	-	-	-	1	1	-
R-11L-2L-1L	7	7	-	-	6	2	1	2	2	-
R-11L-2L-2L	6	-	3	-	-	-	2	2	-	-
TOTALS FOR LATERAL R-11L	47	8	10	-	12	2	6	15	7	1
R-12L	5	-	-	-	-	1	1	-	2	-
R-12L-1R	6	-	-	-	1	-	-	-	1	-
R-12L-1R-1L	5	-	-	-	-	-	-	-	-	-
TOTALS FOR LATERAL R-12L	16	-	-	-	1	1	1	-	3	-
R-13L	10	-	1	-	1	-	-	1	3	-
R-13L-1L	1	-	-	-	-	-	-	-	-	-
R-13L-1R	9	1	-	-	-	-	2	3	1	-
TOTALS FOR LATERAL R-13L	20	1	1	-	1	-	2	4	4	-
R-14L	2	-	-	-	-	-	-	-	1	-
R-15L	11	2	1	-	-	1	-	-	-	1
R-16L	18	-	1	-	[illegible]	-	1	1	3	-
R-16L-1L	6	-	-	-	-	-	-	-	5	-
R-16L-1R	12	-	1	-	-	-	-	1	5	-
R-16L-1R-1L	8	-	-	-	2	2	-	-	3	3
R-16L-3R	16	-	-	-	[illegible]	-	-	-	2	-
TOTALS FOR LATERAL R-16L	60	-	2	-	3	2	1	2	18	3
R-17L	12	2	1	-	-	2	1	1	2	-
R-17L-1L	14	11	-	-	3	2	3	1	1	-
R-17L-1L-1L	12	16	-	-	2	-	1	2	1	1
R-17L-2L	4	-	-	-	-	-	1	-	-	-
TOTALS FOR LATERAL R-17L	42	29	1	-	5	4	6	4	4	1
TOTALS FOR ALL RMC LATERALS	407	100	60	40	49	26	44	48	85	8
TOTALS FOR RMC SYSTEM	474	123	68	40	59	32	58	59	108	17

Table 12. Damage to Constant Head Orifice (CHO) Turnouts and Outlet Structures under the Left Main Canal System

Canal Lateral Sub-Lateral	Constant Head Orifice (CHO) Turnouts and Outlet Structures									
	No.	Turnouts			Outlets					
		Cavi-ties	Gate Repair	Walkway Panels Missing	Cavi-ties	Cracks	Holes or Broken	Failed	Rubble Masonry Walls	Rubble Masonry Floor
LMC	51	13	1	38	9	2	8	-	4	3
L-1L	22	9	1	9	9	3	10	2	9	4
L-1L-1L	9	2	5	10	1	-	2	1	-	-
L-1L-2L	31	4	1	5	3	2	3	3	14	3
L-1L-2L-1R	7	-	1	2	-	-	-	3	-	-
TOTALS FOR LATERAL L-1L	69	15	8	26	13	5	15	9	23	7
L-1R	18	8	3	4	3	1	7	4	-	-
L-1R-1L	5	-	1	-	-	-	-	-	-	-
L-1R-1L-1R	6	-	7	2	-	1	-	-	-	-
TOTALS FOR LATERAL L-1R	29	8	11	6	3	2	7	4	-	-
L-2L	9	7	4	6	7	-	3	1	-	-
L-2L-1R	9	4	1	7	2	-	1	2	-	-
TOTALS FOR LATERAL L-2L	18	11	5	13	9	-	4	3	-	-
L-3L	1	-	-	1	-	-	-	1	-	-
L-3L-1R	9	2	-	8	-	-	-	3	3	2
L-3L-1R-1R	15	-	3	13	6	2	1	3	6	4
L-3L-1R-1L	11	2	-	9	-	-	-	-	5	5
L-3L-1L	6	-	-	-	-	-	1	3	3	2
L-3L-1L-1L	7	-	1	-	2	-	-	-	3	2
L-3L-1L-2L	21	5	5	16	-	-	-	-	11	11
L-3L-1L-2L-1R	8	1	1	6	-	2	1	-	2	1
L-3L-1L-2L-1L	8	-	1	7	6	2	1	-	2	1
TOTALS FOR LATERAL L-3L	86	10	11	60	14	6	4	10	35	28
L-4L	1	-	-	1	-	-	-	-	-	-
L-5L	7	8	-	3	-	-	-	-	-	-
L-2R	10	4	1	2	1	3	2	-	-	-
L-2R-1L	5	2	2	2	1	-	-	-	1	1
TOTALS FOR LATERAL L-2R	15	6	3	4	2	3	2	-	1	1
L-3R	10	4	2	9	4	2	3	-	1	-
L-4R	5	2	1	4	-	-	2	-	-	-
L-5R	7	3	1	1	-	2	1	-	-	-
TOTALS FOR ALL LMC LATERALS	247	67	42	123	45	20	38	26	60	36
TOTALS FOR LMC SYSTEM	298	80	43	161	54	22	46	26	64	30

Table 13. Volume of Sediment in the Right Main Canal System

Canal	Lateral	Sub-Lateral	Length, km	Volume of Sediment m^3
RMC			45.700	2252
	R-1L		11.415	6545
		R-1L-1L	2.500	472
		R-1L-2L	2.800	1557
	TOTALS FOR LATERAL R-1L		16.715	8574
	R-2L		3.515	416
	R-3L		1.600	31
	R-4L		4.600	524
		R-4L-1L	0.800	213
		R-4L-2L	1.120	68
		R-4L-3L	2.020	497
		R-4L-1R	3.200	799
		R-4L-1R-1R	1.150	100
	TOTALS FOR LATERAL R-4L		12.890	2201
	R-6L		4.900	1380
		R-6L-1L	0.900	178
		R-6L-2L	7.790	2835
		R-6L-3L	1.300	168
		R-6L-2L-1L	1.120	83
		R-6L-2L-1L-1R	5.400	335
		R-6L-2L-1L-1R-1L	1.550	207
		R-6L-2L-1R	1.200	187
		R-6L-2L-1R-1L	1.810	330
	TOTALS FOR LATERAL R-6L		25.970	5703

Table 13. continued

Canal	Lateral	Sub-Lateral	Length, km	Volume of Sediment m^3
	R-7L		6.120	1050
		R-7L-1L	0.620	61
		R-7L-1R	2.500	-
		R-7L-2L	1.020	329
		R-7L-2R	3.420	652
	TOTALS FOR LATERAL R-7L		13.680	2092
	R-8L		3.050	302
	R-9L		2.655	1020
		R-9L-1L	1.180	173
		R-9L-2L	2.160	199
		R-9L-2L-1R	3.450	567
	TOTALS FOR LATERAL R-9L		9.445	1959
	R-10L		1.100	-
	R-11L		4.800	131
		R-11L-1L	1.500	128
		R-11L-2L	4.500	-
		R-11L-2L-1R	2.300	324
		R-11L-2L-1L	2.900	407
		R-11L-2L-2L	2.100	469
	TOTALS FOR LATERAL R-11L		18.100	1459
	R-12L		0.800	-
		R-12L-1R	3.700	538
		R-12L-1R-1L	1.230	218
	TOTALS FOR LATERAL R-12L		5.730	756

Table 13. continued

Canal	Lateral	Sub-Lateral	Length, km	Volume of Sediment m^3
	R-13L		3.720	-
		R-13L-1L	0.760	-
		R-13L-1R	3.050	-
	TOTALS FOR LATERAL R-13L		7.530	0
	R-14L		1.300	54
	R-15L		3.700	306
	R-16L		9.500	-
		R-16L-1L	2.068	-
		R-16L-1R	5.000	-
		R-16L-1R-1L	2.943	-
		R-16L-3R	3.430	-
	TOTALS FOR LATERAL R-16L		22.941	0
	R-17L		8.370	-
		R-17L-1L	5.580	-
		R-17L-1L-1L	3.870	-
		R-17L-2L	2.460	-
	TOTALS FOR LATERAL R-17L		20.080	0
TOTALS FOR RMC SYSTEM			213.046	26,105

Table 14. Volume of Sediment in the Left Main Canal System

Canal	Lateral	Sub-Lateral	Length, km	Volume of Sediment m^3
LMC			28.040	1287
	L-1L		9.310	1906
		L-1L-1R	3.400	1757
		L-1L-2L	6.500	1099
		L-1L-2L-1R	1.500	265
	TOTALS FOR LATERAL L-1L		20.710	5027
	L-1R		6.624	1612
		L-1R-1L	1.170	482
		L-1R-1L-1R	1.569	1292
	TOTALS FOR LATERAL L-1R		9.363	3386
	L-2L		3.500	1123
		L-2L-1R	2.880	710
	TOTALS FOR LATERAL L-2L		6.380	1833
	L-3L		0.835	80
		L-3L-1R	3.173	607
		L-3L-1R-1R	3.500	354
		L-3L-1R-1L	1.920	134
		L-3L-1L	2.020	1309
		L-3L-1L-1L	1.900	-
		L-3L-1L-2L	6.320	1055
		L-3L-2L-1R	2.155	554
		L-3L-1L-2L-1L	2.000	765
	TOTALS FOR LATERAL L-3L		23.823	4858
	L-4L		0.530	102
	L-5L		1.600	107

Table 14. continued

Canal	Lateral	Sub-Lateral	Length, km	Volume of Sediment m^3
	L-2R		3.010	288
		L-2R-1L	1.250	282
	TOTALS FOR LATERAL L-2R		4.260	570
	L-3R		2.500	498
	L-4R		1.500	107
	L-5R		1.650	254
TOTALS FOR LMC SYSTEM			100.356	18,029

SECTION V

MAINTENANCE COSTS

EMERGENCY MAINTENANCE

To provide deep open drains on both sides of the Left Main Canal between stations 12+500 and 16+000 will involve the excavation of roughly 325,000 cubic meters of soil. Using a unit cost of Baht 26 per cubic meter, the estimated cost for excavation is Baht 8,450,000. Probably, two drain culverts underneath the Left Main Canal will have to be constructed and possibly a culvert under the asphalt highway. Therefore, a rough estimate for the cost of this emergency maintenance would be Baht 9,000,000. Another Baht 500,000 is needed for compacted backfill and repair and replacement of concrete lining panels.

CONTRACT MAINTENANCE

Right Main Canal

The most expensive reach on the Right Main Canal for providing surface and subsurface drainage is from 0+000 to 3+000. In this reach, there is an estimated 192,000 cubic meters of soil excavation needed. With a unit cost of Baht 26 per cubic meter, the estimated cost of excavation would be Baht 4,992,000, or rounded, Baht 5,000,000. About 525 cubic meters of concrete would be needed, so that a unit cost of Baht 1,855 per cubic meter would require a total cost of Baht 973,875, rounded to Baht 1,000,000. Therefore, the estimated cost of providing drainage between stations 0+000 and 3+000 is Baht 6,000,000.

The remaining 3,370 m of left road open drain and 12,629 m of right berm open drain along the canal would require roughly 280,000 cubic meters of excavation with an estimated cost of Baht 7,280,000. Allowing for

concrete erosion control structures, the total estimated cost would be Baht 8,000,000. The total estimated cost for providing drainage along the Right Main Canal is Baht 14,000,000.

Left Main Canal

To provide adequate surface and subsurface drainage along the Left Main Canal, an estimated 171,900 cubic meters of excavation will be required at a cost of Baht 4,471,600. The left road drainage between stations 0+000 and 1+300 will require roughly Baht 500,000 for concrete. Therefore, a total estimated cost of Baht 5,000,000 can be used at this time until complete designs and estimates are prepared. Thirty percent of this total cost is required for the left road drainage between stations 0+000 and 1+300.

FORCE ACCOUNT MAINTENANCE

Established unit costs developed by the Operation and Maintenance Division at Lam Nam Oon have been used in developing estimates of required maintenance costs. Some of the unit costs are: (a) Baht 1,855 per cubic meter for rough concrete used for lining; (b) Baht 3,555 per cubic meter for fine concrete used for structures; (c) Baht 24 per cubic meter for removing sediment by hand; (d) Baht 48 per cubic meter for compacted soil backfill; (e) Baht 26 per cubic meter for soil excavation; and (f) Baht 1,015 per cubic meter of rubble masonry.

These unit costs were used in conjunction with the results of the maintenance inventory listed in Section IV to arrive at estimated costs for correcting present maintenance problems. For example, the maintenance costs for the repair or replacement of concrete lining panels and the filling of cavities for the Right and Left Main Canal systems are shown in Tables 15 and 16, respectively. In Table 16, Baht 260,000 of the Baht 287,562 shown as panel replacement for the Left Main Canal is actually included under the

Table 15. Maintenance Costs for the Repair or Replacement of Concrete Lining Panels and the Filling of Cavities for the Right Main Canal System

Canal	Lateral	Sub-Lateral	Maintenance Costs, in Baht		
			Fill Cavities	Repair Panels	Replace Panels
RMC			254,135	57,852	13,757
	R-1L		20,405	3,157	6,611
		R-1L-1L	1,855	124	500
		R-1L-2L	1,855	372	2,000
TOTALS FOR LATERAL R-1L			24,115	3,653	9,111
	R-2L		1,855	372	500
	R-3L		-	-	-
	R-4L		14,840	744	2,500
		R-4L-1L	-	-	-
		R-4L-2L	1,855	62	-
		R-4L-3L	-	-	-
		R-4L-1R	150,255	868	4,500
		R-4L-1R-1R	20,405	372	500
TOTALS FOR LATERAL R-4L			187,355	2,046	7,500
	R-6L		14,840	1,984	1,500
		R-6L-1L	-	620	-
		R-6L-2L	152,100	2,976	15,000
		R-6L-3L	-	-	1,000
		R-6L-2L-1L	1,855	62	-
		R-6L-2L-1L-1R	42,665	310	-
		R-6L-2L-1L-1R-1L	3,710	248	-
		R-6L-2L-1R	-	-	-
		R-6L-2L-1R-1L	-	-	-
TOTALS FOR LATERAL R-6L			215,180	6,200	17,500
	R-7L		48,230	930	4,500
		R-7L-1L	-	-	-
		R-7L-1R	-	-	-
		R-7L-7L	-	-	-
		R-7L-1R	-	-	-
TOTALS FOR LATERAL R-7L			48,230	930	4,500
	R-8L		16,695	372	4,000
	R-9L		1,855	62	3,000
		R-9L-1L	-	-	-
		R-9L-2L	1,855	434	2,000
		R-9L-2L-1R	3,710	-	-
TOTALS FOR LATERAL R-9L			7,420	496	5,000

Table 15. continued

Canal	Lateral	Sub-Lateral	Maintenance Costs, in Baht		
			Fill Cavities	Repair Panels	Replace Panels
	R-10L		-	-	13,000
	R-11L		7,420	124	-
		R-11L-1L	-	-	10,500
		R-11L-2L	9,275	124	11,000
		R-11L-2L-1R	-	62	500
		R-11L-2L-1L	9,275	-	-
		R-11L-2L-2L	-	62	-
TOTALS FOR LATERAL R-11L			25,970	372	22,000
	R-12L		-	-	-
		R-12L-1R	-	124	1,000
		R-12L-1R-1L	-	-	-
TOTALS FOR LATERAL R-12L			-	124	1,000
	R-13L		18,550	-	25,000
		R-13L-1L	1,855	-	-
		R-13L-1R	11,130	-	-
TOTALS FOR LATERAL R-13L			31,535	-	25,000
	R-14L		-	-	-
	R-15L		-	-	-
	R-16L		1,855	558	-
		R-16L-1L	1,855	62	-
		R-16L-1R-1L	-	-	-
		R-16L-3R	-	124	-
TOTALS FOR LATERAL R-16L			3,710	868	-
	R-17L		-	186	-
		R-17L-1L	-	372	-
		R-17L-1L-1L	24,115	-	500
		R-17L-2L	3,710	-	-
TOTALS FOR LATERAL R-17L			27,825	558	500
TOTALS FOR ALL RMC LATERALS			589,890	15,991	109,611
TOTALS FOR RMC SYSTEM			844,025	73,843	123,368

Table 16. Maintenance Costs for the Repair or Replacement of Concrete Lining Panels and the Filling of Cavities for the Left Main Canal System

Canal	Lateral	Sub-Lateral	Maintenance Costs, in Baht		
			Fill Cavities	Repair Panels	Replace Panels
LMC			556,500	109,458	287,562
	L-1L		209,615	1,288	3,432
		L-1L-1L	90,895	2,604	1,500
		L-1L-2L	22,260	434	-
		L-1L-2L-1R	-	-	-
TOTALS FOR LATERAL L-1L			322,770	4,326	4,932
	L-1R		-	310	500
		L-1R-1L	-	-	-
		L-1R-1L-1R	-	-	1,000
TOTALS FOR LATERAL L-1R			-	310	1,500
	L-2L		11,130	806	-
		L-2L-1R	5,565	186	-
TOTALS FOR LATERAL L-2L			16,695	992	-
	L-3L		9,275	930	500
		L-3L-1R	-	248	-
		L-3L-1R-1R	3,710	-	-
		L-3L-1R-1L	-	496	-
		L-3L-1L	3,710	1,674	5,500
		L-3L-1L-2L	20,405	248	-
		L-3L-1L-2L-1R	12,985	-	-
		L-3L-1L-2L-1L	11,130	-	-
TOTALS FOR LATERAL L-3L			70,490	3,596	6,000
	L-4L		-	-	-
	L-5L		3,710	-	-
	L-2R		1,855	-	-
		L-2R-1L	-	62	-
TOTALS FOR LATERAL L-2R			1,855	62	-
	L-3R		68,635	496	-
	L-4R		-	-	-
	L-5R		1,855	-	-
TOTALS FOR LMC LATERALS			486,010	9,782	12,432
TOTALS FOR LMC SYSTEM			1,042,510	119,420	299,994

estimated costs for emergency maintenance, while Baht 47,500 listed under panel repair for the canal would be accomplished under the proposed emergency maintenance. When the emergency maintenance costs are excluded from Table 16, then the only significant cost is for filling cavities.

Tables 17 and 18 list the estimated maintenance costs for the Constant Head Orifice structures along both canal systems. The estimated maintenance costs for other structures are listed in Tables 19 and 20. These tables show that filling cavities and replacing failed Constant Head Orifice outlet structures are the most significant costs.

COST SUMMARY

A summary of maintenance costs is given in Table 21. Although only 18 percent of the maintenance costs are shown under Force Account Maintenance, two points should be kept in mind: (a) these costs are only for catch-up maintenance and do not include the regular preventive maintenance costs that will continue on a recurring basis; and (b) the proposed Emergency Maintenance will likely have to be done by the Royal Irrigation Department's Force Account.

Table 17. Maintenance Costs for Constant Head Orifice Turnouts and Outlet Structures under the Right Main Canal System

Irrigation Channel	Constant Head Orifice (CHO) Structure					
	No.	Cavities	Gate Repair	Outlet Repair	Replace Outlet	Rubble Masonry
RMC	67	61,215	10,200	50,000	110,000	24,320
TOTAL FOR LATERAL R-1L	32	44,520	17,850	32,500	20,000	1,520
TOTAL FOR LATERAL R-2L	7	3,710	3,825	2,500	-	-
TOTAL FOR LATERAL R-3L	4	5,565	1,275	7,500	-	-
TOTAL FOR LATERAL R-4L	37	24,115	1,275	22,500	70,000	6,080
TOTAL FOR LATERAL R-6L	60	40,810	24,225	1[illegible],500	70,000	15,960
TOTAL FOR LATERAL R-7L	31	18,550	5,100	15,000	30,000	7,600
TOTAL FOR LATERAL R-8L	8	1,855	-	7,500	-	760
TOTAL FOR LATERAL R-9L	28	22,260	2,550	10,000	40,000	3,040
TOTAL FOR LATERAL R-10L	2	-	1,275	-	-	-
TOTAL FOR LATERAL R-11L	47	37,100	12,750	20,000	150,000	6,080
TOTAL FOR LATERAL R-12L	16	1,855	-	5,000	-	2,280
TOTAL FOR LATERAL R-13L	20	3,710	1,275	5,000	40,000	3,040
TOTAL FOR LATERAL R-14L	2	-	-	-	-	760
TOTAL FOR LATERAL R-15L	11	3,710	1,275	2,500	-	6,110
TOTAL FOR LATERAL R-16L	60	5,565	2,550	7,500	20,000	13,680
TOTAL FOR LATERAL R-17L	42	63,070	1,275	25,000	40,000	3,800
TOTALS FOR ALL RMC LATERALS	407	276,395	76,500	175,000	480,000	70,380
TOTALS FOR RMC SYSTEM	474	307,610	86,700	225,000	590,000	95,000

Table 18. Main'enance Costs for Constant Head Orifice Turnouts and Outlet Structures under the Left Main Canal System

Irrigation Channel	Constant Head Orifice (CHO) Structure					
	No.	Cavities	Gate Repair	Outlet Repair	Replace Outlet	Rubble Masonry
LMC	51	40,810	1,275	25,000	-	5,320
TOTALS FOR LATERAL L-1L	69	51,940	10,200	50,000	90,000	22,800
TOTALS FOR LATERAL L-1R	29	20,405	14,025	22,500	40,000	-
TOTALS FOR LATERAL L-2L	18	37,100	6,375	10,000	30,000	-
TOTALS FOR LATERAL L-3L	86	44,520	14,025	25,000	100,000	47,880
TOTALS FOR LATERAL L-4L	1	-	-	-	-	-
TOTALS FOR LATERAL L-5L	7	14,840	-	-	-	-
TOTALS FOR LATERAL L-2R	15	14,840	3,825	12,500	-	1,520
TOTALS FOR LATERAL L-3R	10	14,840	2,550	12,500	-	760
TOTALS FOR LATERAL L-4R	5	3,710	1,275	5,000	-	-
TOTALS FOR LATERAL L-5R	7	5,560	1,275	7,500	-	-
TOTALS FOR ALL LMC LATERALS	247	207,760	53,550	145,000	260,000	72,960
TOTALS FOR LMC SYSTEM	298	248,570	54,825	170,000	260,000	78,280

Table 19. Maintenance Costs for Other Structures (Bridges, Drops, Checks, etc.) under the Right Main Canal System

Irrigation Channel	Other Structures (Bridges, Drops, Checks, etc.)			
	Cavities	Adjacent Concrete Lining Panels		Replace Rails
		Holes or Broken	Failed	
RMC	255,990	5,600	12,040	5,250
TOTALS FOR LATERAL R-1L	18,550	600	-	2,100
TOTALS FOR LATERAL R-2L	-	-	-	-
TOTALS FOR LATERAL R-3L	1,855	-	-	-
TOTALS FOR LATERAL R-4L	16,695	300	-	1,050
TOTALS FOR LATERAL R-6L	77,910	700	-	5,250
TOTALS FOR LATERAL R-7L	25,970	100	-	1,050
TOTALS FOR LATERAL R-8L	3,710	-	-	-
TOTALS FOR LATERAL R-9L	16,695	500	2,500	2,100
TOTALS FOR LATERAL R-10L	-	-	-	-
TOTALS FOR LATERAL R-11L	42,665	500	-	3,150
TOTALS FOR LATERAL R-12L	7,420	100	-	1,050
TOTALS FOR LATERAL R-13L	3,710	100	-	-
TOTALS FOR LATERAL R-14L	-	-	-	-
TOTALS FOR LATERAL R-15L	1,855	-	-	-
TOTALS FOR LATERAL R-16L	18,550	800	-	-
TOTALS FOR LATERAL R-17L	50,085	700	-	1,050
TOTALS FOR ALL RMC LATERALS	285,670	4,400	2,500	16,800
TOTALS FOR RMC SYSTEM	541,660	10,000	14,540	22,050

Table 20. Maintenance Costs for Other Structures (Bridges, Drops, Checks, etc.) under the Left Main Canal System

Irrigation Channel	Other Structures (Bridges, Drops, Checks, etc.)			
	Cavities	Adjacent Concrete Lining Panels		Replace Rails
		Holes or Broken	Failed	
LMC	61,215	6,000	12,500	9,450
TOTALS FOR LATERAL L-1L	37,100	100	-	3,150
TOTALS FOR LATERAL L-1R	25,970	200	-	1,050
TOTALS FOR LATERAL L-2L	9,275	-	-	3,150
TOTALS FOR LATERAL L-3L	20,405	-	-	6,300
TOTALS FOR LATERAL L-4L	-	-	-	-
TOTALS FOR LATERAL L-5L	-	-	-	-
TOTALS FOR LATERAL L-2L	1,855	-	-	2,100
TOTALS FOR LATERAL L-3R	3,710	-	-	1,050
TOTALS FOR LATERAL L-4R	1,855	-	-	1,050
TOTALS FOR LATERAL L-5R	1,855	-	-	-
TOTALS FOR ALL LMC LATERALS	157,115	300	-	17,850
TOALS FOR LMC SYSTEM	163,240	6,300	12,500	27,300

Table 21. Summary of Maintenance Costs for the Lam Nam Oon Irrigation System

Item	System Costs in Baht		
	Right Main Canal	Left Main Canal	Total
Emergency Maintenance	-	9,500,000	9,500,000
Contract Maintenance	14,000,000	5,000,000	19,000,000
Force Account Maintenance:			
Concrete Lining*	1,041,236	1,154,244	2,195,480
CHO Structures	1,334,310	811,675	2,145,985
Other Structures	588,250	209,340	797,590
Sediment	626,520	432,696	1,059,216
Sub-Totals	3,590,316	2,607,955	6,198,271
TOTALS	17,590,316	17,107,955	34,698,271

*Takes into account that Baht 307,500 listed in Table 16 will be done under Emergency Maintenance.

SECTION VI

MAINTENANCE EQUIPMENT REQUIREMENTS

PRESENT EQUIPMENT INVENTORY

The Operation and Maintenance Division of the Lam Nam Oon Irrigation Project prepared the equipment inventory listed in Table 22. An inspection of this equipment disclosed that most of the vehicles presently belonging to the O&M Division are quite old, so it is quite impressive that they are still functioning. The most valuable equipment presently available to the O&M Division are the vehicles, concrete mixers, and the soil compaction machine. Quite obviously, this is a very meager amount of equipment when considering an irrigation project with 73 km of concrete-lined canal and 240 km of concrete-lined laterals and sub-laterals. Even more striking is a comparison of this equipment list (Table 21) with the "Inventory of Required Maintenance" in Section IV, which indicates the extreme difficulty in ever catching-up with the present maintenance problems.

IMMEDIATE EQUIPMENT NEEDS

The Royal Thai Government and U.S. Agency for International Development (USAID) are presently funding the Lam Nam Oon Integrated Rural Development Project, which includes USAID funding for maintenance equipment. The proposed purchases using USAID funding are listed in Table 23. This is a fairly substantial list of maintenance equipment, which would provide the Lam Nam Oon O&M Division the equipment capability for a catch-up maintenance program.

The proposed equipment purchases, listed in Table 23, would represent a manifold increase in the present maintenance capability. With so much needing to be done, it is not difficult to realize how dismal the prospects

are for ever catching-up on the required maintenance in light of the present equipment situation. Purchase of the proposed equipment would provide the necessary capability to accomplish this huge task, as well as being a significant morale booster to all of those personnel responsible for maintenance within the Lam Nam Oon irrigation system.

In addition to the proposed equipment purchase (Table 23), it is recommended that a gunnite machine also be purchased. This machine mixes cement, sand, and water, which then flows under pressure through a hose and out of a nozzle. The most important use of this machine would be for filling the numerous cavities behind concrete lining wall panels and alongside structures. In addition, this machine could be used for repair of panels that have holes.

REPAIR OF EQUIPMENT

The Construction Division Repair Shop at Lam Nam Oon is also used for the repair of O&M equipment. This repair shop can do all types of repairs for small vehicles including engine work, but any interior work (e.g., upholstery) is done in Bangkok.

There is a Trailer Center in Ubol and Korat where spare parts can be obtained for heavy equipment, such as scrapers and draglines. Someone will travel from Lam Nam Oon to one of these trailer centers to obtain the necessary spare part(s), which then will be installed at the Construction Division Repair Shop at Lam Nam Oon. If major repairs are needed for a piece of heavy equipment, then only the component needing major repair will be transported to Bangkok for such repair.

Probaby the best testimony to the effectiveness of any equipment maintenance and repair program is whether or not the serviced equipment

previously, there are many old pieces of equipment doing just that at Lam Nam Oon. This would indicate that their maintenance and repair program is highly effective.

Table 22. Present Equipment Inventory for the Operation and Maintenance (O&M) Division of the Lam Nam Oon Irrigation Project

I. Mechanical Engineering Division

1. A concrete mixer, capacity 7/5 cubic feet, made in Thailand by SMC, Model SMC, driven by diesel engine (SMC Model 175) made in China mainland, including spare parts. Ser. No. 17987, Baht 14,500.

2. A concrete mixer, capacity 7/5 cubic feet, made in Thailand by Master Model Senior, driven by diesel engine (Yanmar Model 7-H-4) made in Japan. Ser. No. 804658, Baht 17,523.

3. A concrete mixer, capacity 7/5 cubic feet, made in Thailand by Baton, driven by diesel engine (CMC Model) made in China mainland. Ser. No. 104, Baht 20,000.

4. A pumping machine, capacity Ø 3", made in India by Kirleskar, functioned by diesel engine (Kirleskar Model AVI) made in India. Ser. No. Pump 80014 engine + 10.1145/8020.

5. Pressure soil compaction machine, made by Ingersol Rand, Model 44112. Ser. No. 58986, Baht 8,234.67.

II. Workshop Machine Division

1. Electric screw, Ser. No. 8316E, Baht 11,983.

2. Steel cutter, Baht 11,722.11.

III. Survey Section Division

1. A theodolite and spare parts (third order level) made by Sorkisha, Model C-3-A-8334. Baht 7,900.

2. One second theodolite and spare parts (made by Zeiss). Baht 76,000.

IV. Transportation Division

1. 1 ton truck, TOYOTA HILUX, Model RN. 20 JR, Baht 66,450.

2. A motorcycle, SUZUKI, Model A-100 NR. Baht 10,280.

3. Dump Truck, capacity 6.45 CV/D, functioned by diesel engine, Model T 80 SD 1969. Baht 189,000. Note - handed over by Construction Section.

4. Land Rover A 109", Baht 81,750. Note - handed over by Construction Section.

Table 22. continued

5. A truck, TOYOTA, PA. 1965, Baht 72,300. Note - handed over by Construction Section.

6. A 100 c.c. motorcycle, YAMAHA YL 2K, Baht, 10,600.

7. A 100 c.c. motorcycle, YAMAHA YL 2K, Baht, 10,600.

8. A boat - Baht 6,500.

9. An engine for boat, 25 horsepower made by Rotax, Australia, Baht 9,950.

10. Land Rover AA 109", Baht 105,000. Note - handed over by Construction Section.

11. A 2 ton truck, Nissan Carbon Model GC 340, Baht 119,500. Note - belong to Yasothorn Irrigation Project.

V. Design Section

1. 2 steel boxes for documents made by Samson Thailand, Model 4 FCE RO, Baht 1,624.

2. A pack of stationery (TXP Spectrum), Baht 2,000.

3. An office calculator, Baht 4,590.

4. 2 steel boxes for document, Baht 2,800.

VI. Budget Planning Division

1. A typewriter made by Olympia, Model SG.SN, Baht 7,900.

2. A copy maker, hand operated, made by Roneo, England, Baht 20,000.

VII. Hydrology Division

1. 5 rain gauges, Baht 4,700.

VIII. Storage Division

1. 10 wheel barrows, Baht 12,000.

2. 2 grass cutters, Baht 11,500.

3. 10 water containers (storage tank), Baht 16,300.

4. 8 office desks with chairs, BAht 11,000.

5. A desk for typewriter, Baht 1,200.

Table 23. Proposed Maintenance Equipment Purchases for the Lam Nam Oon Integrated Rural Development Project Using USAID Funding in U.S. Dollars

High Priorities	Set	Unit Cost	Total
1. Field testing equipment, special recording devices, to be used in conjunction with an Apple III computer, which now operates manually and record for transcription to a computer, details see Annex B of special procedurement list.	1	19,000	19,000
2. Motorcycles, generally used by extension officers for operation and maintenance system, 100-125 cc, standard transmission, 2 cylinders, preferably Japanese local assembly.	37	850	31,450
3. Tractors, industrial size, at least 80 hp, diesel engine for small to moderate construction and maintenance works, equipped with accessories with variety of applications, comfort, easy and convenient to operate, for the following:	3	6,000	180,000
a) Front-end loader with backhoe, with digging as primary purpose, 2 sets.			
b) Loader, front-end loader, for loading and dump off as primary purpose, 1 set.			
4. Concrete mixing machine, movable, diesel engine, capacity of mixer as			8,550
a) 10/7 cubic feet	1	6,000	
b) 7/5 cubic feet	3	850	
5. Concrete vibrators, Ø 2" vibration rod, gasoline engine, portable, light-weight and compact unit, able to be operated by one man.	4	850	3,400
6. Compacting machines, gasoline engine, 2 strokes, Ø 8" compacting face, portable, light-weight and compact unit.	3	1,300	3,900
7. Communication System Tools, portable, light-weight and compact unit, high transmitting/receiving capability, powered as following			40,600
a) Base station, 100 Watt or Fixed Station	4	3,900	

Table 23. continued

High Priorities	Set	Unit Cost	Total
b) Mobile station, 60 Watt	4	1,750	
c) Walkie-Talkie, 5 Watt hand carried unit	12	1,500	
8. Hand tool set, for general field service/ repair of machines and equipment, complete set in hand carry case, hardening and high strength steel made or rust protective coating.	4	1,100	4,400
9. Crack sealing machine, portable, light-weight and compact unit, Tar-pitch asphalt pressure injection/sealing type, easy to operate by one person, enable the filling of concrete cracks, air pressure power drive, equipped with connection and hoses in connection with the air compressor, generally used as water sealing and proofing of concrete canal leakage.	1	2,600	2,600
10. Air compressor, diesel engine, min. 150 CFM, movable, compact unit with rubber wheels, equipped with air hammer, concrete digger and hoses in complete set for the purpose of soil compaction/digging and repaving the concrete in areas not easily accessible.	1	11,000	11,000
Second Priorities	**Set**	**Unit Cost**	**Total**
11. Pickup trucks, 1,200 - 1,600 cc. standard transmission, gasoline engine, 4 cylinders, short length of flat bed, preferably Japanese local assembly.	4	6,500	26,000
12. Dump trucks, hydraulic dump-off, 6 wheels, medium size, 8 tons, volumetric capacity around 4 cubic yards, diesel engine.	3	20,000	60,000
13. Truck equipped with heavy duty chopper pump, Vaughan Crane Dredge System, hard surfaced impeller pump, with cutter bar, discharge elbow and disintegrator tool, for handling agricultural and others solid wastes, including two complete sets of spare parts.	1	110,000	110,000
14. Trailer, for transporting of the Crawler Tractor, joints must be designed to connect with flat bed truck.	1	17,500	17,500

Table 23. continued

Second Priorities	Set	Unit Cost	Total
15. Grass cutting tractor, for side slope and cutting and trimming of canal, equipped with horizontal-rotating blades and mowers, smallest size tractor, 15-30 hp, extendable and adjustable blade, diesel engine.	1	17,500	17,500
16. Crawler tractor, equipped with ditch and dozer, diesel engine, min. 75 hp, power shift and direct drive, 6 cylinders.	1	55,000	55,000
17. Pump, ≥ 3" discharge line, gasoline engine driven, air cooling type, total heads exceed 21 meters, protable by mounting on moving cart with rubber wheels, 220 VAC, 50 HZ.	3	3,500	10,500
18. Water tank truck, diesel engine, 6 wheels, 6 tons capacity of water transport, equipped with outlet valves, color protective coating.	1	16,500	16,500
19. Welding machine, 100 A, diesel, or gasoline engine with generator in both AC and DC, portable light-weight and compact unit, 5 KVA.	1	4,500	4,500
20. Heavy duty machine tools, for maintenance of construction equipment inside workshop, complete set with all variety of machine tools, made of high strength steel and rust protective coating.	1	8,700	8,700
21. Electric generator, movable unit, diesel engine, about 15 KVA generated capacity, compact unit.	1	4,500	4,500

Low Priorities	Set	Unit Cost	Total
22. Equipment and other accessories including spare parts which will be determined later on, and in any cases where the above equipment list is inadequate, additional budget shall be executed from this item.	1	130,400	130,400

Conclusion

High Priorities	$304,900
Second Priorities	$384,700
Low Priorities	$130,400
Total:	$820,000

Rate of Exchange: U.S.$1.00 = Baht 23.00

SECTION VII

MAINTENANCE MANPOWER REQUIREMENTS

EMERGENCY MAINTENANCE

The proposed emergency maintenance on the Left Main Canal between stations 12+500 and 16+000 can probably best be done by Force Account. This would require the use of Construction Division equipment at Lam Nam Oon, unless other equipment is brought in from other irrigation projects or private contractor equipment is used.

The most essential construction work is the excavation of open drains on both sides of this 3.5 km reach. This phase of emergency maintenance should be completed by April 30, 1983, when the canals will be closed for at least one month. The necessary concrete work for repairing and replacing the damaged concrete lining panels can begin then with completion necessary during May 1983. The sealing of the lining panel joints with asphalt will probably have to wait until November 1983 when the canals again are closed.

CONTRACT MAINTENANCE

In providing the necessary surface and subsurface drainage along the two main canals, the primary reasons for recommending contract maintenance are: (a) the job is too big to be accommodated by O&M personnel at Lam Nam Oon; and (b) detailed designs are required. Detailed designs followed by good construction techniques are required so that future costs along the main canals will be minimized.

This particular approach has the advantage of allowing present O&M personnel to catch-up on the backlog of needed maintenance as listed in Appendix B. Also by contracting for the construction of the necessary drains along the main canals (except for the proposed emergency

maintenance), it is possible to minimize the request for new O&M positions at Lam Nam Oon.

FORCE ACCOUNT MAINTENANCE

The O&M Division of the Lam Nam Oon Irrigation Project has completed in the fall of 1982 their request to the Royal Irrigation Department in Bangkok and the Bureau of Budget for new personnel positions. Table 24, taken from the O&M Division report, shows the present authorized positions and requests for: (a) changes in positions; and (b) new positions.

One hundred (100) of the requested new positions will affect the future capability of the Lam Nam Oon Irrigation Project to effectively maintain the system. Seven new positions requested for the Transportation Unit can be utilized for repair of maintenance equipment. The number of Structure Keepers is presently 21, while a total of 82 is proposed, an increase of 61 positions. Presently, four Zonemen are authorized, with 32 new positions being requested, giving a total of 36.

The requested new positions in the Transportation Unit are: (a) one machinist; (b) three mechanics; and (c) three laborers. As adequate maintenance equipment is obtained, these new positions will be required. In particular, if the full complement of equipment listed in Section VI is procured, there then will be a large increase in the demand for repair services.

The postion of Structure Keeper is to provide surveillance of the irrigation structures and channels. The criteria for determining the number of people in this position has been established by the Bureau of Budget and is related to the number of structures larger than a specified size (one meter diameter). A Structure Keeper is also assigned a length of irrigation channel upstream and downstream of a structure for surveillance.

Besides understanding the operation of that portion of the irrigation system under his responsibility, the Structure Keeper should be well-trained in the detection and correction of maintenance problems. In particular, Structure Keepers need to be trained in the art of preventive maintenance so as not to allow small problems to grow into large, more expensive problems. Providing such training should not be difficult because it can be done on-the-job. In addition, it is very important that the Structure Keeper participate in the maintenance activities as a trained laborer rather than just supervising other laborers. Thus, a Structure Keeper should be doing preventive maintenance activities while the irrigation system is being operated as well as actively participating in those maintenance activities that can only be done when the canals are closed.

The most important position in an irrigation system is that of Zoneman, provided there has been adequate training. The request for 32 new positions in the classification of Zoneman is highly justified. The criteria being used is one Zoneman for 5,000 rai of cultivated irrigated land, a reasonable criteria based on experience at other irrigation projects in Thailand.

The Zoneman is the government link with the farmer. This is a critical position both for the operation of the on-farm delivery facilities and for the maintenance of these facilities by the farmers. The people in this position should receive more training than any other position in O&M. This training needs to be done for short time intervals (1-5 days) throughout the year. Most of this training should be done on-the-job and requires that a highly trained Water Master, or higher position, continually provide and monitor the training activities of the Zoneman.

Because so much training effort is needed in order to have a highly qualified Zoneman, it becomes very important that these people do not leave

this position for employment elsewhere. Thus, an effort needs to be made to provide a larger range of pay scales for this position. As a minimum, a Zoneman should be allowed to advance to Grade 2 after: (a) being properly trained; (b) demonstrating an effectiveness for working with farmers; and (c) displaying a capability for efficient operation of the on-farm delivery facilities as shown in the irrigation channels being properly maintained by the farmers. A highly trained and effective Zoneman also should be allowed to advance to the position of Water Master, which can begin at Grade 3 and advance to Grade 4.

Table 24. Maintenance Manpower Requirements for the O&M Division, Nam Oon Irrigation Project (Newly Improved), The Regional Irrigation Office V, Royal Irrigation Department

Division and Position	Grade	Specified by Bureau of Budget	Newly Improved: Division and Position	Newly Improved: Grade	Newly Improved: Specified by Bureau of Budget: Government Employees	Newly Improved: Specified by Bureau of Budget: Regular Employee	Specified by O&M	Note
construction (leader of project)	1	1	irrigation engineer	-	-	1	-	
1. general admin.'s activities			1. admin. sub-division					
			admin. staff	1	-	-	1	leader of sub-division
			1.1 admin. unit					
admin. staff	2-1	1	admin. staff	2-1	-	1	-	leader of the unit
admin. staff	4-2	2	admin. staff	4-2	-	2	-	
typist	4-3	2	typist	3-2	-	2	-	
nurse assistant			nurse assistant	4-2	-	1	-	
janitor	-	1	janitor	-	-	1	-	
			1.2 accountantancy and financial unit					
accountant	4-2	2	accountant	2-1	-	-	1	leader of the unit
			accountant	4-2	-	2	4	
			1.3 inventory unit					
store keeper	4-2	2	store keeper	2-1	-	-	1	leader of the unit
			1.4 storage unit					
laborer for storage management	-	1	store keeper	2-1	-	-	1	leader of the unit
			store keeper	4-2	-	-	2	
			laborer for store management	-	-	1	1	
			1.5 security unit					
			construction man	2-1	-	-	1	leader of the unit
laborer for the guest house		2	leader of the watchman	-	-	1	3	
			watchman	-	-	29	10	
NOTE	One leader of the watchman transferred from the first part, 29 watchmen transferred from the first part							
			TOTAL			43	27	

Table 24. continued

Division and Position	Grade	Specified by Bureau of Budget	Newly Improved: Division and Position	Grade	Specified by Bureau of Budget: Government Employees	Regular Employee	Specified by O&M	Note
2. irrigation engineer sub-division								
			2. engineering sub-division construction man	1	-	-	1	leader sub-division
			admin. staff	4-2	-	-	1	
			2.1 budget planning unit					
construction man	2-1	1	construction man	2-1	-	1	-	leader of the unit
construction man	4-2	1	construction man	4-2	-	1	2	
draftsman	4-2	2	draftsman	4-2	-	2	-	
			2.2 water management unit					
agricultureal staff	4-2	3	agricultural staff	2-1	-	-	1	leader of the unit
			agricultural staff	4-2	-	3	1	
			2.3 basic survey unit					
surveyor	4-2	2	surveyer	2-1	-	-	1	leader of the unit
surveyer staff (laborer)	-	4	surveyer	4-2	-	2	-	
			surveyer staff (laborer)	-	-	4	4	
			TOTAL			13	11	

Table 24. continued

Division and Position	Grade	Specified by Bureau of Budget	Newly Improved				Specified by O&M	Note
			Division and Position	Grade	Specified by Bureau of Budget			
					Government Employees	Regular Employee		
3. mechanical engineering division								
			3. mechanical sub-division					
workshop technician	2-1	1	machinist	1	-	-	1	leader of sub-division
admin. staff	4-3	1	admin. staff	4-2	-	1	-	
workshop technician	4-2	3	3.1 transportation unit					
field technician	4-3	2	workshop technician	2-1	-	1	-	leader of sub-division
driver		3	workshop technician	4-2	-	3	2	
electrician	4-2	2	driver	-	-	3	7	
			field technician	4-2	-	2	-	
			boat driver	4-7	-	-	1	
			mechanical man	4-2	-	-	3	
			laborer	-	-	-	3	
			electrician	4-2	-	2	1	
			janitor	-	-	-	1	
			3.2 communication unit					
communication		3	communication technician	2-1	-	-	1	leader of the unit
communication technician	4-2	2	communication staff	4-2	-	3	-	
			communication technician	4-2	-	2	6	
			TOTAL			17	26	

Table 24. continued

Division and Position	Grade	Specified by Bureau of Budget	Newly Improved: Division and Position	Grade	Specified by Bureau of Budget: Government Employees	Regular Employee	Specified by O&M	Note
Part I: headriork area								
			operation and maintenance sub-division in the first part					
construction man	2-1	1	construction man	1	-	-	1	leader of sub-division
hydrographer		1	admin. unit					
structure keeper		4	admin. staff	4-2	-	-	1	leader of the unit
field technicial	4-3	6	hydrographer	-	-	1	-	
			laborer	-	-	2	-	
leader of laborer		1	operation and maintenance unit					
gardener		2	construction man	2-1	-	1	-	leader of the unit
laborer		52	field technician	4-2	-	6	-	
			structure keeper		-	4	2	
			gardener	-	-	2	2	
leader of the watchman		1	laborer	-	-	52	-	
watchman		29	leader of laborer	-	-	1	4	
			TOTAL			69	10	

NOTE One leader of the watchman and 29 watchmen are transferred to general admin. activities

Table 24. continued

Division and Position	Grade	Specified by Bureau of Budget	Newly Improved				Specified by O&M	Note
			Division and Position	Grade	Specified by Bureau of Budget			
					Government Employees	Regular Employee		
Part II (LMC): irrigation area 39,400 ria								
			operation and maintenance sub-division					
			construction man	1	-	-	1	leader of sub-division
			admin. unit					
			admin. staff	4-2	-	1	1	
			watchman	-	-	3	-	
			laborer	-	-	2	-	
			janitor	-	-	-	1	
			operation and maintenance unit					
			construction man	2-1	-	1	-	leader of the unit
			zoneman	-	-	4	4	5,000 rai for a zone-man
			electrician	4-2	-	-	4	1 pumping station operating 24 hours 6 hours a period 1 period for 1 electrician and 1 dump operator
			laborer	-	-	-	3	for pumping station
			watchman	-	-	-	3	for pumping station
			field technician	4-2	-	4	-	
			structure keeper	-	-	17	3	1.00 m. capacity structure and higher 20 structures
			lining keeper	-	-	17	-	
			hydrographer	-	-	1	-	
			TOTAL			50	20	
			TOTAL			192	94	

Table 24. continued

Division and Position	Grade	Specified by Bureau of Budget	Newly Improved: Division and Position	Newly Improved: Grade	Newly Improved: Specified by Bureau of Budget: Government Employees	Newly Improved: Specified by Bureau of Budget: Regular Employee	Specified by O&M	Note
Part III (LMC) irrigation area: 37,000 rai								
			operation and main maintenance sub-division for the III part					
			construction man	1	-	-	1	leader of sub-division
			admin. unit					
			admin. staff	4-2	-	-	2	
			laborer	-	-	-	2	
			watchman	-	-	-	3	
			janitor	-	-	-	1	
			operation and maintenance unit					
			construction man	2-1	-	-	1	leader of the unit
			zoneman	-	-	-	7	5,000 rai for a zoneman
			electrician	4-2	-	-	7	pumping station operated 24 hours, 3 period 1 electrician for a period 1
			field technician	4-2	-	-	4	pump operator
			structure keeper					Ø1.00 m capacity structure and higher 13 structure
			lining keeper	-	-	-	-	
			hydrography	-	-	-	1	
			laborer	-	-	-	6	laborer for a period of operating
			watchman	-	-	-	6	for pumping station
			TOTAL	-	-	-	54	

Table 24. continued

Division and Position	Grade	Specified by Bureau of Budget	Newly Improved				Specified by O&M	Note
			Division and Position	Grade	Specified by Bureau of Budget			
					Government Employees	Regular Employee		
Part IV: 46,000 rai								
			operation & maintenance sub-division in the IV part					
			construction man	1	-	-	1	leader of sub-division
			admin. unit					
			admin. staff	4-2	-	-	2	
			laborer	-	-	-	2	
			watchman	-	-	-	3	
			janitor	-	-	-	1	
			construction man	2-1	-	-	1	
			zoneman	-	-	-	9	5,000 rai for a zoneman
			electrician	4-2	-	-	4	a pumping station operated 24 hours, 8 periods 1 electrician for a period
			field technician	4-2	-	-	4	
			structure keeper	-	-	-	28	Ø1.00 m capacity structure and higher
			lining keeper	-	-	-	-	
			zoneman	-	-	-	1	
			laborer	-	-	-	3	1 laborer for a period
			watchman	-	-	-	3	for pumping station
			TOTAL	-	-	-	62	

Table 24. continued

Division and Position	Grade	Specified by Bureau of Budget	Newly Improved				Specified by O&M	Note
			Division and Position	Grade	Specified by Bureau of Budget			
					Government Employees	Regular Employee		
Part V (RMC): 33,600 rai								
			operation and maintenance sub-division in the V part					
			construction man	1	-	-	1	leader of the sub-division
			admin. unit					
			admin. staff	4-2	-	-	2	
			laborer		-	-	2	
			watchman		-	-	3	
			janitor		-	-	1	
			operation and maintenance unit					
			construction man	2-1	-	-	1	
			zoneman		-	-	7	5,000 rai for a zoneman
			structure keeper	-	-	-	17	Ø1.00 m capacity structure and higher
			lining keeper	-	-	-	-	
			hydrographer	-	-	-	1	
			field technician	4-2	-	-	4	
			TOTAL	-	-	-	39	

Table 24. continued

Division and Position	Grade	Specified by Bureau of Budget	Newly Improved				Specified by O&M	Note
			Division and Position	Grade	Specified by Bureau of Budget			
					Government Employees	Regular Employee		
Part VI (RMC): 47,000 rai								
			operation and maintenance sub-division in the V part					
			construction man	1	-	-	1	leader of the sub-division
			admin. unit					
			admin. staff	4-2	-	-	2	
			laborer	-	-	-	2	
			watchman	-	-	-	3	
			janitor	-	-	-	1	
			operation and maintenance unit					
			construction man	1	-	-	1	
			zoneman	-	-	-	9	5,000 rai for a zoneman
			structure keeper	-	-	-	19	Ø1.00 m capacity structures and higher
			lining keeper	-	-	-	-	
			hydrographer	-	-	-	1	
			field technician	4-2	-	-	4	
			TOTAL	-	-	-	43	

Table 24. continued

Division and Position	Grade	Specified by Bureau of Budget	Newly Improved				Specified by O&M	Note
			Division and Position	Grade	Specified by Bureau of Budget			
					Government Employees	Regular Employee		
Nam Oon Resettlement								
			operation and maintenance sub-division part V					
			construction man	1	-	-	1	leader of the sub-division
			admin. unit					
			admin. staff	4-2	-	-	1	
			laborer	-	-	-	2	
			watchman	-	-	-	3	
			O&M unit					
			construction man	2-1	-	-	1	leader of the unit
			zoneman	-	-	-	3	5,000 rai for a zoneman
			structure keeper	-	-	-	9	Ø1.00 m capacity structure
			field technician	4-2	-	-	2	
			lining keeper	-	-	-	-	
			electrician	4-2	-	-	4	1 pump station operate 2 hours a day: 3 periods an electrician for a period
			watchman	-	-	-	3	for pump machine
			hydrographer	-	-	-	1	
			watchman	-	-	-	3	for pump machine
			janitor	-	-	-	1	
			TOTAL	-	-	-	34	
		TOTAL AMOUNT OF PERSONNEL IN THE PROJECT		-	-	192	326	

SECTION VIII

MAINTENANCE REQUIREMENTS FOR THE WATER USERS GROUPS

A detailed maintenance inventory of the on-farm water delivery network was not undertaken for a variety of reasons: (a) after walking along a number of the existing on-farm irrigation channels, it was possible to interpret or predict the longer-term maintenance needs; (b) only 10 percent of the project land now has on-farm facilities; (c) most of the farm water delivery channels are relatively new, so that present maintenance needs are not great; and (d) at the present time, it appeared more judicious to devote most of the time to the maintenance inventory of the irrigation canals, laterals, and sublaterals operated by The Royal Irrigation Department.

Timewise, the medium-term and long-term maintenance plans must give serious consideration to accomplishing appropriate maintenance of the farm irrigation channels. A study of the problems being faced by the Water Users Groups in operating the irrigation water supply provides some insights regarding the difficulties that will be encountered in attempting to maintain these facilities.

The Water Users Groups are plagued by: (a) use of their water supply by non-members; (b) damage to structures and dikes by fishermen; (c) nonconformance by members to the Water User Groups' rules and regulations; (d) difficulties of tail end irrigators in receiving sufficient water, and the inability to get water onto their land because the irrigation channel is too low; and (e) the inability of the Royal Irrigation Department to provide sufficient technical assistance or correct deficiencies in the design or construction of the facilities.

In discussing Water Users Groups with various professional people around the Northeast, there appears to be only a few truly successful

groups. A universal problem cited many times is the inability to gain conformance among the members in operating under existing rules and regulations. There is an unwillingness to report offenders and apply sanctions, problems peculiar to Thai culture.

This general weakness of the organizations can be largely attributed to a lack of experience by Northeast farmers with irrigated agriculture. Also, most of the Northeast irrigation projects have not matured to the point where the demand for irrigation water exceeds the supply; but this situation will soon change.

If the Water Users Groups continue to encounter much difficulty in equitably distributing the available irrigation water supply, then it can be expected that they will have even more problems in gaining farmer participation for necessary maintenance activities. If this continues to be the case, then the farm delivery network can be expected to rapidly deteriorate.

Certainly, the Zoneman (whose responsibilities are similar to ditch riders or zanjero in other countries) can play a significant role in mobilizing the members of the Water User Groups for undertaking maintenance. However, this only treats the symptoms of the problem, rather than getting at the root cause of the problem. There is still a need for an institutional change in the way in which farmers are organized so that the problems of dealing with offenders and applying sanctions can be overcome. Solving these problems, combined with a continued integrated thrust in providing technical assistance for better irrigated agricultural practices, improved on-farm water management practices, and the marketing of the final products of these endeavors, will create the necessary ingredients for a highly successful irrigation project.

Four components, then, are being advocated to ensure the success of the Lam Nam Oon Irrigation Project:

1. An institutional change in the organization of Water Users Groups;
2. A long-term training program for Zonemen;
3. A long-term technical assistance program for the farmer organizations focused upon improving agricultural and on-farm water management practices; and
4. An active marketing program.

These activities are primarily directed towards agricultural production, but, if successful, will create a demand for the irrigation water, which in turn requires that all of the irrigation and drainage channels be adequately maintained.

A national task force should be established for addressing the problems being faced by Water Users Groups. In particular, the problem of reporting offenders and applying sanctions needs to be addressed in the context of Thai culture. This will require the services of highly trained social scientists with vast experince in Thai rural life. Concepts used in various irrigation systems around the world should be evaluated as to their potential application in Thailand. For example, in Valencia and Murcia, Spain, there is a Tribunal of Waters consisting of the presidents of the local canal companies who meet at noon every Thursday under the Cathedral arch to hear reported cases of irrigation offenses. This Tribunal of Waters investigates each reported offense and then applies appropriate sanctions. Although this particular concept may not be directly applicable in Thailand, perhaps this concept, or others, can be modified to fit Thai cultural values.

As mentioned in Section VI, the Zoneman should be a highly trained individual because of being the government linkage with the farmers through the Water Users Groups. Besides having a detailed knowledge of the operational and maintenance requirements of the irrigation system, the Zoneman needs to have some knowledge of agricultural and on-farm water management practices. To impart all of this knowledge to individuals without a formal education in these subject areas requires many periodic on-the-job training courses. Most of this training should be 1-5 day interjections into the Zonemen's busy schedule. Such programs require trainers with field experience who also can be provided with the necessary time needed to continually monitor the activities of the Zonemen, thereby ensuring that they truly understand how to fulfill their field responsibilities.

A 10-year program should be implemented that would provide technical assistance to Water Users Groups for improving agricultural and on-farm water management practices. Farmers in the Lam Nam Oon project area have very limited, or no, experience with irrigated agriculture. Their agricultural experience is largely rice production during the monsoon season and their concept of sufficient water is the monsoon rains. Thus, there is a great need to assist farmers in adapting to the production of upland field crops and improved water management practices. Without such a program, farmers will continue to develop poor habits regarding on-farm water management that eventually will limit the area that can be irrigated during the dry season; this is a common occurrence on new irrigation projects throughout the world. Besides implementing improved agricultural and water management practices, this technical assistance program should be directed towards strengthening the Water Users Groups so that they can easily continue the operation and maintenance of their portion of the irrigation and drainage system on a long-term basis.

An active marketing program is already underway as part of the Lam Nam Oon Integrated Rural Development Project. This effort needs to be continued on a long-term basis until long after all of the reservoir water is being used each dry season for irrigating crops. This activity should be a part of the ten-year technical assistance program to Water Users Groups and may still be needed even afterwards.

SECTION IX

MAINTENANCE PLANS

Originally, the concept was to develop a short-term, medium-term, and long-term maintenance plan as follows: (a) the short-term plan would be accomplished with existing O&M manpower, equipment, and budget at Lam Nam Oon; (b) the medium-term would provide for "catch-up" maintenance to be accomplished; and (c) the long-term plan would provide for the necessary manpower, equipment, and budget for a regular preventive maintenance program after all on-farm facilities have been completed and construction activities terminated. These guidelines have been utilized in developing the maintenance plans described below, but they have been modified to some extent to fit into a time frame, or schedule, as well. The proposed short-term plan includes maintenance activities that can, or should, be done during Fiscal Year 1983 (FY 83), while the proposed medium-term plan would be accomplished during FY 1984, 1985, 1986 and 1987. The proposed long-term plan would begin in FY 1988.

SHORT-TERM PLAN

Emergency Maintenance

The proposed emergency maintenance along the Left Main Canal between stations 12+500 and 16+000 should be completed during FY 83. The excavation work for the deep open drains on both sides of the Left Main Canal should be completed by the time of canal closure on April 30, 1983. The repair and replacement of concrete lining panels will have to be completed during May 1983. Most of the existing panel joints can be filled with asphalt during canal closure; however, new joints created by having to replace 108 panels will have to be sealed during canal closure in November 1983.

Contract Maintenance

During FY 83, field surveys would be completed along those reaches of the Right Main Canal and Left Main Canal specified in Tables 6 and 7. Also, a design team would be assigned to begin the designs for surface and subsurface drainage.

Force Account Maintenance

Using presently available manpower, equipment, and budget, the Critical Maintenance Needs listed in Appendix A would be undertaken; however, only a fraction of this list can really be accomplished. In addition, sediment should be removed from those reaches of laterals and sublaterals that are more than half full of sediment. If additional funds were provided for materials (e.g., cement) and the temporary employment of laborers, substantially more maintenance could be accomplished before the 1983 monsoon season begins. This would reduce the amount of additional damage that would invariably occur during each subsequent monsoon season.

The proposed maintenance equipment list in Table 23, which would be purchased with USAID funding, would be approved by the Royal Irrigation Department, a call for bids made, bids received, and a bid accepted during FY 83.

MEDIUM-TERM PLAN

Contract Maintenance

Bidding documents would be completed during FY 84 for providing surface and subsurface drainage along both canals in those reaches specified in Tables 6 and 7. The construction work should begin no later than FY 85 and be completed during FY 86 before the 1986 monsoon season begins.

Force Account Maintenance

The basic premise of the medium-term plan for force account maintenance at Lam Nam Oon is that additional manpower, equipment, and budget will be provided. For example, the maintenance equipment to be purchased with USAID funds should be available during FY 84. Consequently, the positions in the Transportation Unit need to be approved and filled at this time. The positions for Structure Keeper need to be approved and filled as soon as possible. The Zoneman positions should be filled on the basis of the completion of constructed on-farm facilities (one Zoneman for each 5,000 rai). An urgent need is for additional budget for purchase of materials required for maintenance, as well as for the employment of temporary laborers during canal closure.

The Critical Maintenance Needs listed in Appendix A should be taken care of as soon as possible, preferably no later than June 1984. The sediment from all irrigation channels should be removed, or as a minimum, all channels having more than 15 percent of the cross-sectional area filled with sediment. All of the catch-up maintenance listed in Appendix B should be completed before the 1987 monsoon season.

LONG-TERM PLAN

The primary goal of a long-term plan is to have in-place trained manpower, sufficient equipment, and an adequate budget for a highly effective preventive maintenance program. Other goals would be: (a) complete all of the required surface and subsurface drainage facilities for the laterals and sublaterals; (b) eliminate at least 90 percent of all sediment sources along the irrigation channels; and (c) complete the sealing of all panel joints with asphalt. In order to accomplish these goals, attention must be given to periodic replacement of maintenance equipment and the continual provision of funds for maintenance materials.

SECTION X

CONCLUSIONS

BASIC PROBLEMS

1. The combination of sandy soils and monsoon rains presents a unique set of maintenance problems for irrigation systems.
2. The most serious problem affecting the maintenance of Northeast irrigation projects is the formation of cavities behing the concrete panels that form the lining for the irrigation channels. These cavities lead to the eventual failure of the concrete lining panel.
3. Surface runoff and erosion from roadways and berms results in considerable sediment being conveyed into the irrigation channels.
4. Aquatic growth is a significant maintenance problem that needs major attention as to the development of appropriate mechanical equipment for its removal during operation of the irrigation channels.
5. Because preventive maintenance is not being done, small maintenance problems quickly grow into large expensive maintenance problems, and as a result there is a greater and ever increasing backlog of catch-up maintenance needs.

IMPACT OF FARM ANIMALS

6. In some locations, animals are allowed to cross through an irrigation channel with surface runoff and erosion then becoming concentrated in the animal pathways.
7. Buffalo wallows located near irrigation channels have, on occasions, resulted in damage to concrete lining panels, and sediment transport into the channel.

FISHING PROBLEMS AND BENEFITS

8. Fishing activities have resulted in considerable sediment getting into irrigation channels, as well as damage to the lining panels.

9. Fishing is a significant benefit resulting from the Lam Nam Oon Irrigation System.

IMPACT OF DESIGN AND CONSTRUCTION METHODS

10. The degree of concrete curing affects the width of the panel joint openings. Proper curing would increase the strength of the concrete panels, but more importantly, it would minimize the width of the panel joint openings. This, in turn, would minimize seepage and sediment transport through the joints, greatly reducing the likelihood of cavity formation.

11. Concrete-lined irrigation channels constructed in cut areas result in higher soil-water pressures behind the concrete lining panels, which causes greater seepage and sediment transport rates through the panel joints and the enlargement of cavities that eventually results in panel failure.

12. The construction of roadways high above the concrete-lined channel results in the same problems described above.

13. Concrete-lined irrigation channels constructed in fill areas have a tremendous advantage in that surface and subsurface drainage is provided; however, oftentimes, the lining panels adjacent to the berm will be cracked because of soil settlement on that side.

14. Whenever the drop in water surface elevation between the Constant Head Orifice outlet structure and the downstream irrigation channel is more than 10 cm, the structure will fail; thus, Constant Head Orifice

structures in fill areas have a high probability of failure unless appropriate measures are taken to avoid these large drops in water surface elevation.

15. Bridges constructed over concrete-lined irrigation channels frequently experience surface erosion near the abutments as well as cavity formation behind the lining panels that eventually result in the failure of these panels.

16. The Construction Division personnel do not seem to be keenly aware of the critical importance of: (a) proper concrete curing of lining panels; (b) providing adequate surface and subsurface drainage along irrigation channels; (c) providing for the hydraulic energy dissipation of flows from the Constant Head Orifice outlet structures; and (d) meticulously doing the final shaping and grading near irrigation channels and structures so as to minimize erosion.

17. The Design Division personnel do not place sufficient emphasis on: (a) providing adequate surface and subsurface drainage; and (b) providing for hydraulic energy dissipation from the Constant Head Orifice outlet structures.

SOME WEAKNESSES OF ON-FARM COMPONENT

18. The Water Users Groups have a major institutional weakness due to their inability to report offenders and apply sanctions. This impacts upon the equitability of water delivery to individual irrigators and consequently irrigation benefits. Without equity, such groups will remain weak and face considerable difficulty in maintaining their portion of the irrigation system.

19. The Water Users Groups are being organized at Lam Nam Oon by participants in the Integrated Rural Development Project, but much more effort is needed in follow-up activities.

20. The Royal Irrigation Department does not appear to have the capability, neither sufficiently trained manpower nor funds, for correcting design and construction problems with on-farm facilities.

LACK OF MAINTENANCE RESOURCES

21. The O&M Division is seriously handicapped by the lack of maintenance equipment.

22. Sufficient funds for purchasing maintenance materials (e.g., cement) and the hiring of temporary laborers are not being provided.

NEED FOR TRAINING

23. More trained Zonemen are needed, not only for the operation of the irrigation system, but to provide more follow-up with the Water Users Groups including maintenance of the on-farm facilities.

24. There is a lack of both awareness and trained personnel for accomplishing preventive maintenance.

25. Surprisingly, there is a lack of adequate training for Royal Irrigation Department officers in the operation of an irrigation system. They have the requisite technical knowledge but have not incorporated it into a systematic and detailed operation of the system.

SECTION XI

RECOMMENDATIONS

IMPLEMENT MAINTENANCE PLAN

1. Provide emergency funds during Fiscal Year 1983 (FY 83) to construct deep open drains along the Left Main Canal between stations 12+500 to 16+000, as well as funds for repairing and replacing damaged concrete lining panels in this reach.
2. Correct as many as possible of the Critical Maintenance Needs listed in Appendix A before the 1983 monsoon season with existing manpower, equipment, and budget. Any additional budget for maintenance materials and temporary laborers would certainly reduce the amount of continued damage that will occur during the next monsoon season.
3. The design of adequate surface and subsurface drainage along the Right Main Canal and Left Main Canal should be initiated this fiscal year and the necessary contract documentation completed in FY 84 so that construction can be initiated early in FY 85 and completed before the 1986 monsoon season.
4. Procure the necessary maintenance equipment as listed in Table 23. In addition, a gunnite or grouting machine should be purchased for use in filling of cavities and repairing concrete lining panels. A serious effort should be undertaken by The Royal Irrigation Department to develop appropriate mechanical equipment for removing aquatic growth from irrigation channels.
5. Approve and fill the requested manpower positions (e.g., Zonemen, Structure Keepers, and those requested positions in the O&M Transportation Unit) in a timely manner beginning as soon as possible.

6. Besides providing maintenance funds at the beginning of the fiscal year (October 1), rather than late November, additional funds should also be provided for catch-up maintenance.
7. Complete the catch-up maintenance needs listed in Appendix B as rapidly as possible. Preferably, this work should be completed before the 1987 monsoon season.
8. Establish some mechanism for independent on-site monitoring of maintenance expenditures and accomplishments.
9. Place increasing emphasis on preventive maintenance so that small problems are not allowed to become large expensive problems.
10. On a long-term basis, there is a need to provide for: (a) periodic replacement of worn out maintenance equipment; and (b) continued funding for maintenance materials such as cement, rock, asphalt, etc.
11. When removing sediment from irrigation channels, it should not be placed anywhere near the concrete lining panels, not even temporarily, because of destroying vegetation and causing problems in reshaping the berm.

STRENGTHEN WATER USERS GROUPS

12. A national study should be undertaken to address institutional changes in the formation of Water Users Groups that will address the problem of reporting offenders and applying sanctions. Experiences from around the world should be utilized in this study, but the final solution will be dictated by Thai cultural values.
13. A ten-year program should be implemented that would provide technical assistance to Water Users Group's for improving agricultural and on-farm water management practices. In addition, this technical assistance program should be directed towards strengthening such groups so that they can easily continue the operation and maintenance of their portion of the irrigation and drainage system on a long-term basis.

IMPROVE OPERATING PROCEDURES

14. When water delivery is to be terminated in an irrigation channel, the water level should be allowed to recede at a slow rate so as not to cause displacement or failure of the concrete lining panels.
15. Better locks should be used on all of the irrigation control gates and water users should not be allowed to operate these gates.

IMPROVE CONSTRUCTION TECHNIQUES

16. More effort should be expended in properly curing concrete lining panels, both for increased concrete strength and to minimize the width of joint openings.
17. Use rubble masonry, rather than riprap, for erosion control around the Constant Head Orifice outlet structures, bridge abutments, etc.
18. Construction engineers should be trained in the importance of surface and subsurface drainage for the irrigation channels so that when open drains have been designed they are not later ignored by construction personnel.
19. During the construction of the Constant Head Orifice outlet structures, adequate provisions should be made for dissipating excess hydraulic energy.
20. For irrigation channels constructed on high fills, the compaction requirements should be increased, particularly for the berm.
21. Construction personnel should be trained to place more effort on the final shaping and grading of irrigation facilities so as to minimize surface erosion.

EXPAND DESIGN CRITERIA

22. Subsurface drainage should be included in the design criteria for irrigation channels in the Northeast.

23. Better field surveys for the Constant Head Orifice outlet structures are needed so that adequate hydraulic energy dissipation can be included in the design whenever necessary.

APPENDIX A

LIST OF CRITICAL MAINTENANCE NEEDS

RIGHT MAIN CANAL (45.700 km)

3+920 Serious roadway erosion that must be corrected before next monsoon season, and which has resulted in failure of left panel.

18+708 Inverted Siphon. There is leakage from the outlet structure seeping back behind the headwall through the fill, which needs immediate attention before water is turned into Right Main Canal again on Dec. 10, 1982.

24+200 Concrete bridge is structurally good (not listed). Cavities behind left and right panels and one right downstream panel has begun to fail.

24+850 Concrete bridge is structurally good. Small, large, and huge cavities behind left and right panels with cracks and holes. These panels will eventually fail if these cavities are not filled soon.

25+125 Concrete bridge is structurally good. Huge cavities behind left and right panels with failed right panels and left panels will soon fail. Repair is badly needed.

25+350 Left Constant Head Orifice (CHO) is good. Outlet structure has failed, except for pipe outlet structure which will soon fail.

28+220 Concrete bridge is structurally good. Large cavities behind right panels, with bulging and displacement of five panels. These panels will completely fail. For right berm surface drainage, a culvert is needed under village road.

29+750 Very large cavities behind eight left panels, which are failing and will fail completely in another monsoon season, or two.

Lateral R-1L (11.415 km)

Sub-lateral R-1L-1L (2.500 km)

Sub-lateral R-1L-2L (2.800 km)

Lateral R-2L (3.515 km)

Lateral R-3L (1.600 km)

Lateral R-4L (4.600 km)

Sub-lateral R-4L-1L (0.800 km)

Sub-lateral R-4L-2L (1.120 km)

1+120	Final CHO outlet structure. It is structurally good but there is a serious erosion problem on right wall and endwall that needs attention so that the concrete pipe will not fail. Outlet structure has huge cavities at headwall, failed right panel, and part of left panel and floor has failed. Immediate attention is needed before dry season irrigation to prevent further failure of the outlet basin and concrete pipe. Farmer told us someone closed this CHO and water overtopped lining and ran around right side.

Sub-lateral R-4L-3L (2.020 km)

Sub-lateral R-4L-1R (3.200 km)

0+820	Drop structure with inlet gate and USBR Stilling Basin VI Outlet structure is good but 3/4 full of sediment. Huge cavity between inlet and outlet structures.
NOTE -	The reach of sub-lateral R-4L-1R below 0+820 should not receive water until the necessary maintenance can be done because there will be too many panel failures.
2+460	Large cavity on right panel and holes and large cavities below floor panel. Also cavity on left panel. Upstream 15 meters there are small holes in the lining but huge cavities under floor panels. Large cavity on left panel. This reach of lateral needs immediate attention or there will be considerable failure. Water should not be allowed in this reach until this repair has occurred. This reach has water flowing under the floor and then out a cut on the right berm into a pond, so states a farmer [which looks very plausible].

Sub-lateral R-4L-1R-1R (1.150 km)

Lateral R-6L (4.900 km)

Sub-lateral R-6L-1L (0.900 km)

Sub-lateral R-6L-2L (7.790 km)

0+000 to 1+500	Needs major attention on cavities and repair and replacement of concrete lining panels. Need right berm open drain from 0+000 to 1+050 plus cutting and grading of right berm. This will be a relatively simple job.
6+800 to 7+000	Will require subsurface drainage on both sides.
6+994	Bridge. There are cavities at left downstream and right upstream abutments that have resulted from bridge deck drain holes running water onto soil above lining and creating these cavities.

Sub-lateral R-6L-3L (1.300 km)

Sub-lateral R-6L-2L-1L (1.120 km)

Sub-lateral R-6L-2L-1L-1R (5.400 km)

1+368	Bridge, good. On both sides of this lateral, the land is higher than the lateral. The drain ditches on both sides are rapidly filling with sediment and should be cleaned before the next monsoon season; otherwise, water will overflow the drain ditches and run into the lateral, thereby creating cavities behind the lining panels and conveying much sediment into the lateral.
2+100	Patched left panel has large cavity. There are many left panels with cavities in about 50 meters of reach.
4+000	Left CHO, good. Serious problem with outlet structure because of 20 cm drop. End panels have failed but could be salvaged. Needs compacted backfill plus rubble masonry and cascading rubble masonry floor.
5+400	Final Outlet Structure with one gate. There is a floor crack at beginning of gate inlet structure, with small hole in right side of floor. Outlet structure is buried under trees, but consisted only of pipe outlet structure, which will soon fail. Riprap has been placed in this large eroded basin. Immediate attention is needed before dry season irrigation to prevent failure of pipe outlet structure. Needs extensive rubble masonry. A Drop Structure should have been designed and constructed here (1.00-1.50 m drop).

Sub-lateral R-6L-2L-1L-1R-1L (1.550 km)

Sub-lateral R-6L-2L-1R (1.200 km)

Sub-lateral R-6L-2L-1R-1L (1.810 km)

Lateral R-7L (6.120 km)

4+400	9 m of lateral section missing with 6 m upstream and 6 m downstream with huge cavities. This problem has resulted from a parallel ditch only 6 m to right of right bank with buffalo wallow at this section. The right berm should be raised and a ditch overflow structure constructed to carry excess water into lateral, otherwise ditch excess flow overtops right berm and runs behind lining, with eventual destruction of the lining.

Sub-lateral R-7L-1L (0.620 km)

Sub-lateral R-7L-1R (2.500 km)

Sub-lateral R-7L-2L (1.020 km)

Sub-lateral R-7L-2R (3.420 km)

2+400	Left CHO is good. Outlet structure is mostly intact except for last 20 cm of floor section. Heavily undermined because of deep scour hole. Water should not be allowed through until this problem can be corrected. The scour hole should be backfilled and then rubble masonry installed for a length of 6 m, where a control sill should be constructed of rubble masonry with a crest elevation 5 cm below outlet floor elevation. Then, provide necessary rubble masonry to allow cascading of water to level of land below.

Lateral R-8L (3.050 km)

Lateral R-9L (2.655 km)

Sub-lateral R-9L-1L (1.180 km)

Sub-lateral R-9L-2L (2.160 km)

1+300	Left CHO is good. Outlet structure has headwall, then 6 m of panels failed mostly because of pond drainage into left bank. Also, the concrete lining in the bend is very thin, 1-2 cm. Constructed April 1982, as part of Ditch and Dike construction. Actually, the outlet structure and panels may have failed in 1979, 1980 or 1981.

Sub-lateral R-9L-2L-1R (3.450 km)

Lateral R-10L (1.100 km)

0+500 to 1+000	Needs lateral lining repair and replacement. Needs right berm open drain from 0+000 to 1+115. Roadway encroaches on lateral and should be sloped flatter between lateral and road.

Lateral R-11L (4.800 km)

1+440	Left CHO, good. Outlet structure has failed, except for headwall. Riprapping would save remaining structure.
2+520	Left CHO, good. Outlet structure has completely failed including one concrete pipe joint upstream from headwall.
3+400	Two CHO's, good. Left outlet structure is excellent. Right outlet structure has failed mostly, but this structure should receive immediate attention to salvage the headwall, which requires heavy riprapping of floor and headwall.

Sub-lateral R-11L-1L (1.500 km)

0+440 Left CHO with serious embankment failure that might have been caused by leaky joint in outlet pipe. Requires immediate attention. Outlet structure is half failed.

Sub-lateral R-11L-2L (4.500 km)

Sub-lateral R-11L-2L-1R (2.300 km)

Sub-lateral R-11L-2L-1L (2.900 km)

2+700 Two CHO's. Big cavities on both sides of Left CHO. Right Outlet structure has last 15 cm of floor lining gone and end panels need rubble masonry. Left Outlet structure has completely failed back to CHO. Should consider not using left CHO until on-farm facilities are constructed.

Sub-lateral R-11L-2L-2L (2.100 km)

0+600 Left CHO, good. Outlet structure has floor failure and right end panel failed. This structure could be salvaged by placing compacted backfill in floor, pouring new floor, pull right end panel up to reduce width of crack, compact behind end panels, and rubble masonry at endwall and rubble masonry floor to dissipate excess energy.

1+460 Right Wasteway Structure, good. Outlet structure is rubble masonry with last 50-80 cm failed. In another year, floor to concrete pipe outlet will fail, plus top of end panels.

Lateral R-12L (0.800 km)

0+080 Drop structure with USBR Stilling Basin VI. Inlet is good. Outlet structure has embankment with three large cavities. This should be investigated immediately. Check outlet pipe first, then remove embankment, compact, and go to rubble masonry with surface runoff flowing into USBR Stilling Basin VI.

Sub-Lateral R-12L-1R (3.700 km)

Sub-lateral R-12L-1R-1L (1.230 km)

Lateral R-13L (3.720 km)

Sub-lateral R-13L-1L (0.760 km)

Sub-lateral R-13L-1R (3.050 km)

2+320 Left CHO, good. Outlet structure in place but bad breakoff on left side. Needs rubble masonry and immediate attention.

2+650 Pipe drop structure with gate, good, except 1 m downstream from gate there is a huge cavity and embankment over pipe has failed. Outlet structure, USBR VI, good but fishermen have removed riprap from damming water 1-3 m downstream. Downstream channel heavily covered with sediment. Perhaps drop pipe has failed, causing cavity on failed embankment. Check pipe, then excavate soil and backfill with compacted soil, and provide surface drainage.

Lateral R-14L (1.300 km)

Lateral R-15L (3.700 km)

Lateral R-16L (9.500 km)

8+100 Canal Overflow with single gate [Wasteway Structure is very good type of structure]. Downstream two panels with cracks near top. Upstream two panels on both sides with cracks. Outlet culvert with concrete chute experiencing serious undermining under floor and two holes on left side. [In one more year, about 5 m of length will give way.] Continual lateral gate leaking is reflected by moss in chute. Minor roadway erosion, which will get worse with time.

Sub-lateral R-16L-1L (2.068 km)

Sub-lateral R-16L-1R (5.000 km)

4+870 Two CHO's, good. Left Outlet Structure good except for undermining of endwalls. Right Outlet Structure has had floor failure and undermining of endwalls, which will fail after another monsoon season. The downstream water level is too low, so a solution would be to build a rubble masonry wall with downstream rubble masonry floor to dissipate excess hydraulic energy.

Sub-lateral R-16L-1R-1L (2.943 km)

Sub-lateral R-16L-3R (3.430 km)

Lateral R-17L (8.370 km)

Sub-lateral R-17L-1L (5.580 km)

3+600 Two CHO's. Left Outlet Structure has end panels that have failed and more will fail in future. Correcting problem now would help. Right Outlet Structure also has broken panels.

5+465 Final CHO. Outlet Structure has undermining of final panels. Immediate maintenance will save this structure.

Sub-lateral R-17L-1L-1L (3.670 km)

0+650 to 0+700	Many cavities along right wall that need immediate attention. A few panels already have been displaced.
1+450	Serious road erosion. Needs immediate attention. Needs an asphaltic ridge on right side of roadway with rigid berm chute structure to drop water, plus have vegetation planted on slopes.

Sub-lateral R-17L-2L (2.460 km)

1+200	Two CHO's, with left one to have a problem in future with outlet too high for surrounding land, which will result in serious erosion but will probably be a good elevation when on-farm facilities are constructed.

LEFT MAIN CANAL (28.040 km)

0+250	Large holes in six left panels. Should repair these panels so they will not fail.
0+800	Large hole in left panel that should be repaired to avoid failure in near future.
1+000	Large holes in four left panels. Two of these holes should be repaired soon.
1+500	Some erosion of right panels and floor joint. Cavity behind left panel with small hole in joint at floor level and panel cracked. Cracked left and right panels.
	Many panels with cavities and small holes, which need surface drains.
	Left panel with large cavity and bulging displaced panel that will soon fail.
2+595	Inverted Siphon without gate. Inlet Structure is good. Parallel concrete bridge has cavities at upper corners of right concrete abutment pond. At downstream end of bridge there is a huge cavity at right corner that needs to be fixed soon. Also there is a cavity in left abutment panel just below the cavity at downstream end of bridge.
	Adjacent land is below Left Main Canal invert. However, right berm needs to be cut down a small amount and graded to convey water away from Left Main Canal.

Lateral L-1L (9.310 km)

0+250	Right berm has surface drainage into lateral that has resulted in large cavities behind right panels and horizontal cracks on three right panels.

0+475	Four right panels have a continuous crack that will become worse with time. There are many cavities.
0+900	Drain Culvert. Inlet Structure is good. There is no Outlet Structure. Serious roadway erosion. The pipe outlet should be extended about 8 m and a concrete outlet structure constructed. Then, compacted backfill should be placed so that the road is reconstructed. There is also serious erosion of right berm, which should be corrected.
1+300 to 2+500	Most right panels are cracked and some cracks are getting wider. Also, some cracks in left panels. The main problem is the right berm which is quite high, so that soil settlement has occurred. In addition, there are cavities behind the right panels. This entire reach needs serious attention by grading and sodding right berm and filling cavities.

Sub-lateral L-1L-1L (3.400 km)

Sub-lateral L-1L-2L (6.500 km)

Sub-lateral L-1L-2L-1R (1.500 km)

Lateral L-1R (6.624 km)

1+850	Drop Structure with inlet gate and USBR Stilling Basin VI. Inlet is structurally good but has cavities on both side walls and endwall. There are large cavities over concrete pipe between inlet and outlet structures. Outlet Structure is good.
2+350	Drop Structure with inlet gate and USBR Stilling Basin VI. Inlet Structure is good except for a small cavity behind headwall. Serious problem of huge cavities over concrete pipe between inlet and outlet structures; suspect they are caused by leaky joints in concrete pipe. Outlet Structure is good. Hairline cracks in right panels.
3+025	Drop Structure with inlet gate and USBR Stilling Basin VI. Inlet structure good, but a small cavity near head wall. Cavities over concrete pipeline between inlet and outlet structures. Outlet Structure is very good.

Sub-lateral L-1R-1L (1.170 km)

Sub-lateral L-1R-1L-1R (1.569 km)

Lateral L-2L (3.500 km)

1+490	Left CHO [not listed]. Cavities on both abutments and huge cavity over concrete pipeline. Concrete walkway panels are missing. Outlet Structure is good structurally, but has cavities.

1+500	Floor of lateral badly broken and should be fixed soon.
3+235	Tail Regulator is good, but has huge cavity over concrete pipeline, which has failed. Pipe outlet structure is good.

Sub-lateral L-2L-1R (2.880 km)

1+500	Two CHO's are good, but concrete walkway panels are missing. Left Outlet Structure has failed, including last three lengths of concrete pipe. Right pipe outlet structure feeds concrete pipeline. There is considerable need for compacted backfill around concrete pipe upstream from outlet and lined channel downstream, which has much exposed lining and many cavities.
2+000	Left CHO is good, but concrete walkway panels are missing. Outlet structure has completely failed. Only first length of concrete pipe is attached to CHO. Large cavities along downstream CHO wall and headwall.

Lateral L-3L (0.835 km)

0+560	Right CHO is good except concrete walkway panels are missing. Outlet Structure has failed except for pipe outlet structure, which will probably fail soon.
0+790	Huge cavities behind two right panels with bulging of both panels and a hole in one right panel. Both panels will eventually fail completely unless these cavities are filled soon and cracks sealed.

Sub-lateral L-3L-1R (3.173 km)

Sub-lateral L-3L-1R-1R (3.500 km)

Sub-lateral L-3L-1R-1L (1.920 km)

1+100	Two CHO's are good, except concrete walkway panels are missing. Left pipe outlet structure is good, but has erosion that is serious and needs correction. Right pipe outlet structure also has serious erosion problem that will result in eventual failure of the structure.
1+800 to 1+850	Much erosion on left berm which will leave left panels exposed, so that they will crack and break. If corrected now, the lining will remain intact.
1+900	Two CHO's are good, except concrete walkway panels are missing. Left pipe outlet structure has erosion above headwall and serious erosion below. Right Pipe Outlet structure also has serious erosion because of large drop (60 cm).

Sub-lateral L-3L-1L (2.020 km)

Sub-lateral L-3L-1L-1L (1.900 km)

Sub-lateral L-3L-1L-2L (6.320 km)

1+310	Right CHO is good, but concrete walkway panels are missing. Outlet Structure is good, but needs immediate attention to placement of rubble masonry at endwalls and rubbie masonry cascading floor before further downstream erosion results in failure of the outlet structure.
2+350	Two CHO's are good, except concrete walkway panels are missing. Outlet is structurally good, but floor and walls are undermined for 1 m. There is approximately a 60 cm drop. Rubble masonry at endwalls and floor will prevent failure of this structure.
3+000	Two CHO's, both have concrete walkway panels missing. Left CHO has cavity along downstream wall, which has caused hole in left panel. Left Outlet Structure has pipe outlet structure with much erosion. Right Outlet Structure is good, except left endwall needs compacted backfill and rubble masonry.
5+100	Two CHO's are missing concrete walkway panels. Right one needs first gate repaired and second gate is missing. Right pipe outlet structure is good. Left pipe outlet structure is now good, but there is serious erosion and this structure will fail unless compacted backfill and rubble masonry is placed around structure.
6+320	Final Outlet Structure is a Tail Regulator with a single gate. Inlet structure is good. Outlet Structure is intact, but needs immediate attention because of serious erosion downstream which will soon result in failure of the structure. Also, there is a cavity at the head wall.

Sub-lateral L-3L-1L-2L-1R (2.155 km)

Sub-lateral L-3L-1L-2L-1L (2.000 km)

Lateral L-4L (0.530 km)

Lateral L-5L (1.600 km)

Lateral L-2R (3.010 km)

Sub-lateral L-2R-1L (1.250 km)

Lateral L-3R (2.500 km)

1+875 to 2+150	Need surface drainage on left and right sides for 375 m.

Lateral L-4R (1.500 km)

0+800	[Listed as 0+850] Drain culvert has failed along right edge of road on right of lateral.

Lateral L-5R (1.650 km)

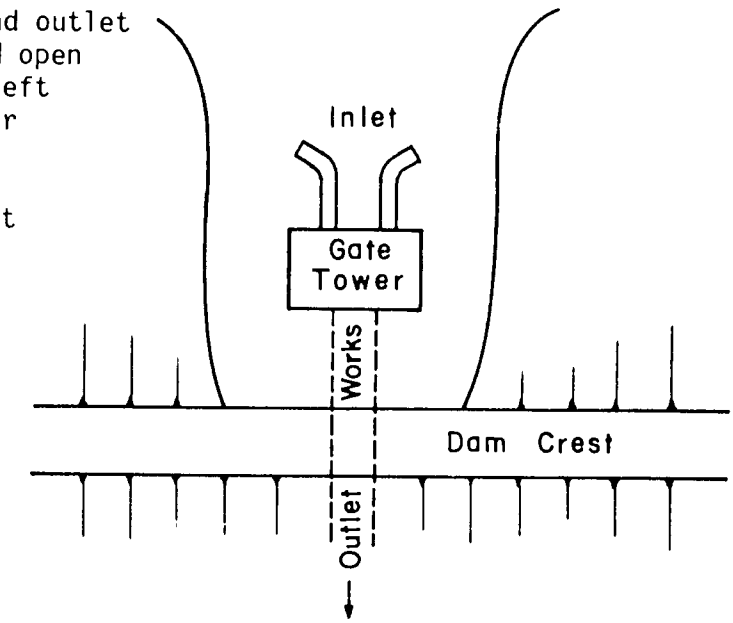
APPENDIX B

MAINTENANCE INVENTORY

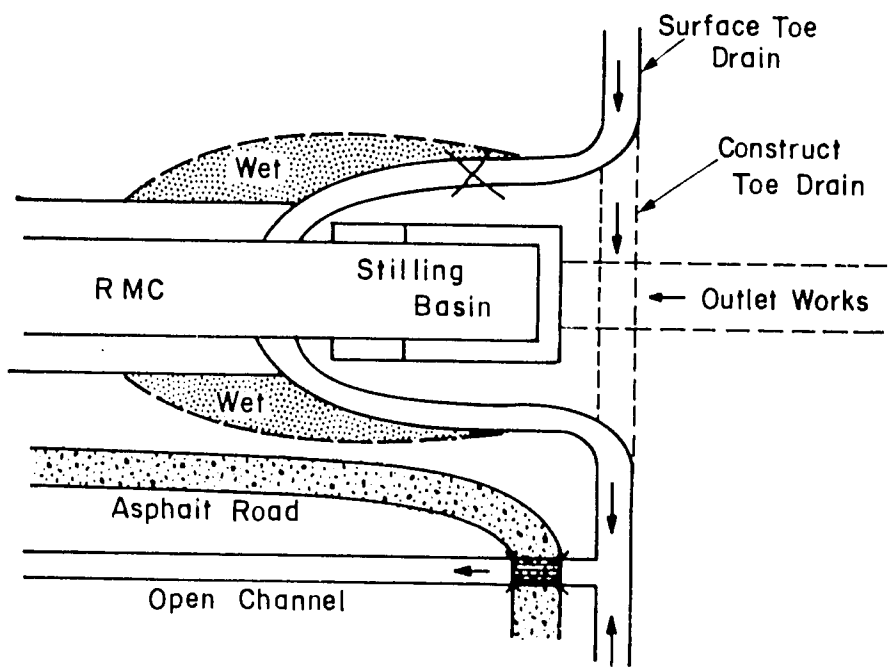
RIGHT MAIN CANAL (45.7 km)

Control gates for RMC outlet works. They have a screen for keeping aquatic growth from getting into the outlet works gates, which is attached by cables to the top of the gate control tower. There is water coming through the outlet works, even though the gates are closed. Estimated Q ≅ 50-100 lps.

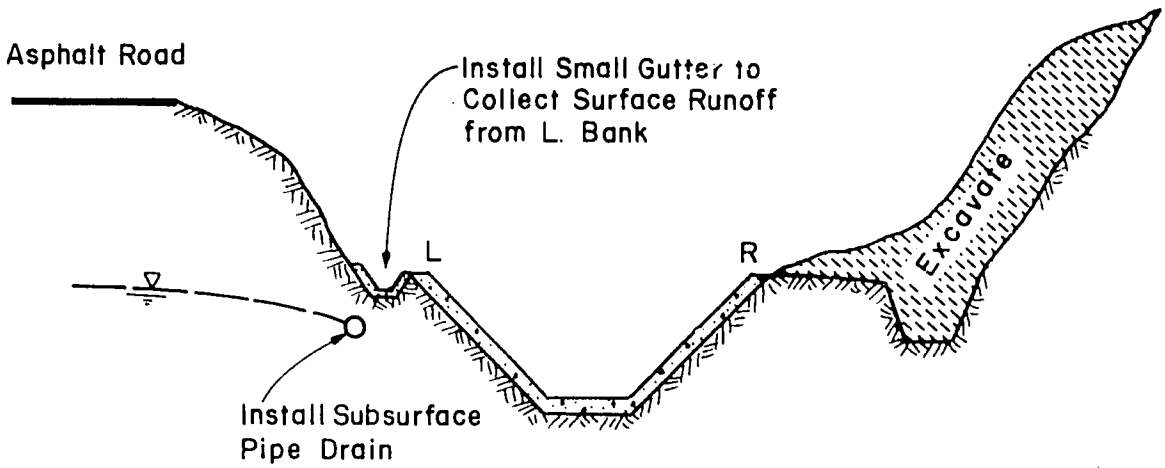
Note - Take surface toe drains and outlet under asphalt road, then by lined open channel 350 m to concrete lined left roadway drainage channel lined for 40-50 m. Left of asphalt highway (see drawing on next page). This water can then be conveyed to left wasteway at 0+400.



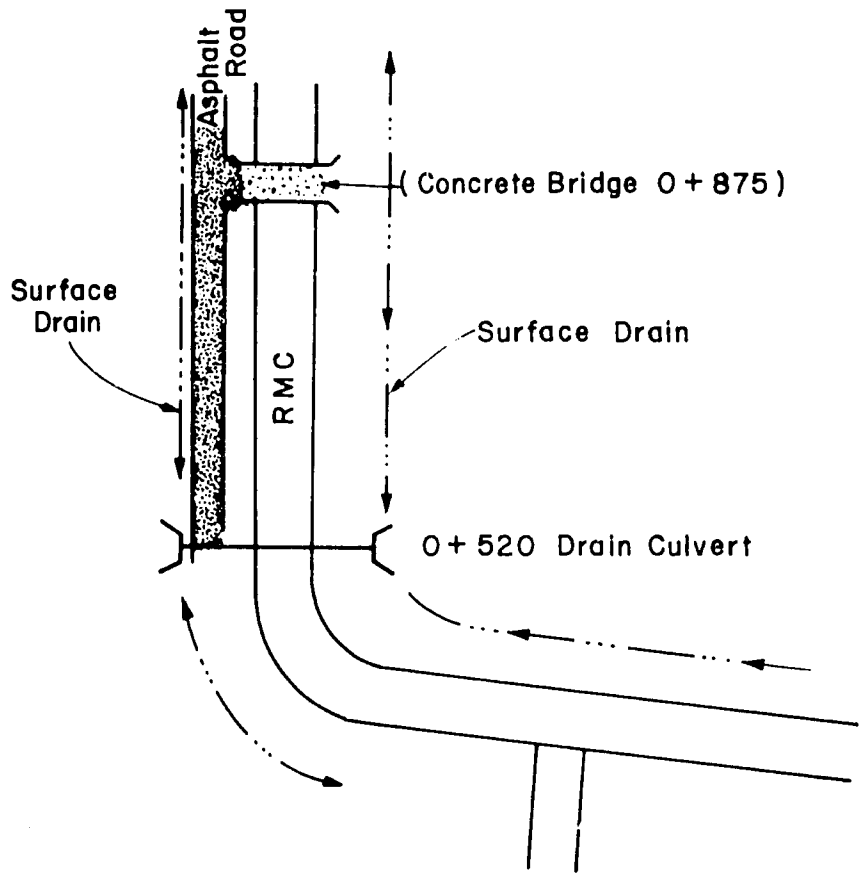
0+000 End of outlet works stilling basin. The area above the RMC from the toe of the dam to 0+000 is very wet (saturated) and there is flow over left and right panels.

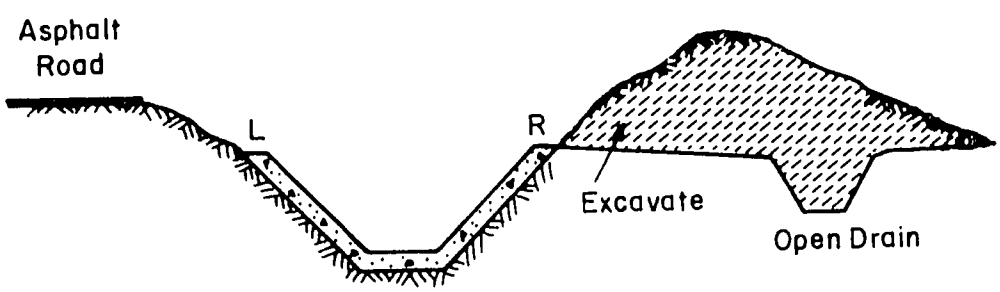


Note - Concrete panels have been repaired at joints from 0+000 to 0+100.



0+060 to 0+100	Erosion of berms on both sides. This erosion will continue and take away more of the banks. Soil is saturated to top of left panels. Leaking joints below, with moss.
~0+200	Three left panels have large cavities underneath. One left panel is near failure and the other two left panels will eventually fail.
~0+250	Small holes at joints that need repair. Cavity behind left panel. Many small holes in panels as a result of high water pressures behind panels.
0+400	Wasteway Structure with three large gates is good except for cavities on both upstream and downstream walls.
0+405	Large hole in floor panel.
0+410	Bulging left panel that will eventually fail.
0+520	Drain Culvert. Inlet structure is good. Outlet structure could not be seen because of vegetation.

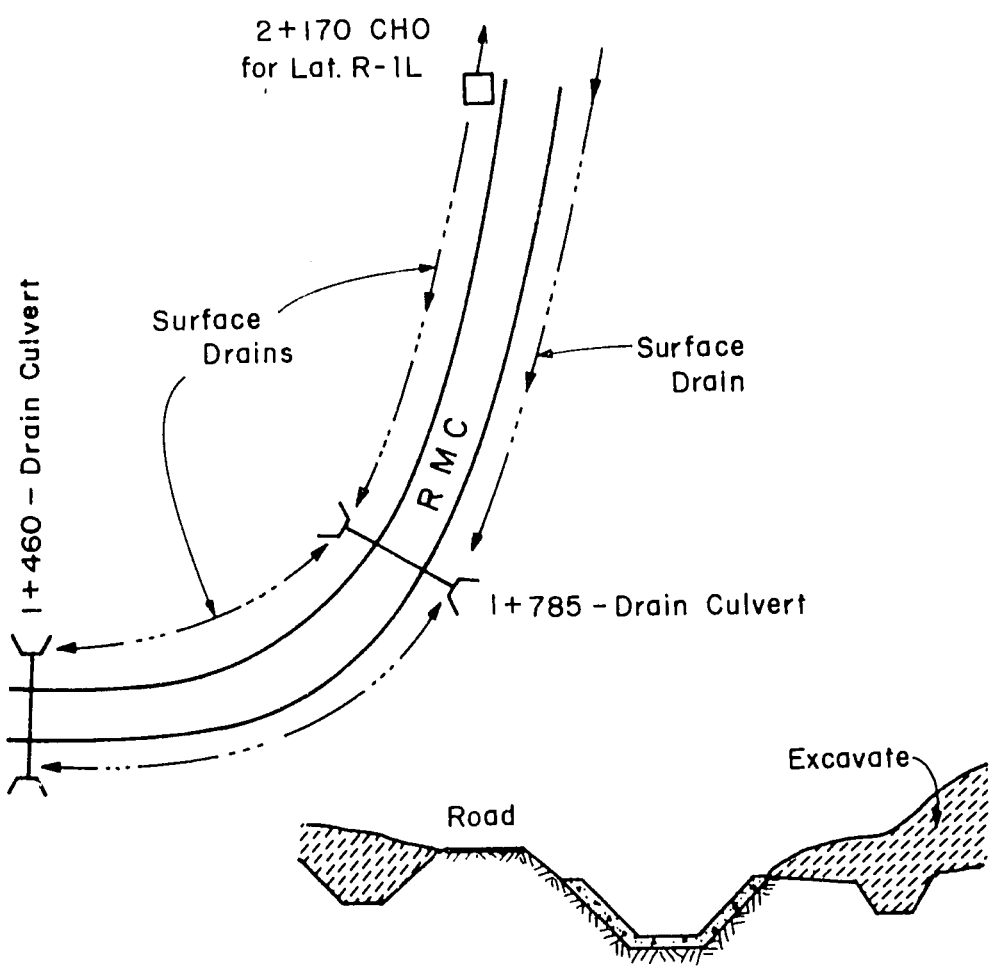




Provide surface drainage and relieve subsurface hydraulic pressure by large open drain left of asphalt road in the above figure.

0+575 to 0+875	Many small holes, some large holes, and many cracks in left and right panels, hut much more damage to left panels.
~0+800	Left panel has failed. Right panel has hole and will soon have huge hole.

0+875	Concrete Bridge is good. The dirt road on the right has a culvert where the discharge is onto the right berm, which aggravates erosion problems.
1+400	Siphon, looks good.
~1+460	Drain Culvert. Outlet structure on left. This drain culvert should be used as outlet for surface drains on left and right of RMC.
0+875 to 1+600	Many small and large holes in panels. Leakage at present time and water running over top of panels in some locations, which shows that soil behind panels is saturated.
1+785	Drain Culvert. Could not see outlet, but perhaps it is under small pond of water. This drain culvert should be used as outlet for surface drainage left and right of RMC. - Aquatic growth.
1+850	Left CHO is good and outlet structure is good.
2+150	Concrete Bridge [not on list] is good.
1+600 to 1+900	Cracked panels, but not so many holes because of natural surface drainage.
2+170	CHO Regulator for Lateral R-1L.



2+755	Concrete Bridge is structurally good. Upstream (u.s.) left panel has huge hole. Roadway erosion.
2+780 to 2+810	Three left panels have failed. Panels in between failed panels will likely fail.
3+000	Drain Culvert. Outlet structure on left side of RMC is covered with water. Use this drain culvert as outlet for left and right side surface drainage.
2+900 to	Natural subsurface drainage on left side because land is below RMC. Still need to provide surface drainage on right side. Left panels in this reach are in good condition. Right panels are also good, but have seepage water and small holes.
3+290	Concrete Bridge is structurally good.
3+390	Left CHO is good. Pipe outlet structure feeds concrete pipeline, all of which are good.
3+500	Drain Culvert. Outlet structure is under water. Left side surface drainage not needed in this reach, but right side surface drainage can feed into this drain culvert.
3+760	Drain Culvert. Outlet structure is good.
3+820	Left CHO is good. Pipe outlet structure is good.
~3+920	Serious roadway erosion that must be corrected before next monsoon season, which has resulted in failure of left panel.
	- Roadway erosion.
	- Panels look quite good.
3+990	Concrete Bridge is structurally good. Erosion on left side of bridge.
4+030	Large holes in three left panels. Need surface drainings on both left and right sides.
	- Roadway erosion.
~4+200	CHO Regulator for Lateral R-2L.
4+252	Left CHO is good, except first gate needs repair and large cavity along downstream wall. Pipe outlet structure feeds concrete pipeline, all of which are good.
4+230	Hole in left panel.
4+260	Failed left panel.
4+270	Hole in left panel.
	- Do not need left surface drainage downstream from 4+200.
	- Do not need right surface drainage downstream from 4+250, but still need right berm shaping.

4+444	Drain Culvert does exist, but did not inspect. Eight right panels have recently been replaced.
	- Adjacent land is many meters lower than RMC invert.
	- Need surface drainage on right side beginning again at station 4+600 and going to 4+800.
4+740	Roadway Culvert with 3 gates is structurally good, but has a cavity along left inlet wall. Outlet structure is good.
4+800	Left CHO is good. Pipe outlet structure is good.
4+900	Drain Culvert. Outlet structure is good. Cracks in some panels, but lining looks very good.
5+160	Drain Culvert. Outlet structure is good.
5+350	Left CHO is good. Outlet structure is very good.
~5+550	Bulge in right panel halfway up.
5+650	Left CHO is good, except for cavity on downstream wall. Outlet structure is good, except for a few cracks and needs some compacted backfill on both sides.
5+665	Large hole in right panel.
5+765	Left CHO Regulator for Lateral R-3L.
5+800	Left CHO is good. Outlet structure is good, but could use some compacted backfill along left headwall and a short section of left panel.
5+870	Concrete Bridge is structurally good. Cavities on both abutments on right side and also left upstream abutment. Cracked left and right panels under bridge.
5+875	Big hole in left panel joint.
	- Aquatic growth.
	- Sediment.
5+924	Drain Culvert. Inlet and outlet structures are good.
6+200	Left CHO is structurally good, but 1 m of panel missing on each side of CHO. Roadway erosion and first left panel downstream is half broken off. Outlet structure is good, but needs compacted backfill near headwall. Lining upstream and downstream looks good. Need surface drains on left and right, same as drawn before, from here to 6+900.
~6+500	Big hole in right panel and smaller holes in nearby right panels.
~6+700	Erosion from right berm and large holes and broken right panels below.
6+800	Concrete Bridge is structurally good. Cavity on right side, but panels are not cracked.

6+850	Left CHO is good. Pipe outlet structure is good.
	- Need left and right surface drainage to 6+900.
7+000	Drain Culvert. Inlet and outlet structures are good.
	- Lining looks very good.
	- Sediment and aquatic growth.
7+250	Drain Culvert. Inlet and outlet structures are good. Right panel over drain culvert is badly broken near floor.
7+310	Five right panels are badly broken above floor level.
7+330	Right panel badly broken near floor level.
7+370	Right panel badly broken near floor level.
7+390	Right panel badly broken near floor level.
7+525	Drain Culvert. Inlet structure is good, but needs compacted backfill around headwall. Outlet structure is good.
7+600	Left CHO is good. Outlet structure is good. Need left and right surface drainage from here at 7+600 to 8+400 (drain culvert).
7+615	Right panel badly broken near floor level.
7+,)0	Hole in right panel.
7+830	Concrete Bridge is structurally good. There has been extensive damage to left, right and floor panels which are presently being repaired.
	- Seepage from bank above right berm.
	- Dragline is presently removing sediment from RMC.
	- Serious requirement for left and right surface drainage, but mostly right drainage.
8+170	Concrete Bridge is structurally good. Four left panels under bridge and immediately downstream have failed.
8+195	Left panel has failed.
	- Erosion on right berm.
8+400	Drain Culvert. Outlet structure is good. Land on left of asphalt road is below RMC invert, but land on right of right berm is slightly above RMC invert but below top of lining.
8+600	Left CHO is good and outlet structure is good.
8+650	Concrete Bridge is structurally good. Big cavities on both left and right sides, but no damage to lining yet.
	- Lining is good.
~8+750	CHO outlet for Lateral R-4L.
~8+850	Two cracked and bulged right panels near floor level.
9+030	Drain Culvert. Outlet structure is good.

9+122	Drain Culvert. Outlet structure is good.
9+470	Concrete Bridge is structurally good. Large cavities along left and right panels, with cracked panels. Left panels immediately downstream have cavities.
9+700	Left CHO is structurally good, but there is a huge cavity at endwall and the adjacent panels have cavities underneath. Immediate attention will prevent failure of these panels. Outlet structure has much erosion and broken left and right panels.
9+735	Concrete bridge is structurally good. Cavities behind both left and right panels and many panels with cracks, which will get much worse with time.
9+880	Drain Culvert. Outlet structure is good, but could use some compacted backfill.
10+066	Roadway Culvert with 3 gates. Inlet structure is good, but there is a cavity on left side at beginning of inlet transition structure. Outlet structure is good, but has cavities along left wall.
	- Lining looks good.
	- Need to begin right surface drainage from 10+066 to 11+050.
~10+250	Seven right panels are bulged at horizontal joints.
~10+680	Concrete bridge is good. There is surface drainage ponds left of road, but they should be interconnected and have an outlet. Road is now at proper level, whereas from 0+000 to 10+000 the road has usually been made too high.
11+100	Left CHO is good, except cavities upstream and downstream. Pipe outlet structure is good.
11+180	Drain Culvert. Outlet structure is good.
	- Most right panels are cracked, probably from soil settlement in the high fill.
11+748	Drain Culvert. Outlet structure is under water.
11+550	Left CHO is good. Outlet structure is good, but scouring at end of structure, with undermining of endwalls, which needs compacted backfill and rubble masonry.
	- Need to begin left and right surface drainage at station 11+600 and go to 12+450.
11+885	Badly busted right panel.
11+900	Hole halfway up right panel that is seeping water.
11+940	CHO Regulator for Lateral R-6L.
11+980	Concrete bridge is structurally good. Cavity on right downstream abutment. Cracks in left and right panels under bridge.

12+000	Holes in two right panels.
12+150	Concrete bridge is structurally good. Cavities on both left and right sides, with left panels cracked. Lining looks good.
12+783	Drain Culvert. Outlet structure is good.
13+000	Left CHO is good. Outlet structure has failed except for pipe outlet structure.
	- Begin left and right surface drainage at 13+200 and go to 13+500.
~13+350	Concrete bridge is good. No cavities. [not listed]
13+600	Left CHO is good. Outlet structure has two large holes in left panels.
13+823	Drain Culvert. Outlet structure is good.
	- Lining looks good.
	- Begin right surface drainage at station 13+980 and go to 15+000.
14+207	Roadway culvert with 3 gates. Inlet structure is good, but 2 small cavities along right wall. Outlet structure is good.
~14+300	Vertical and horizontal large crack in right panel.
~14+500	Left and right side surface drainage can be easily accomplished to 15+000 by interconnecting ponds and providing outlet.
14+960	Left CHO is good. Outlet structure has failed except for headwall.
15+000	Adjacent land is below RMC invert.
15+020	Concrete bridge is structurally good. Cavities on left and right sides and panels underneath bridge are cracked.
15+200	Drain Culvert. Outlet structure is good.
15+430	Concrete Bridge is structurally good. Cavities behind both left and right panels, but only left panel has a crack.
	- Lining looks very good.
~16+500	Concrete Bridge [not listed] is structurally good. Cavities behind left and right panels, but only right panels have cracks.
16+800	Left CHO is good. Outlet structure is good, but downstream lining broken on right side.
	- Lining looks good.
17+100	Drain Culvert. Outlet structure is under water.

17+200	Begin right side surface drainage and go to 17+775.
17+300	Concrete Bridge [not listed] is good. No cavities. Cracks in right panels with seepage.
17+400	Left CHO is good. Outlet structure is good but downstream 15-20 m has broken left and right panels.
17+856	Drain Culvert. Outlet structure is good.
17+950	Left CHO is good. Outlet structure is very good, but needs compacted backfill at headwall and endwalls.
18+120	Concrete bridge [not listed] is structurally good. Cavities behind left and right panels, but only right panels cracked.
	- Begin right surface drainage at station 17+900 and go to 18+200.
	- Adjacent lands below RMC invert.
18+708	Inverted Siphon, with 2 gates. Inlet structure is good, but cavities along left and right walls. Outlet structure is good, but cavities along left and right walls. There is leakage from the outlet structure seeping back behind the headwall through the fill, which needs immediate attention before water is turned into RMC again on Dec. 10, 1982. Large Concrete Bridge between inlet and outlet of inverted siphon looks good, but left railing at outlet end of bridge should be replaced (5 m).
~18+950	CHO Regulator for Lateral R-7L.
	- Need to excavate surface drain on right berm from station 18+900 to 19+900.
19+100	Concrete Bridge [not listed] is good. Cavities behind left and right panels, but no cracks.
	- Lining looks good.
19+305	Left CHO is good. Pipe outlet structure is good.
~19+425	Left CHO Regulator for Lateral R-8L.
19+403	Drain Culvert [could not find].
20+057	Drain Culvert. Outlet structure is good.
20+220	Left CHO is good, but cavities along both sidewalls. Outlet structure is good.
20+453	Drain Culvert. Outlet structure is good.
20+915	Drain Culvert. Outlet structure is good.
21+035	Concrete Bridge is structurally good. Cavities behind left and right panels, but no cracks.
21+200	Left CHO is good, except for cavity on upstream wall. Outlet structure has failed except for headwall.

21+300	Drain Culvert. Outlet structure is good. Begin right surface drainage at station 21+350 and go to 22+500.
~21+450	CHO Regulator for Lateral R-9L.
21+500	Begin left surface drainage and go to station 22+350. Much surface erosion from left bank and left roadway into RMC.
21+940	Five badly damaged right panels. Seepage from right bank flowing over right panels.
22+041	Concrete bridge is good. No cavities. Immediately upstream and downstream on right abutments is village road surface drainage into RMC. Right berm is saturated for 200 m. Many cracked right panels because of saturated right berm.
22+500	Drain Culvert. Outlet structure is covered with water.
22+662	Roadway Culvert with 2 gates. Inlet structure is good. Outlet structure is good, except for small hole in lining at end of outlet transition structure and cavity along left wall.
	- Need right surface drain from station 22+600 to 22+800.
22+800	Left CHO is good. Outlet structure is good, but could use rubble masonry at endwalls.
23+200	Wasteway Structure with overflow and Control Gate. Upstream left panel has bulged. Inlet structure is good except for large cavity at upstream wall. Outlet structure is good.
23+231	Drain Culvert. Outlet structure is good.
23+350	Left CHO is good. Outlet structure is cracked and portions of end panels are broken off. Some soil should be removed from left and right banks to reduce weight on panels and the rubble masonry used to repair the outlet structure.
	- Begin right berm surface drain at station 23+350 and go to station 23+600.
	- Lining looks good.
23+520	CHO Outlet for Lateral R-10L.
23+535	Concrete Bridge [not listed] is structurally good. Large cavities behind left and right panels and cracks in right panels. [This is a good example where the filling of these cavities would prevent the panels from failing in the next few years.]
23+550	Left CHO is good, but cavity on upstream wall. Outlet structure is good except for broken end panels and floor. The outlet structure can be easily repaired with mortar and rubble masonry added at end of outlet structure.
	- Some right panels have cracks.

23+750 Drain Culvert. Outlet structure is very good. Many left panels with cracks and some with slight bulging at horizontal joints. This condition has likely resulted from road fill settlement and is not a problem at this time, but sealing of joints would prevent future problems.

- Adjacent land is below RMC invert.

24+000 Left CHO is good, but there are cavities along both sides. Outlet structure has too much drop, so end panels and floor are broken. Rubble masonry is badly needed to prevent further failure. Also, the laterite pile near the headwall should be removed.

- Need some minor work to provide better right berm surface drainage with outlet to drain culvert at 23+750.

24+060 Cavities behind left panels.

24+150 Some right panels have already been repaired, while some adjacent panels have cracks. One right panel will soon have a big hole. Any cavities should be filled, but more importantly, right berm surface drainage is needed with outlet to drain culvert at 23+750.

~24+200 Concrete Bridge is structurally good [not listed]. Cavities behind left and right panels and one right downstream panel has begun to fail.

- Very little sediment, but aquatic growth.

~24+500 Left CHO Regulator for Lateral R-11L.

- Right berm surface drainage is still needed between 23+750 and 25+250.

Superelevation on roadway should be removed on curve and graded so that rainfall runs away from RMC.

~24+600 Cracked right panels.

~24+850 Concrete Bridge is structurally good. Small, large and huge cavities behind left and right panels with cracks and holes. These panels will eventually fail if these cavities are not filled soon.

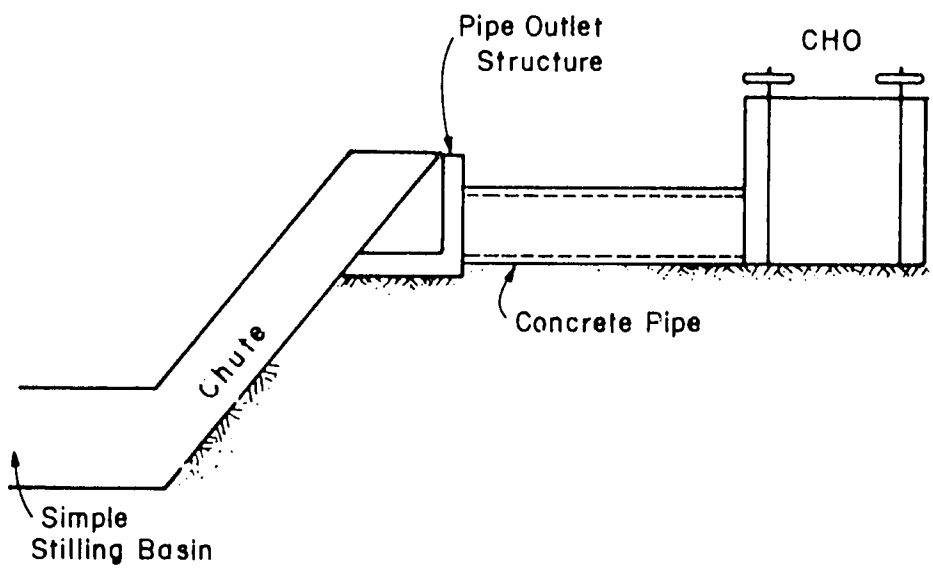
25+125 Concrete Bridge is structurally good. Huge cavities behind left and right panels with failed right panels. Left panels will soon fail. Repair is badly needed.

25+250 Drain Culvert. Inlet structure is good. Outlet structure is under water.

25+350 Left CHO is good. Outlet structure has failed, except for pipe outlet structure which will soon fail.

- Left roadway bank erosion.
- Adjacent land lower than RMC invert.

~25+900	Concrete Bridge [not listed] is structurally good. Small cavity behind left panel and large cavities behind right panels and some cracking.
~26+000	Inverted Siphon is structurally good. Spalling of concrete joints at entrance to inlet transition structure. Cavity along right wall. Right bank of inverted siphon has a large hole which should be repaired so that a large cavity does not form under the rubble masonry. Large concrete bridge paralleling inverted siphon looks very good structurally, but rubble masonry near left upstream abutment should be repaired. Top of rubble masonry near outlet structure needs minor filling in to prevent rainfall from getting underneath rubble masonry. Outlet structure is good, but there are cavities along left and right walls.
26+300	Left CHO is good. Left outlet structure is intact because riprap has been placed at outlet. Would be helpful to do rubble masonry at outlet endwalls and floor, as well as remove soil covering headwall.
~26+350	Cavity behind left panel.
~26+450	CHO Regulator for Lateral R-12L.
~26+490	Cavity behind left panel.
~26+520	Left panel joint is displaced. Fill cavities and then seal joint.
26+550	Left CHO is good. Outlet structure has headwall, chute and stilling basin, which is very good design. The fill on both sides should be partially removed, graded and sodded.



This design should be used at other CHO outlet structures where the drop is large and would result in failure before on-farm facilities are constructed.

26+700	Drain Culvert. Outlet structure is good.
26+950	Left CHO [not listed] is good Outlet structure is good, but soil along walls needs shaping.
27+005	Concrete Bridge is structurally good. Cavities behind left and right panels, but no cracking of panels.
27+065	Drain Culvert [listed as 27+025]. Inlet structure is good. Outlet structure is under water.
27+500	Drain Culvert. Outlet structure is good.
27+550	Left CHO is good, but cavity along upstream wall. Outlet structure is good, except for roadway erosion onto headwall.
28+080	Drain Culvert. Outlet structure is under water.
	- Need right berm surface drain channel for about 300 m between 27+500 and 28+080.
	- Lining looks good.
28+220	Concrete Bridge is structurally good. Large cavities behind right panels, with bulging and displacement of five panels. These panels will completely fail. For right berm surface drainage, a culvert is needed under village road.
28+385	Concrete Bridge is structurally good, but downstream left railing has been knocked over. Cavities behind left and right panels, but no cracks in panels.
28+396	Left CHO is good and outlet structure is good.
	- Right berm surface drainage is good from 28+500 onwards.
28+796	Left CHO is good. Outlet structure is very good.
29+000	Drain Culvert. Outlet structure is good.
	- Cavities behind left panels.
29+245	Concrete Bridge is structurally good. Cavities behind left and right panels with small cracks in left panels.
29+410	Drain Culvert. Outlet structure is good.

Note: Having many Drain Culverts along RMC is a great asset for surface drainage to protect panels.

	Many cavities behind left panels.
29+645	Left CHO is good, except cavity behind left upstream panel. Outlet structure has failed left and right panels with roadway erosion into structure. This structure can be salvaged.
	- Cavities behind left panels.
~29+750	Very large cavities behind eight left panels, which are failing and will completely fail in another monsoon season or two.

29+835 Left CHO has large cavities around walls, which has caused much damage to underlying left panel. Outlet structure has failed, including much of the pipe outlet structure.

- Many cavities behind left panels.

30+195 Left CHO has huge cavity, which has damaged underlying left panel. Outlet structure has broken left and right panels and very large drop, with only headwall intact.

- Left roadway erosion.

~30+700 Concrete Bridge [not listed] is structurally good. Cavities behind left and right panels, but no cracks. Top of left and right panels have been broken, probably because the bridge has settled.

- Left roadway erosion.

30+875 Drain Culvert. Outlet structure has much erosion of roadway bank. The outlet should be extended and the roadway bank backfilled and sodded.

- Need right berm surface drainage from 31+000 to 31+500 outlet.

- Left roadway erosion.

31+500 Drain Culvert [listed as 31+441]. Outlet structure is under water. Inlet structure is good, but could use compacted backfill behind headwall.

31+540 Left CHO is good, except second gate frame and gate is missing. Outlet structure has headwall and first left and right panels intact, the rest have failed. This structure can be salvaged by placing rubble masonry at endwalls and floor.

31+577 Roadway Culvert with 2 gates. Inlet structure is good, but cavities along both walls, with right wall having a very large cavity that should be filled. Outlet structure is good. Second left panel downstream has displaced joint that should be sealed.

31+786 Canal overflow structure is good.

31+790 Drain Culvert. Inlet structure is good. Outlet structure is under water.

31+820 Left CHO is good, but has cavity along endwall. Outlet structure is good, but needs rubble masonry at end of structure.

31+860 CHO Regulator for Lateral R-13L.

32+140 Drain Culvert. Outlet structure is under water.

32+230 Concrete Bridge [not listed] is structurally good. No cavities and no cracked panels.

- Need right berm surface drainage from 32+140 to 32+700.

32+400	Left CHO is good. Outlet structure is good, but has cavities behind left and right panels with cracking of panels. Needs rubble masonry at endwalls.
32+750	Drain Culvert. Outlet structure is good.
32+940	Left CHO is good. Outlet structure has failed except for headwall.
33+000	Drain Culvert. Outlet structure is good.
33+130	Concrete Bridge [listed as 32+855] is structurally good. Cavities behind left and right panels, with left panel cracked and settled.
33+350	Drain Culvert. Outlet structure is good.
33+650	Drain Culvert. Outlet structure is under water.
33+752	Roadway Culvert under Udon-Sakhon Nakhorn highway with 3 gates. Inlet structure is good, but large cavity along right wall. Outlet structure is good.
33+980	Drain Culvert. Outlet structure on left is good.
	- Lining looks good.
34+030	Left CHO is good. Outlet structure has failed except for headwall.
34+200	Drain Culvert. Outlet structure is good.
34+500	Left CHO is good, but first gate needs repair. Outlet structure is good, but could use rubble masonry at endwalls.
34+675	Drain Culvert. Outlet structure is under water.
	- Need right berm surface drainage channel from 34+900 to 35+200.
~34+800	Right panel cracked and bulging.
34+815	Concrete Bridge is good except for some broken railing. Cavities behind right panels, but no cracks.
34+830	Concrete surface drain inlet to RMC has hole in right panel below and a large pile of sediment.
35+015	Concrete Bridge is structurally good. Cavities behind left and right panels with left panels cracked, bulging and displaced. Leaky upstream left joints that would be relieved with right berm surface drain.
~35+100	Cracked right panels.
35+596	Inverted Siphon with 2 gates. Inlet structure is good, but has cavity along right wall. Trash in inlet needs to be removed. Rubble masonry on left and right walls upstream and under bridge needs repair, including sealing top of rubble masonry walls so rainfall runoff cannot get under rubble masonry. Large concrete bridge paralleling inverted siphon looks good structurally. Outlet structure is good except for cavity along left wall.

35+660	Left CHO is good and outlet structure is good.
35+700	Left panel has cavity, bulging and displaced.
35+720	Left CHO Regulator for Lateral R-14L.
35+800	Left CHO is good and outlet structure is good.
35+923	Right surface drain inlet structure is good.
36+000	Left CHO is good. Outlet structure is good, but could use rubble masonry and endwalls.
~36+100	Left CHO Regulator for Lateral R-15L.
~36+120	Damaged right panels that look like they are replacements, but right berm needs to be cut down and shaped. Cavities need to be filled.
36+190	Cavities behind left panels.
36+200	Left CHO is good and outlet structure is good, with only a crack in the headwall.
36+527	Drain Culvert. Outlet structure is under water.
36+530	Large cavities behind right panel that is cracked and settled. Cavity behind left panel.
36+607	Concrete Bridge is structurally good. Cavity behind right panel. Left panel has small crack.
36+650	Left CHO is good, except for hand wheel missing on second gate. Outlet structure is good except for undermining of endwalls, which needs rubble masonry.
~36+700	Cavity behind left panel, which is badly displaced. Joint needs sealing after filling cavity.
~36+850	Large cavity behind left panel, which has been displaced.
	- Many cavities behind left panels. Fill cavities, grade road for surface runoff away from RMC.
37+000	Left CHO is good, but there are cavities behind left downstream panels. Outlet structure has failed.
	- There are four sections of large diameter concrete pipe lying in RMC.
	- Left bank roadway erosion.
	- Road erosion.
	- Right berm needs cutting down and graded.
	- Many cavities, cracked panels and bulging, although adjacent land is below RMC invert.
37+340	Wasteway Structure with overflow weir and gate control is good.
37+345	Drain Culvert. Outlet structure is good.
37+355	Drain Culvert. Outlet structure is good.

~37+400	Cavity behind left panel, which is displaced.
37+500	Left CHO is good. Outlet structure has end panels failed and remaining structure being undermined, which needs compacted backfill and rubble masonry.
37+640	Concrete Bridge is structurally good, except for broken downstream rail. Cavities behind left and right panels, some of them large, but there are no cracks in lining panels.
~37+750	Large cavity behind left panel.
38+000	Left CHO is good. Outlet structure is good, but has much roadway erosion depositing sediment in outlet structure, holes in right panels, and rubble masonry needed at endwalls.
38+100	Left CHO Regulator for Lateral R-16L.
38+280	Drain Culvert. Inlet structure is good. Outlet structure is under water.
	- Some cavities behind left panels.
38+500	Left CHO is good. Outlet structure is good, but much erosion, so rubble masonry is needed at end of structure. Also, need compacted backfill behind sidewalls.
38+525	Large cavity behind left panel.
~38+600	Cavities behind left panels and broken left panel. Also, there are cavities behind right panels.
	- Many cavities behind panels.
38+685	Roadway Culvert with inlet gate. Inlet structure is good. Outlet structure is good, but there are cavities along sidewalls.
	- Cavities behind right panels and badly cracked and bulging right panels. Also, some cavities behind left panels.
	- Need right berm surface drain from 38+280 to 39+200.
38+850	Left CHO is good except no hand wheel on first gate. Outlet structure is good, but there is erosion around headwall.
38+900	Left CHO Regulator for Lateral R-17L.
38+930	Cavity behind left panel.
	- Some cracked right panels.
39+200	Left CHO is good. Outlet structure is good, but could use compacted backfill plus rubble masonry at endwalls.
39+250	Roadway culvert with inlet gate. Inlet structure is good. Outlet structure is good. There are two drain culverts that cross perpendicular to roadway culvert, which have some cavities behind rubble masonry walls.

- Right berm surface drain exists from 39+200 to 43+650.
- One-fourth sediment.

~39+750 Cracked right panels and displaced right panel.

~39+800 Cracked right panels.

39+867 Concrete overflow structure is good, but has cavities behind left and right panels on upstream side and right downstream side.

~39+900 Drain Culvert. Outlet structure is under water.

- One-third sediment.

40+250 Concrete bridge is structurally good, but upstream top railing is broken. Large cavities at all abutments, but no cracks in lining panels.

- Many cavities behind left panels

40+500 Left CHO is good. Outlet structure is fairly good, but cavities behind headwall and right panel. Broken end panels. Compacted backfill and rubble masonry at endwalls is needed.

- Many cavities behind left panels.

~40+700 Failed left panel and others will fail in another season or two.

41+042 Drain Culvert. Inlet structure is good. Outlet structure is under water.

- One-fourth sediment.

41+380 Large cavities behind six left panels.

41+400 Left CHO is good. Outlet structure has broken left panel and right panel failed, with cavities behind left panel and headwall.

~41+600 Broken left panel joint.

41+780 Drain Culvert. Inlet and outlet structures are good.

- One-eighth sediment.

~41+900 Cavities behind left panels.

42+000 Left CHO is good except second gate is missing. Outlet structure has concrete pipe broken, so much erosion near headwall, which needs concrete pipe replaced and compacted backfill. Outlet structure has broken right panel and needs compacted backfill plus rubble masonry at endwalls.

- Left roadway bank erosion.
- One-sixth sediment.

42+200 Drain Culvert. Inlet and outlet structures are good, but each structure could use compacted backfill behind headwalls.

42+350	Left CHO is good, but second gate needs repair. Outlet structure has failed except for headwall which will soon go. Huge cavity near headwall.
42+377	Concrete Bridge is structurally good. Cavities behind left and right panels, but panels are not cracked.
42+550	Drop Structure with inlet gate and USBR VI. Inlet structure is good except threaded gate rod is bent. Outlet structure is good.
	- Still have right berm surface drain, but top of berm is about the same elevation as adjacent land.
~42+500	Hole in left panel near floor.
	- One-sixth sediment.
~43+000	Concrete Bridge [not listed] is structurally good. Cavities behind left and right panels, but no cracks in panels.
	- Lining looks good.
43+100	Drain Culvert. Inlet and outlet structures are good.
~43+500	Concrete Bridge [not listed] is structurally good. Cavities behind left and right panels, but no cracks in panels. Two right panels downstream are cracked.
43+625	Inverted Siphon without gate. Inlet structure is good. Large double-barrel concrete culvert under roadway, which is end of right berm drainage. Outlet structure is good.
	- One-fifth sediment.
43+700	Left CHO is good except for cavities along sidewalls. Outlet structure is good, but needs rubble masonry at endwalls.
44+050	Drain Culvert. Inlet and outlet structures are good.
~44+350	Concrete Bridge is structurally good. Cavities behind right panels, but panels are not cracked.
44+460	Drain Culvert. Inlet structure is good, but more riprap along right wingwall would be good. Outlet structure is under water.
	- Lining looks good for last 2-3 km.
	- One-fifth sediment.
44+700	Left CHO is good, but has cavity along downstream walls. Outlet structure is good, but has cavity behind right panel. Needs rubble masonry at endwalls.
44+800	Vertical Drop structure is good, except cavities behind left and right panels just upstream from structure. Cavity behind first left panel downstream from structure.
45+000	Right Tail Regulator is good.

45+070	Concrete Bridge [not listed] is structurally good, but upstream railing has been hit hard, probably by a truck. Cavities behind left and right panels, but no cracks in panels.
45+230	Right CHO is good, but has cavity along upstream wall. Outlet structure is mostly intact, but 1 m of broken right panel and large cavity near headwall. Considerable compacted backfill needed along both walls plus rubble masonry at endwalls.
45+250	Vertical Drop structure is good. Downstream right panel has hole at joint.
	- Very little sediment.
45+600	Left Tail Regulator. Inlet structure is good. Pipe outlet structure is good, but is being undermined. Riprap has been placed in scour hole. Roadway erosion near headwall of pipe outlet structure. Rubble masonry should be placed around pipe outlet structure.
45+700	Final CHO Outlet Structure. Inlet structure is good, but hand wheel on second gate will need replacement soon. Outlet structure is very good, but there is a cavity behind headwall and rubble masonry should be placed at endwalls.

Lateral R-1L (11.415 km)

0+000	Double CHO Regulator with only second gates installed, good. Outlet structure, good. For about 8 m downstream there is one-fourth sediment.
0+040	Holes in 2 right panels [road on left]. Both road and right bank very high above lateral.
~0+070	Roadway erosion over left panel.
~0+100	Right berm erosion into lateral and eroded right panel joint.
	- One-sixth sediment.
0+320	Drain Culvert. Outlet structure has large fall at outlet with much erosion. Should install rubble masonry energy dissipation basin.
~0+450	Failed right panel.
~0+840	One-eighth sediment.
~0+850	Large hole in right panel joint near floor.
1+000	Road Culvert without gate. Inlet structure, good. Outlet structure, good.
1+050	Two CHO's. Right CHO, good except missing concrete walkway panels. Right outlet structure has 3 m of failed right panel and a cavity behind left panel near headwall. Farmer has constructed outlet by punching hole through left panel with log, which will always

	leak. This outlet should be closed. Left CHO, good. Left outlet structure is good except for a hole in right panel.
	- One-fourth sediment.
1+280	Drain Culvert. Outlet structure, good.
1+250	Hole in right panel.
~1+550	Holes in 3 right panels.
~1+600	Holes in right panel.
~1+130	Cracked right joint with hole.
1+800	Concrete Bridge, good.
1+840	Two cracked right panels.
1+900	Hole in right panel.
1+980	Holes in 2 right panels.
2+000	Two CHO's. Right CHO is good structurally but second gate is missing. Right outlet structure has cavity behind right panel and small hole in right panel. Left CHO, good. Left outlet structure, good.
2+035	Lots of laterite washed into lateral, which severely constricts the flow (15 m long and 1/3 full).
	- One-eighth sediment and aquatic growth.
~2+300	Hole in right panel and panel joint displaced.
~2+400	Large hole in left panel.
2+500	Drain Culvert. Inlet structure, good. Outlet structure, good, but has much vegetation in structure.
2+550	Surface drainage from right berm.
	- One-sixth sediment and vegetation.
2+800	Drop structure with inlet gate and USBR VI. Inlet structure, good, but has cavity at headwall and some erosion. Outlet structure is very good and does not have the usual holes in the joints at floor level in last outlet transition panels.
2+850	Two CHO's. Right CHO is good and right outlet structure is good. Left CHO is good and left outlet structure has many holes in panels on both sides.
	- One-eighth sediment.
~2+900	Large hole in 2 left panels.
~2+960	Large hole in left panel.
3+000	Drop structure without gate and USBR VI. Inlet and outlet structures are good. First right panel after outlet transition has a horizontal crack.

3+040	Two failed left panels that can be salvaged by filling many cavities behind left panels.
3+060	Drop structure without gate and USBR VI. Inlet structure is structurally good, but a roadway has been cut too deeply near headwall and concrete pipe is exposed. Compacted fill needed here. Outlet structure is good except for 2 cavities on left outlet transition panel and hole in right outlet transition panel.
~3+100	Large cavities behind left panels.
~3+120	Hole in left panel joint.
~3+140	Failed left panel and adjoining left panel will soon fail unless the failed panel is replaced.
3+300	Concrete bridge on list does not exist.
3+500	Right CHO, good, but concrete walkway panels missing. Right outlet structure is very good.
3+550	Drop structure without gate and USBR VI. Inlet structure is good. Cavity at left headwall of stilling basin. Hole at left joint at beginning of outlet transition panel.
~3+575	Hole in right panel.
3+700	[Should be more like 3+900, or 4+100]. Check structure is good except for 3 holes in right panel.
	- One-eighth sediment.
4+253	Roadway Culvert without gate. Inlet structure is good. Outlet structure is good. Right panels after broken plane outlet transition structure are cracked. Small cavity behind left panel. Nine m downstream are cavities on both left and right sides.
~4+500	Small hole in right panel.
4+600	Failed right panel that needs replacement, otherwise adjacent panels will fail.
4+600	Left CHO is good except for cavity on upstream side. Outlet structure is very good. Concrete walkway panels missing on CHO.
4+800	CHO Regulator for Lateral R-1L-1L
	From CHO Regulator at 4+800 for Lateral R-1L-1L
4+810	Roadway Culvert and Drop Structure. Inlet structure (without gate) is good. USBR VI Stilling Basin is good. Small holes in right outlet transition panels.
4+850	One-half sediment.
4+900	Left CHO is good except for second gate missing and concrete walkway panels missing. Outlet structure is good except for cavities at headwall.
	- One-half sediment.

~5+100	One-third sediment.
~5+170	Failed left panel. There is an unlisted concrete pipe drain culvert here without outlet structure. 15 m downstream is another failed left panel needing replacement also.
5+286	Concrete Bridge is structually good with no cavities. Left lining panel is cracked.
~5+400	Hole in right panel.
~5+500	Portions of 2 left panels have failed.
~5+600	Huge hole 1.5 m long in left panel.
5+750	Right CHO is good and outlet structure is very good.
	- One-third sediment (maybe 40%).
~5+800	Small hole at right panel joint.
~5+850	Unlisted drain culvert with failed left panel and hole in right panel. Concrete pipe drain has no outlet structure.
~5+900	Hole in left panel joint.
6+170	Left CHO needs first gate repaired because it is now inoperable and the second gate is missing. Outlet structure is good except for one large hole in outlet basin.
~6+200	Huge hole in left panel.
6+400	Right CHO is good except second gate needs repair. Outlet structure is good, but has one crack in right panel.
~6+500	Hole in left panel joint.
6+760	Vertical Drop Structure is good but metal railing is missing.
~6+800	Small holes in right panel.
	- One-fourth sediment and one-third water, but clear.
~6+850	Cracks in right panels.
~6+900	Hole and crack in right panel.
6+952	Concrete Bridge is good with no cavities behind lining. Small holes in right panels downstream.
	- One-fourth sediment.
7+215	Hole in right panel.
7+220	Left CHO is good with small cavity on both sides. Outlet structure is good except for cracked left and right joints.
~7+270	Badly cracked left panel with hole.
~7+300	Eroded right joint.
7+350	Right CHO is good. Outlet structure is good.

~7+400	Left CHO Regulator for Lateral R-1L-2L.
From CHO Regulator for Lateral R-1L-2L (Station 7+400) to End	
	- One-fourth sediment.
~7+500	Left CHO, good, except second gate frame in-place but not gate. Outlet structure is good except for large hole in left panel at floor level and another hole downstream 7 m in left panel at bend.
~7+700	Cracks in 2 right panels.
~8+100	Hole in panel as outlet.
8+212	Concrete Bridge, good, but cracks in panels both left and right under bridge.
	- One-fourth sediment.
~8+400	Three small holes in right panel.
~8+500	Have constructed pipe outlet through left panel, where 1.5 m of left panel are gone. Pipe outlet has no structure. Outlet is one large buffalo wallow with irrigation ditches leaving in 3 directions.
~8+900	One-third sediment and aquatic growth upstream and one-fourth sediment downstream.
9+000	Two CHO's. Concrete walkway panels missing on both CHO's. Right CHO has no second gate. Right outlet structure has cavity behind left panel; otherwise, very good. Left CHO, good. Outlet structure, good, except for 3 small and 1 large hole in lining.
9+050	Vertical Drop Structure, good, except for cavities behind both left and right walls. The railing is missing.
	- One-fifth sediment.
9+121	Concrete Bridge, very good.
9+200	One-fourth sediment.
9+750	Concrete Bridge, is structurally good. Right abuments have cavities, but no cracks in lining.
	- One-third sediment.
9+950	Two CHO's. Concrete walkway panels missing on both CHO's. Right CHO is good. Right outlet structure is good. Left CHO is good except for cavities on both abutments. Left outlet structure has a small hole in both left and right panels.
	- Forty percent sediment for 50 m and then one-third sediment.
~10+200	One-fourth sediment.
~10+300	Holes at both left and right panel joints, with huge cavity behind left panel.

10+638	Concrete Bridge is structurally good. Large cavities on both right abutments, but lining is not cracked.
~10+850	[Listed as 10+700] Drain Culvert is under water.
~10+900	Right overflow structure has earth and logs at entrance to prevent use of this structure.
	- One-fourth sediment.
11+200	Two CHO's. Both CHO's are missing concrete walkway panels. Left CHO is structurally good but has large cavity at endwall. Outlet is concrete pipeline, which is in good condition. Right CHO is structurally good, but has cavities alongside upstream wall and endwall. Outlet structure has failed except for pipe outlet structure.
11+230	Left panel has failed.
11+235	Righ overflow structure, good.
11+239	End of concrete lining.

Sub-Lateral R-1L-1L (2.500 km)

0+000	CHO Regulator has large cavity on upstream panel. Concrete walkway panels are missing. Small cavity on downstream side. Outlet structure is good but has a cavity of first right panel downstream.
0+050	Vertical drop structure is good.
0+075	Large hole in left panel.
	- One-fourth sediment.
0+080	Large cavity behind left panel.
0+100 to 0+150	Many cracked right panels.
	- One-fifth sediment.
1+000	Left CHO is good but has cavities on each side and concrete walkway panels are missing. Outlet structure is good, but needs rubble masonry at endwalls.
~1+400	One-sixth sediment.
1+520	Roadway Culvert. Inlet structure without gate is good. Outlet broken-plane transition structure is good.
	- One-third sediment.
~1+600	One-fourth sediment.
1+700	Two CHO's. Concrete walkway panels missing on both CHO's. Right CHO needs repair of both gates and has cavity on each side. Right outlet structure is good. Left CHO is good but has cavity on each side. Left outlet structure is good.
	- One-third sediment.
~1+800	One-fifth sediment.

~2+000	Small holes in right panel.
	- One-fourth sediment.
~2+450	Two CHO's. Left CHO has second gate missing. Left outlet is pipe outlet structure, which is good structurally. Right CHO is good, but a small cavity on upstream side. Right outlet structure has cracked left panels, otherwise this structure is good.
2+500	End of concrete lining. Needs rubble masonry at left endwall.

Sub-Lateral R-1L-2L (2.800 km)

0+000	CHO Regulator with second gate missing, concrete walkway panels missing, and small cavity on both sides. Outlet broken-plane transition structure is good.
	- One-sixth sediment and one-third water.
0+100	One-fourth sediment.
0+185	Drain Culvert covered with water.
~0+300	Much sediment and left panels covered completely with sediment and vegetation (one-third sediment). This greatly constricts the flow.
0+640	Two CHO's. Left CHO is structurally good, but 1 m of left panel is gone and large hole in left downstream panel. Left outlet structure is good. Right CHO is good except for 1 m of right upstream panel gone and cavities at endwall. Right outlet structure has large holes 1 m long at floor level in both left and right panels.
0+686	Concrete Bridge is very good.
0+700	Drop structure with inlet gate and USBR VI. Inlet structure has gate frame, but no gate, and cavity near headwall. Outlet structure is good.
	- One-half sediment.
~0+750	Water from pond on left side has overflowed and caused failure of 5 m of left panel.
	- One-half sediment and vegetation and two-thirds water.
0+800	Drain Culvert covered with water.
~1+000	Surface drainage into left panel. Needs repair.
	- One-half sediment and vegetation and aquatic growth.
1+354	Concrete Bridge, no cavities, no cracks, so very good.
1+500	Listed concrete bridge does not exist.
1+600	Two CHO's. Right CHO has second gate gone (farmer said stolen) but gate frame in-place. Small cavity on upstream panel. Outlet structure is good except left

and right walls have purposely been broken for a water conveyance channel. Some concrete lining for 3 m on each side would be good. Concrete walkway panels on both CHO's are missing. Left CHO has first gate missing. Left outlet structure is good.

1+620 Vertical drop structure is good except for cavity behind left wall.

- The lateral downstream from 1+620 is completely filled with sediment and vegetation. Water cannot be conveyed in this channel.

1+950 Concrete bridge, good. Roadway needs maintenance. This road is nearly impassible now.

~2+500 Surface drainage from adjacent pond over left panel. Raise left berm.

~2+600 Broken right and left panels as a result of surface drainage and fishing.

2+780 Left Tail Regulator with one gate. Intake structure is good. Outlet structure is good.

2+800 Final CHO outlet structure with one gate, good. Outlet structure is good.

- Channel upstream has three-fourth's sediment to 1+950.

Lateral R-2L (3.515 km)

3+515 CHO Tailgate Regulator. CHO is good. Outlet structure is rubble masonry and looks very good.

- One-sixth sediment and vegetation and aquatic growth.

3+010 Concrete Bridge, very good.

3+000 Right concrete wasteway structure, very good. Outlet structure is under water.

3+000 Left CHO, good. Outlet structure, good. Ten m downstream is a hole in left panel.

- One-third sediment and vegetation.

~2+750 Lateral nearly full of sediment. This condition exists to outlet structure at 2+680.

2+665 Roadway Culvert without gate. Inlet structure is good. Outlet structure is nearly completely full of sediment. Upstream (u.s.) from inlet structure there is no sediment. [Check change in grade upstream and downstream from this structure.]

~2+200 Hole in left panel at floor level.

2+120 Concrete Bridge is good. The bridge approach on left side needs embankment because there is a big drop (20 cm) at end of concrete. One cavity on left upstream lining panel.

2+100	Vertical Drop Structure, good. Upstream lateral section has ~ one-tenth sediment.
1+980	Two CHO's. Left CHO is missing second gate and concrete walkway panels. Left outlet structure is good. Right CHO is good and right outlet structure is good.
	- From 1+980 to 2+100 the sediment is about one-third. Upstream from 1+980 only a small amount of sediment (one-sixth).
~1+800	One-fourth sediment.
1+700	One-third sediment.
1+600	Right CHO is good. Outlet is concrete pipeline, which is in good condition. Inlet to concrete pipeline could be improved.
1+590	Leakage from pond on left has resulted in failure of left panel and cavity behind upstream left panel. Left berm should be raised and compacted. Another possibility would be to install a drain culvert.
	- One-third sediment and vegetation.
~1+530	Erosion from left berm into lateral.
~1+480	Erosion from left berm into lateral as result of buffalo crossing. Broken right panel.
~1+400	One-fourth sediment.
~1+300	Needs concrete bridge to avoid surface drainage erosion into lateral upstream as a result of animal crossing.
	- One-fourth sediment.
1+190	Drain Culvert. Both inlet and outlet structures are good, but it would be good to construct a rubble masonry basin at outlet structure.
	- One-sixth sediment.
1+000	Right CHO needs both gates repaired. Cavity on upstream wall. Outlet structure is good except for 1 m long hole in bottom of right panel.
0+760	Holes and crack in left and right panels at animal crossing.
0+740	Drain Culvert. Inlet structure has largely failed. Outlet structure is good.
~0+550	Left concrete surface drainage inflow to lateral with crack in left downstream and upstream panels.
	- One-eighth sediment.
~0+450	Surface drainage over left panels.
~0+350	Erosion of left berm, which flows into lateral. Need to rebuild left berm for 6 m and place sod.

0+200	Drain Culvert. Inlet structure is covered with vegetation and contains much sediment, so the structure cannot really be seen. Outlet structure is good.
0+195	Vertical crack in left panel.
	- One-sixth sediment.
0+000	CHO Regulator, good, but has a small cavity on each side. Outlet structure is good.

Lateral R-3L (1.600 km)

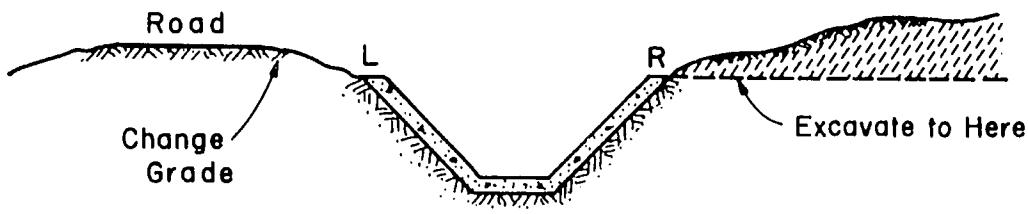
0+000	CHO Regulator, good. Outlet structure, good.
0+100	Drop structure without gate (not necessary) and USBR VI. Inlet structure, good. Outlet structure, good.
0+260	Drain Culvert. Outlet structure, good. Inlet structure, good structurally, but with sediment in inlet.
~1+050	Many panels with cracks in floor.
1+228	Road Culvert. Both inlet and outlet structures are good.
	- One-fifth sediment.
1+258	Two CHO's. Right CHO, good, but cavity on downstream right panel. Right outlet structure is good. Left CHO, good. Left outlet structure is good except for crack in left end panel.
	- One-sixth sediment.
1+380	Left overflow structure is good except that backfill is needed at end of structure because wing walls are exposed. Also, there is a cavity behind left panel near overflow structure inlet.
1+600	Final outlet structure. Gate at inlet structure needs repair. Cavities on both walls of inlet structure. Outlet structure has a hole in right panel and left panel is cracked. Then, 5 m of right panel downstream has failed.

Tonly Zola suggested that full pump maintenance be done this dry season because pumping units will not be used since on-farm facilities are being constructed this dry season.

Lateral R-4L (4.600 km)

0+000	Double CHO Regulator, good. Double Barrel Culvert. Outlet Broken Plane Transition structure is good except for left joint at end of transition. Right panels immediately downstream have cracks.
	- Many right panels have cracks.

~0+090	Right berm [road on left] has erosion into pond on right.
~0+090	[Listed as 0+100]. Drain Culvert, good. The right berm erosion cited above is above the drain culvert outlet structure.
~0+160	Cracked right panels. Road grade is towards lateral rather than away from lateral.
~0+200	Eight cracked right panels.
~0+250	Two failed right panels and next downstream panel will fail in one or two monsoon seasons because of cavities. Besides replacing these two panels, surface drainage on right berm is required for 200 m.



~0+350	Large cavity behind right panel.
0+430	Large cavity behind right panel with failed lower section.
0+450	Right CHO is good except concrete walkway panels are missing. Outlet structure has large cavity behind headwall and broken right panel near floor. Needs compacted backfill behind endwalls and rubble masonry.
~0+600	Two cracked right panels.
0+640	Drain Culvert. Inlet structure is good. Outlet structure not inspected.
	- Some sediment.
	- Roadway grade, good.
1+150	Drain Culvert. Outlet structure is good. Inlet structure is good. Failed left panel and next downstream panel is cracked. Right panel has holes at both joints plus hole near floor.
1+270	Three cracked right panels.
1+300	Right CHO, good. Outlet structure has failed except for pipe outlet structure. Drop is more than 1 m.
	- No water.
	- Some sediment.

1+350	CHO Regulator for Lateral R-4L-1L.
	Between Laterals R-4L-1L and R-4L-2L
1+377	Bridge, with cavity on right upstream embankment and cracked right panel. Bridge is structurally good.
1+390	Cavities behind right panels.
1+400	Check structure and beginning of rectangular chute. Last 20 m of chute needs compacted backfill to wall height on both sides.
1+600	Cavity behind right panel.
1+605	Drainage channel from right of right berm is lined for last 15 m before discharging into lateral. There is a hole in the right panel below this point plus 2 cracked right panels.
1+610	Concrete bridge, good except cavity on right upstream abutment.
1+615	Holes in right panel joint.
1+640	Three cracked righ panels.
1+660	Hole in right joint.
1+680	Hole in right panel near floor.
1+835	Drain Culvert. Inlet structure is good and outlet structure is good.
1+840	Hole in right panel and big crack horizontally and vertically.
2+000	CHO Regulator for Lateral R-4L-2L.
2+030	Right CHO Regulator for Lateral 4-4L-1R.
2+047	Concrete bridge, good.
2+060	Vertical Drop Structure, very good.
2+100	Right CHO, good, but concrete walkway panels missing and small cavity on upstream embankment. Outlet structure consists of pipe outlet structure only, which is in good condition.
2+200	Left CHO, good, except concrete walkway panels missing and medium cavity on upstream embankment. Outlet structure has huge hole in right wall, probably caused by embankment settlement resulting from inadequate compaction.
2+220	Big hole in left panel at joint near floor.
	- No sediment.
2+275	Cracked right panel and displaced left joint.
2+300	Drop structure with inlet gate and USBR VI. Inlet structure, good. Outlet structure is good. The end of the outlet transition structure does not have a joint,

	so then the problem has moved downstream 1 panel, where the joints leak and are slowly eroding.
2+800	Two CHO's. Left CHO, good. Left outlet structure is good except for a crack in right and left panels. Right CHO, good. Right outlet structure is good, has much sediment, but this is no problem.
~2+970	Concrete bridge, good. Lining looks very good. Aquatic growth.
3+100	Drain Culvert looks good, but mostly under water. Compacted backfill needed on outlet structure. Inlet structure also has some erosion.
3+150	CHO Regulator for Lateral R-4L-3L.

From CHO Regulator for Lateral R-4L-3L (Station 3+150) to End

3+200	Left CHO, good, except for large cavity at endwall. Outlet structure is pipe outlet structure only, which is good structurally.
~3+400	Hole at joint in right panel.
~3+450	Concrete outlet (or inlet?) structure with 3 wood planks for a gate. Immediately downstream, the lateral is half full of sediment. This structure should be replaced.
~3+500	One-third sediment.
~3+600	One-fourth sediment.
3+660	Concrete bridge, good.
3+680	New right CHO needs second gate installed. Needs compacted backfill on downstream abutment. Opposite CHO is extensive sedimentation. Outlet structure is very good. In this case, the drop is more than 10 cm, but by lining the downstream channel and lining at downstream bends the usual erosion problems have been avoided. [This is a very good design and good construction.]
3+700	Vertical Drop Structure is good. Downstream sediment is more than half at lateral depth for 100 m.
	- Forty percent sediment depth for 100 m.
	- One-third sediment.
4+200	From here downstream, the lateral has been cleaned by O&M, RID.
4+395	Culvert structure without gate, good. Outlet structure, good.
4+525	Left CHO, good, but needs laterite removed from box and concrete walkway panels installed. Outlet structure, good, but needs rubble masonry at endwalls.

4+550 Right CHO is good, but needs concrete walkway. There is a big hole in right panel near floor and adjacent to CHO. One m upstream from CHO is a small hole in lining with large cavity behind lining. Outlet structure has failed, including some of the concrete pipe.

4+600 End of concrete lining, outlet structure gone because of 1 m drop. Serious erosion and undermining of lining. The last 50 m of lining will fail unless the problem is corrected. Needs extensive compacted backfill, plus outlet drop structure. [Farmer said water is running under floor of lateral from 4+550 to end of concrete lining, which is aggravating the undermining of the lining.] Water should not be conveyed in this reach until this problem is corrected.

Sub-Lateral R-4L-1L (0.800 km)

0+000 CHO Regulator for Lateral R-4L-1L, good. Outlet structure is good.

- One-third sediment and vegetation.
- Heavy sediment load.

0+400 Two CHO's, good, except concrete walkway panels have been removed by fisherpersons. Right outlet structure is good. Left outlet structure is good but needs rubble masonry at endwalls.

- One-third sediment and vegetation.

0+600 Right CHO is good. Outlet structure has failed floor. Large cavity behind right wall. This structure can be salvaged with compacted backfill and rubble masonry in floor section.

- One-fourth sediment.

~0+650 Concrete inlet structure that lets drainage from nearby earth channel to flow into lateral.

0+800 Final CHO outlet structure, good. Outlet structure, good.

Sub-Lateral R-4L-2L (1.120 km)

0+000 CHO Regulator, good. Outlet structure is good.

- One-sixth sediment.
- Practically no sediment.

~0+300 Lateral overflow structure on right. Looks like it is being used by farmer as irrigation supply ditch. The adjacent paddy field is 10-15 cm lower than invert of overflow structure. Much erosion and failure of much of the overflow structure. This structure needs compacted backfill and a rubble masonry outlet basin.

0+400	Left CHO is good but needs concrete walkway panels and some concrete patchwork on left panel adjacent to CHO. Outlet structure is very good (dee maak).
0+440	Drop Structure with inlet gate and USBR VI. Inlet structure good. Three cavities between inlet structure and outlet structure. Possibility that the concrete pipe joints are leaking. Outlet structure is good except for holes in left and right joints at end of outlet transition. This is a common problem with these structures. Need sealed joints and add weep holes.
	- One-half sediment at 0+450.
	- One-third sediment from 0+500 to 0+650.
	- One-fifth sediment after 0+650.
0+830	Drain Culvert is good. Nearly covered with water and vegetation.
~0+930	Looks like water has overtopped right side of lateral. Compacted backfill needed behind right panel and reconstruct right berm.
~1+000	Looks like farmer may have taken water over right berm. Compacted backfill needed and right berm reconstructed for 2 m.
1+120	Final CHO Outlet Structure. CHO is structurally good but there is a serious erosion problem on right wall and endwall that needs attention so that the concrete pipe will not fail. Outlet structure has huge cavity at headwall, failed right panel, and part of left panel and floor has failed. Immediate attention is needed before dry season irrigation to prevent further failure of the outlet basin and concrete pipe. Farmer told us someone closed this CHO and water overtopped lining and ran around right side.

Sub-Lateral R-4L-3L (2.020 km)

0+000	CHO Regulator, good. Outlet structure, good.
	- One-third sediment and vegetation.
0+100	One-fifth sediment and aquatic growth.
0+500	One-fourth sediment and aquatic growth.
0+600	Two CHO's. Right CHO, good and outlet structure, good. Left CHO, good and left outlet structure, good.
0+700	Drain Culvert covered by water at both inlet and outlet.
1+000	Left CHO, good, except concrete walkway panels lying in lateral, probably placed there by fisherpersons. Outlet structure has two large cavities behind headwall. There is a crack between the headwall panel and left panel. Cavity behind left panel.

- One-fourth sediment.

1+040 Drain Culvert covered with water at both inlet and outlet.

1+250 Concrete pipe surface drainage inlet to lateral; or, is this an outlet structure (if so, there is no way of turning off the flow). Whatever the purpose of this structure, it is not good.

1+300 Concrete Bridge. Cracks and holes in left and right panels under bridge. Downstream (d.s.) right railing is busted; otherwise bridge is structurally good.

- One-fourth sediment.

1+400 Two CHO's. Right CHO, good, except concrete walkway panels are lying in lateral. Right outlet structure is good except for broken corner on right endwall. Could use rubble masonry on right endwall. Left CHO, good. Left outlet structure has a big crack 2 m from end and part of concrete has broken.

- One-third sediment for 50 m.

- One-fourth sediment.

1+600 Left CHO, good. Outlet structure has failed floor and failed right endwall with shrubbery growing through broken panel. Cavity behind right wall. Left endwall has erosion and needs compacted backfill and rubble masonry.

~1+920 Drain inlet into lateral consisting of concrete pipe. Stoplogs can be used to prevent inflow. Could be used for inflow or outflow. [Tail Regulator.]

2+020 Final CHO outlet structure. Inlet CHO, good. Outlet structure is good.

Sub-Lateral R-4L-1R (3.200 km)

From Tail End to CHO Regulator

3+250 End of concrete lining. There is no structure at end of lining, only an endwall that has failed. This structure could easily be salvaged by lifting the endwall and then placing a small culvert with a gate to control outflow.

3+200 Left Tail Regulator with Culvert and pipe outlet structure. The pipe outlet structure is about 40 cm above downstream pond level and is severely undermined. Eventually, the pipe outlet structure will fail unless an outlet basin is constructed as a means for dissipating excess hydraulic energy.

- One-sixth sediment and much vegetation.

3+100 Drain Culvert. Inlet structure, good. Outlet structure needs compacted backfill over drain culvert. The concrete lateral lining has cavities on both left and right

panels and a large break on right panel.

- One-fourth sediment and vegetation.

2+900 Drain Culvert. Inlet structure looks like it cannot be used, because full of sediment and used mostly as a fish trap. Outlet structure and inlet structure could use compacted backfill behind headwalls.

- One-third sediment and vegetation.

~2+850 Surface drainage over right panel. Channel half full of sediment immediately below.

~2+830 Surface overflow of lateral on left side towards paddy field.

2+725 Culvert Drop Structure. Outlet structure is good, but downstream channel is completely full of sediment. Culvert is 99 m in length. Fourth and fifth manholes have a cavity upstream. Third manhole has cavity on left side and lid is in manhole. Cavities on second manhole, needs backfill. Inlet structure has cavities at endwall.

2+500 Concrete bridge is structurally good. No cavities but surface drainage on right upstream bank has placed enough sediment in lateral to constrict flow. Cracked left panel.

- One-sixth sediment.

~2+470 Cavities on both left and right panels.

~2+460 Large cavity on right panel and holes and large cavities below floor panel. Also, cavity on left panel. Upstream (u.s.) 15 m there are small holes in the lining but huge cavities under floor panels. Large cavity on left panel.

This reach of lateral needs immediate attention or there will be considerable failure. Water should not be allowed in this reach until this repair has occurred. This reach has water flowing under the floor and then out a cut on the right berm into a pond, so states a farmer [which looks very plausible].

- One-sixth sediment.

- Roadway needs repair and maintenance.

1+700 Vertical Drop Structure, good but has cavity alongside right wall. This first right panel downstream has a large hole that needs repair.

~1+640 Concrete Bridge, good, but cavities behind right panel and cavity behind left panel on upstream side.

1+500 Two CHO's, abandoned, with severe erosion around structures and across roadway. Right CHO has break in adjacent right panel. Roadway needs repair and these structures need to be fixed so that no more erosion will occur. There are no gates.

~1+400 Concrete bridge, good.

- One-fourth sediment for 50 m, then one-third sediment upstream from 1+350.

~1+250 Water carried over right panel, which should not be allowed.

- One-half sediment.

~1+200 Big cavities at joints of left and right panels. Many holes in roadway. Were they dug by farmers for water buffalo wallows?

~1+150 Large cavity behind left panel. Many cavities on both left and right panels.

~1+100 Cavities behind left and right panels.

~1+050 Three left panels have failed and need to be replaced.

- One-half sediment.

~1+000 Many cavities behind left and right panels.

- Two-thirds sediment.

0+900 Many cavities behind left and right panels. Eighteen m of right panel have failed. Holes in lining. Too many cavities to even count.

- Two-thirds sediment.

0+820 Drop structure with inlet gate and USBR VI. Outlet structure, good, but three-fourths full of sediment. Huge cavity between inlet and outlet structures.

The reach of lateral R-4L-1R below 0+820 should not receive water until the necessary maintenance can be done because there will be too many panel failures.

0+792 Left CHO, good. Outlet structure has about 1 m drop, so that floor and end panel have failed. Need energy dissipator here using rubble masonry cascading floor after placing compacted backfill.

0+792 Right CHO is CHO Regulator for Lateral R-4L-1R-1R.

From CHO Regulator for Lateral R-4L-1R-1R (Station 0+792) to beginning

0+735 Road culvert without gate. Both inlet and outlet structures are good.

0+725 Spalling of left joint as a result of cavity underneath.

- Small amount of sediment.

0+650 Left CHO is good, but small cavity at downstream abutment and huge cavity along upstream wall. Outlet structure has severe erosion from roadway behind head-wall with 3 m of concrete pipe exposed. Outlet basin

has failed portion of left endwall. Compacted backfill and rubble masonry is needed soon.

- One-eighth sediment.

0+385 Drain Culvert. Both inlet and outlet structures are good, but inlet is experiencing erosion of right berm [road on left] above inlet that needs attention.

- One-tenth sediment.

~0+150 Drain Culvert. Both inlet and outlet structures are good, but there is some erosion of right berm above inlet headwall.

- One-sixth sediment.

0+000 CHO Regulator, good. Outlet structure is good, but has a cavity behind left panel joint at end of broken-plane transition structure.

Sub-Lateral R-4L-1R-1R (1.150 km)

0+000 CHO Regulator, good. Outlet broken plane transition is good.

- One-fourth sediment.

~0+150 Practically no sediment.

0+200 Left CHO, good, but one concrete walkway panel is in lateral and another alongside structure. Outlet structure is pipe outlet structure that is in good condition.

0+365 Right CHO, good. Outlet structure is very good except for small cavity on right bank. Needs rubble masonry on left endwall at bend.

0+400 Check structure, good.

~0+500 Cavity behind left panel.

~0+550 Small hole in right panel at floor.

- Practically no sediment.

~0+560 Small hole in right panel joint at floor level.

0+580 Cavities on left and right panels and small lining holes.

~0+600 One m of right panel has failed.

- One-fourth sediment.

0+650 One-third sediment.

~0+700 Surface drainage from paddy over right bank producing cavity.

- Half full of water.

~0+900 One-half sediment.

1+000	One-fourth sediment.
1+150	Final Outlet Structure. Inlet CHO, good. Outlet structure is good, but endwalls are being undermined, so compacted backfill is required plus rubble masonry at endwalls.

Suphakiet recommended the purchase of a mower for cutting shrubbery along lateral banks.

Lateral R-6L (4.900 km)

Beginning at Tail End

Roadway maintenance badly needed.

4+900 or 4+600	Final CHO Outlet. CHO has gates missing and concrete walkway panels. Outlet structure good. Concrete lining was just brought to CHO without any transition structure.
	- Three-fourths sediment.
4+400	Vertical drop structure intact. Right wingwall exposed because of failure of upstream right panels (6 m).
4+370	Fisherpersons have taken soil from right berm and left roadway for damming lateral.
	- One-fifth sediment and aquatic growth.
4+200	One-third sediment and vegetation.
	- Roadway erosion into lateral.
4+100	One-half sediment and vegetation.
4+000	CHO under construction (left side).
	- Lateral full of sediment.
3+378	Surface Drain Over-chute is good structurally, but there is erosion at upstream abutments.
	- Lateral full of sediment.
4+000	Badly eroded right berm has caused failure of right panels.
3+940	Concrete Bridge, good. Surface drainage from right berm running behind upstream panel.
	- Three-fourths sediment.
3+900	Left CHO without gates and missing concrete walkway panels. Cavity on downstream abutment. Outlet structure is good except portion of endwalls gone and basin half full of sediment.

- Two-thirds sediment.

~3+750	Two cavities behind right panels.
~3+400	Left CHO with both gates but concrete walkway panels missing. Large cavities on downstream wall and headwall. Outlet structure is only pipe outlet structure, which is good structurally.
~3+378	Drain Culvert, good.

- One-sixth sediment.

~3+240	Bridge at Laterite Road, good.
~3+150	Big hole in right panel and adjacent downstream panel badly cracked.
~3+120	Failed right panel.
3+080	Drop Structure, USBR VI structure is good except for huge cavity at headwall. Inlet structure with gate is good except for cavity along left wall.

- One-tenth sediment.

~2+900	Concrete bridge, good.

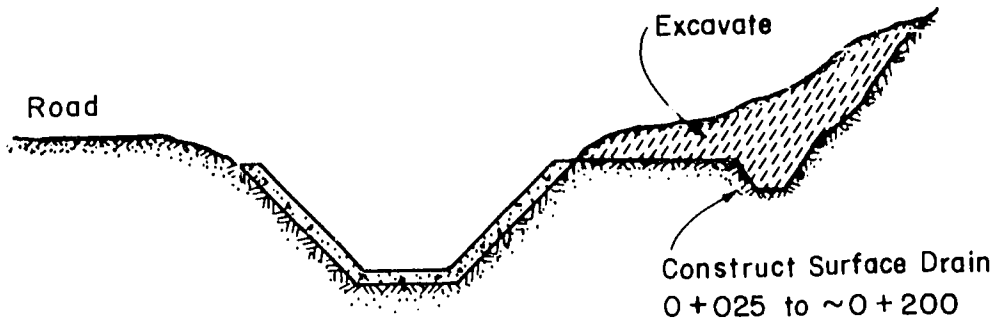
- One-eighth sediment.

2+640	Left CHO, good except for concrete walkway panels missing and large cavity at endwall. Outlet consists of pipe outlet structure, which is good structurally, but roadway erosion along left wall should be corrected.
2+625	CHO Regulators for Lateral R-6L-2L.
2+620	Left panel has cavity at joint with hole in lining near floor.
2+610	Cavity behind left panel.
2+606	Cavities behind right panels.
2+600	Left CHO, good, except for cavity on upstream abutment. Outlet is pipe outlet structure, which is good structurally.
~2+580	Three right panels with holes.
~2+560	Hole in right panel and hole in nearby left panel.
~2+550	Hole in right panel at joint.
~2+540	Hole in right panel at joint.
~2+500	Bridge is good but right panels are cracked.
~2+280	Drain Culvert, good.

- Very little sediment.

~2+250	Three right panels with holes in joints.
2+120	Left CHO, good. Outlet structure is good structurally but has laterite sediment.

2+075	CHO Regulator for Lateral R-6L-1L.
2+000	Spalling and holes in a number of right panels.
1+850	Left CHO, good. Small cavity behind upstream left panel. A concrete walkway panel is lying alongside the structure. Outlet is pipe outlet structure, good, but erosion below floor needs rubble masonry protection.
~1+800	Large hole in left panel.
~1+770	Hole in left panel.
~1+750	Displaced right joint.
~1+720	Hole in left panel.
~1+650	Right bank nearly eroded away. Left panel has hole.
	- One-eighth sediment.
1+200	Chute Inlet, with chute being roughly 400 m long.
1+160	Left CHO, good. Outlet structure has too great of a drop, so much of the floor and endwalls have failed.
1+120	Three left panels are bulged and will soon fail.
~0+900	Bridge, good, except for some chipping of concrete over right end.
0+800	Vertical Drop Structure. Upstream right panel has big hole near floor. Two right panels have small holes at joints. Cavity on left abutment.
0+775	Hole in right panel.
0+740	Hole in left panel.
0+600	Left CHO, good, except for huge cavity at endwall. Outlet structure has too much drop, so all but the headwall has failed.
~0+300	Big hole at floor level and another high one in right panel.
~0+200	Hole in right panel.
	- Very little sediment.
~0+050	Small holes in right panel.
0+040	Holes in left panel.
0+030	Holes in right panel.
0+000	CHO Regulator for Lateral R-6L from RMC. Outlet structure is good, except surface drainage is allowed to run into this structure on right side. Double CHO Regulator has first gates only, good structurally.
	From 0+025 to approximately 0+200 needs surface drainage on right side.



Sub-Lateral R-6L-1L (0.900 km)

0+000	CHO Regulator is good except concrete walkway panels are missing. Outlet structure has erosion over headwall.
~0+025 to 0+075	Many small holes at joints.
~0+150	Hole in left panel.
	- One-fourth sediment.
	- One-sixth sediment.
0+500	Drop structure without inlet gate and USBR VI. The embankment has failed about 3 m downstream from inlet structure headwall. Outlet structure is good.
0+500 to 0+700	Lining cannot be seen because completely covered with sediment.
0+700 to 0+900	Lateral filled with water.
0+900	Final Outlet structure from Lateral. Inlet CHO has no gates. Outlet structure is good, but needs rubble masonry at endwalls.
	Roadway needs maintenance.

Sub-Lateral R-6L-2L (7.790 km)

From Culvert Structure under Udon-Sakhon Nakhorn Highway to End

2+300	Culvert under Udon-Sakhon Nakhorn Highway. Inlet structure, with gate, good. Some concrete spalling at beginning of inlet structure. Outlet structure, good.
2+340	Right CHO, with small cavity on downstream embankment and large cavity at headwall. Outlet structure is very good and connected with lining to bend 1.0 m downstream.
	- One-sixth sediment and aquatic growth.
2+900	Right CHO looks good except for second gate tilted sideways. Outlet structure looks good.

3+254	Bridge, good.
3+370	Bridge, good.
3+400	Right CHO, good, except for large cavity on downstream embankment. Outlet structure, good, but could use rubble masonry at endwalls.
3+500	Drain bridge for conveying surface drainage across lateral from right side to left, capacity is reduced because of sediment and vegetation on bridge deck.
~3+700	Right panel has displaced joint that is seeping water and sediment.
~3+720	Same as 3+700.
3+850	Bridge, with cavities at right upstream and left downstream embankments.
~3+900	Left panel displaced ~ 10 cm. This joint should be sealed to prevent erosion of material behind this panel.
~3+950	Right panel with displaced joint.
~4+000	Three cavities behind two left panels with displaced joints.
~4+130	Cavity behind right panel.
4+185	Bridge. Cavities on three abutments with bad horizontal crack in four right panels. Bridge railings partly damaged.
~4+220	Displaced joint on left panel.
~4+280	Large hole in left panel with cavity at top of joint.
	- Half full of water.
~4+420	Surface drainage onto right panel.
4+470	Right CHO, good. Outlet structure is good, but it would be helpful to place rubble masonry at end of broken-plane outlet transition.
4+500	Abandoned right CHO.
4+570	Left CHO, good. Outlet structure has large hole in floor and left panel and the last panel before the division box has failed because of surface drainage over left panel. The division box 10 m downstream has very serious undermining of right outlet wall.
4+580	Check structure, good.
~5+000	Roadway sloped for ~ 300 m into lateral rather than away from lateral.
~5+400	Surface drainage problems on right berm. Right berm should be shaped to have rainfall run away from lateral.
5+755	Spalling of right panel.

5+800	Two CHO's. Left CHO, good, and left outlet structure fairly good, but with small hole in left headwall and left panel and cracking. Right CHO not used.
5+807 to 5+810	Left panel has bulged and broken into many pieces as a result of a cavity behind the left panel.
6+080	Hole at joint in right panel.
6+085	Bridge, good.
	Should always place concrete between lining panels and bridge wing walls to prevent formation of cavities.
6+100	Two CHO's. Right CHO abandoned. Left CHO structurally good, but there is a hole in the lining adjacent to the left CHO downstream wall. Left outlet structure is good.
	- One-sixth sediment and aquatic growth.
6+180	Right panel has bulged and has a horizontal crack.
6+320	Cracked right panel.
6+310	Two right panels with horizontal cracks.
6+350	Right CHO with one gate, good. Outlet structure is good but needs rubble masonry at endwalls. Outlet is a broken-plane transition.
~6+380	Hole halfway up right panel.
~6+385	Hole halfway up right panel.
~6+540	Small cavity over right panel that needs some soil placed here plus sodding.
6+560	Bridge. Cavities at left abutments. There are cracks and holes near the top of the left panel.
6+575	Left Wasteway Structure is good structurally. Outlet culvert has rubble masonry erosion protection. Left side has cracked and broken and should be repaired.
~6+610	Cavity over right panel joint.
~6+800	Nine m of lateral section has failed. Apparently caused by uplift pressures.
~6+820	Nine m of left panels have failed, apparently as a result of uplift pressures.
~6+840	Six m of right panel have bottom one-third bulged and broken.
~6+860	Nine m of left panel have failed.
~6+880	Nine m of left panel have failed.
~6+900	Six m of right panel have failed.
~6+920	Twenty one m of left panel have failed.

~6+940	Nine m of left panels have failed.
~6+950	Hole in right panel.

To solve the problems, from ~6+800 to 7+000 will require subsurface drainage on <u>both</u> sides.

6+994	Bridge. There are cavities at left downstream and right upstream abutments that have resulted from bridge deck drain holes running water onto soil above lining and creating these cavities. Plug drain holes (2) and fill cavities.
~7+010	Big hole in right panel.
~7+025	Big cavity behind right panel.
~7+040	Small hole in right panel.
~7+055	Hole in right panel.
7+070	Pump Lift Station. Has three pumps, all of which are capable of operating. Because of lateral capacity, only two pumps would be used at one time. No difficulties with pump controls.
7+150	Right CHO, good, except missing concrete walkway panels. Outlet structure has lined section for 12 m, but there is a 50 cm drop and the endwalls are being undermined. Needs extensive earth work and rubble masonry.
	- One-sixth sediment and vegetation.
~7+250	Erosion of right bank, which will need attention soon.
7+700	Two CHO's. Left CHO, good, and left outlet structure has end panels gone and left panel badly cracked. Both CHO's have concrete walkway panels missing. Right CHO, good, and right outlet structure, good, but needs rubble masonry at endwalls.
7+790	CHO Regulators for Laterals R-6L-2L-1L and R-6L-2L-1R.

From Culvert Structure under Udon-Sakhon Nakhorn Highway (2+300) to 0+000.

2+000	Left CHO, good, with cavity on upstream abutment. Needs concrete walkway panels. Outlet structure is good but filled with sediment and vegetation.
~1+500	Two cavities behind left panels.
~1+400	Cavities behind left and right panels.
~1+350	Cavity behind left panel.
~1+325	Cavity behind left panel.
1+310	Cavities behind right panels.

1+300	Check structure is good. There is a small hole on left and right panels at floor level at inlet transition to check structure.
1+275	Many cavities behind left and right panels.
1+200	Right CHO is good structurally, but has cavities on both abutments which has caused a hole in the right panel near floor level. Outlet structure has last 2-3 m gone with serious damage to remaining structure. Because of 30-40 cm drop, this structure will soon completely fail.
~1+100	Cavities behind left and right panels.
1+075	Broken right panels and displaced panels resulting from many cavities.
	Needs major attention on cavities from 1+000 to 1+500 to avoid further extensive damage to the concrete lining.
1+050	Left CHO is good, but needs two concrete walkway panels. Outlet consists only of pipe outlet structure, which is mostly covered with water.
~0+800 to 1+000	Many cavities behind both left and right panels with displaced panels and badly cracked panels.
~0+600	Cavities behind panels.
~0+400	Hole in left panel.
0+200	Holes in panels.
~0+100	Many small holes at joints in this reach.
~0+040	Large hole in right panel at joint.
0+120 to 0+030	Left panels have failed.
0+000	Double CHO outlet, good. Outlet structure is good.
	Needs major attention on cavities and repair and replacement of lining panels from 0+000 to 1+500.
	30 November 1982 - Need right berm open drain from 0+000 to 1+050 plus cutting and grading of right berm. This will be a relatively simple job. Left roadway drainage is good.

Sub-Lateral R-6L-2L-1L (1.120 km)

0+000	Double CHO Regulator, good. Outlet broken-plane transition structure is good. Spalling at right joint at end of transition structure with small cavity at top of joint.

0+120	Drain Culvert could not be seen because covered with water.
0+200	Right CHO, good. Outlet structure is structurally good but some undermining of endwalls, which needs compacted backfill plus rubble masonry.
	- Aquatic growth and some sediment.
0+495	Check structure, good. Some sediment and vegetation and aquatic growth.
0+600	Two CHO's, good. Left outlet structure is good and has riprap at endwalls. Right outlet structure is good, but some riprap at endwalls has been moved, so rubble masonry should be used.
	- One-sixth sediment and vegetation and aquatic growth.
0+900	Left CHO, good. Outlet structure, good.
1+100	Right Tail Regulator, good. Outlet structure is good. Riprap looks good, but some has been moved, so add mortar.
1+120	Final CHO Outlet structure, good. Outlet structure, good. [Road right of lateral.]

Sub-Lateral R-6L-2L-1L-1R (5.400 km)

0+000	Double CHO Regulator. The two gates on the downstream CHO are not operable, so that when the water level is raised in Lateral R-6L-2L-1L, then water will flow through these gates. The gates on the upstream CHO can function, but they still need repair. Outlet structure, good.
	- Aquatic growth.
~0+150	Roadway erosion on right bank. [Road on right of lateral.]
0+170	Drain Culvert (could not find).
0+340	Two cavities behind right panel.
0+350	Left CHO, good. Outlet structure, good.
0+700	Two CHO's, good. Outlet structure is good and have riprap in-place at endwalls.
0+846	Bridge, good. The posts in the center of the bridge to prevent vehicle traffic have been busted off.
~1+360	Right panel has vertical crack with spalling.
	- Aquatic growth.
1+368	Bridge, good.

On both sides of this lateral, the land is higher than the lateral. The drain ditches on both sides are rapidly filling with sediment and should be cleaned

before the next monsoon season; otherwise, water will overflow the drain ditches and run into the lateral, thereby creating cavities behind the lining and conveying much sediment into the lateral.

~1+450	Displaced right panel resulting from two large cavities caused by overflow from right drain ditch flowing over road. Many left and right panels have small vertical cracks (probably shrinkage cracks).
1+505	Two left panels have extensive small cracks that will become much worse with time.
1+755	Crack at top of right panel.
1+775	Bridge. Cavity on right downstream abutment. Cracked two right panels under bridge.
1+785	Cavity behind right panel.
1+900	Two CHO's. Right CHO good and right outlet structure good with riprap in-place. Left CHO good and left outlet structure, good. [Would be helpful to have a precast concrete foot bridge at all double CHO's to facilitate the work of the zoneman.]
~2+100	Patched left panel has large cavity. There are many left panels with cavities in about 50 m of reach.
2+305	CHO Regulator for Lateral R-6L-2L-1L-1R-1L. There are two holes in the floor of Lateral R-6L-2L-1L-1R here.
2+310	Bridge, very good.
2+400	Two CHO's. Left CHO good, but concrete walkway panels need to be properly installed. Left outlet structure is good. Right CHO is good and right outlet structure is good.
	- Aquatic growth.
~2+800	Bridge, good. Cavity on left upstream panel.
2+900	Drop structure with inlet gate and USBR VI. Inlet structure, good. Cavities on both left and right panels at end of outlet structure transition with holes at joints.
	- Practically no sediment or aquatic growth.
3+000	Left CHO, good. Outlet structure is good except for separation of headwall from pipe outlet structure.
3+100	Bridge. Cavities on both left and right abutments with cracked panels. Bridge is structurally good.
~3+300	Roadway erosion
3+500	Right CHO, good. Outlet structure has endwalls being undermined because of 5-10 cm drop. This structure can be easily salvaged if maintenance is done before the next monsoon season, otherwise the end panels will fail. Needs compacted backfill plus rubble masonry.

3+520	Bridge is structurally good. Cavities on both left and right panels.
	- One-sixth sediment and vegetation.
	- Left berm erosion.
~3+900	Spalled left joint.
4+000	Left CHO, good. Serious problem with outlet structure because of 20 cm drop. End panels have failed but could be salvaged. Needs compacted backfill plus rubble masonry and cascading rubble masonry floor.
	- Left berm erosion.
4+485	Road Culvert with inlet gate, good. Broken-plane outlet transition structure is good.
4+780	Drain Culvert, good.
4+950	Two CHO's, good. Outlet structures are good with riprap in-place.
	- One-sixth sediment and vegetation.
5+350	Two CHO's, good. Left outlet structure is good. Right outlet structure has cavity at headwall but is good structurally.
5+400	Final Outlet Structure with one gate. There is a floor crack at beginning of gate inlet structure, with small hole in right side of floor. Outlet structure is buried under trees, but consisted only of pipe outlet structure, which will soon fail. Riprap has been placed in this large eroded basin. Immediate attention is needed before dry season irrigation to prevent failure of pipe outlet structure. Needs extensive rubble masonry. A Drop Structure should have been designed and constructed here (1-1½ m drop).

<u>Sub-Lateral R-6L-2L-1L-1R-1L (1.550 km)</u>

0+000	CHO Regulator, good. Broken plane transition outlet structure, good.
0+015	Cavity behind left panel.
0+023	Cavity behind left panel.
	- One-eighth sediment, laterite and vegetation.
0+200	Drop structure with inlet gate and USBR VI. Inlet structure has two cavities on left side, but is structurally good. Roadway erosion [road on right] into outlet structure. Right panel at end of outlet transition structure is displaced because of cavity. Two cavities behind left panels.
	- One-sixth sediment and vegetation.
0+500	Drop structure with inlet gate and USBR VI. Inlet structure, good. Erosion on both sides of embankment

between inlet structure and USBR VI outlet. Roadway erosion into outlet structure. The last panel on the right side of outlet transition structure has cavities. Outlet is structurally good.

- One-sixth sediment and vegetation and aquatic growth.

0+780 Vertical Drop Structure, good. Left and right panels downstream have cavities. Fill cavities and add mortar to riprap.

0+900 Two CHO's. Right CHO good structurally but has cavities on both abutments. Right outlet structure needs rubble masonry at end walls. Left CHO, good. Left outlet structure needs rubble masonry at endwalls.

- One-fourth sediment.

1+340 Vertical Drop Structure, good. A small hole in left downstream panel, which probably occurred during construction.

- Practially no sediment.

1+480 Drain Culvert is structurally good. The left side of lateral has overtopped and extensive erosion occurred. Six m of left panel are unsupported and some pieces have broken off. Looks like 12 m of lateral section was probably replaced earlier, implying this problem has occurred before.

1+550 Final CHO outlet structure. CHO structure is good and outlet structure is good, but needs rubble masonry at endwalls.

Sub-Lateral R-6L-2L-1R (1.200 km)

0+000 CHO Regulator, good. Outlet structure, good.

- One-sixth sediment and vegetation.

0+200 Left CHO, good. Outlet structure, good, but needs rubble masonry at endwalls.

0+880 Drop structure with inlet gate and USBR VI. Inlet structure, good. Outlet structure good.

0+950 Right CHO, good. Outlet structure, good, but needs rubble masonry at endwalls.

- One-third sediment and vegetation.
- The land on both sides of lateral is below lateral invert, thereby providing good drainage.

1+100 Vertical drop structure, good, but metal railing needs repair.

- One-third sediment and vegetation.

1+200 Final CHO Outlet structure, good. Outlet structure has headwall section only, which is all that can be used.

Place rubble masonry under left panel to prevent erosion.

Sub-Lateral R-6L-2L-1R-1L (1.810 km)

0+000	CHO Regulatory, good. Outlet broken-plane transition, good.
	- One-third sediment and vegetation.
0+200	Right bank is being eroded. Right bank needs shaping and cutting down.
0+410	Bridge. Cavities on right panels. Left railing knocked over.
0+500	Two CHO's. Left CHO, good. Left outlet structure has last 20 cm of floor failed and endwalls need rubble masonry. Also, floor needs rubble masonry cascade. Right CHO, good. Right outlet structure is good and has riprap, but rubble masonry would be better.
0+735	Bridge. Cavities at all abutments. Portion of right top railing bar has been knocked over.
0+800	Two CHO's. Right CHO, good, and right outlet structure is excellent with good riprap at endwalls. Left CHO, good. Left outlet structure, good, but needs rubble masonry at endwalls.
	- One-third sediment and vegetation.
1+100	Right CHO, good. Right outlet structure, good, with good riprap on left endwall, but needs more riprap on right endwall. Preferably, add mortar to riprap in order that fisherpersons cannot remove. Right bank has much erosion that will soon need attention.
1+140	Vertical drop structure, good.
1+150	Surface drainage from right berm into lateral.
	- One-third sediment and vegetation.
1+250	Drain Culvert under lateral, good.
1+540	Right CHO, good. Outlet structure, good.
1+600	Vertical drop structure, good.
	- One-half sediment and vegetation.
1+630	Bridge, good.
	- One-half sediment and vegetation.
1+810	Final CHO Outlet structure, good. Outlet structure, good, because downstream water level is sufficiently high.

Lining is excellent. Mostly because there is good drainage on both sides of lateral because land is lower than lateral.

Sub-Lateral R-6L-3L (1.300 km)

0+000	CHO Regulator needs first gate repaired. Outlet structure, good.
0+025	Drain culvert should be extended at downstream end.
	- One-third sediment and vegetation.
0+100	One-fourth sediment.
0+300	One-third sediment.
0+350	One-fourth sediment.
0+450	One-third sediment.
0+650	Right CHO with first gate badly needing repair and second gate missing. Huge cavitites behind right panels immediately upstream from CHO. A cavity at end of CHO. Outlet structure is a pipe outlet structure, which is good structurally.
0+700	Drop structure without inlet gate and USBR VI. Inlet structure, good, but gate is missing. Outlet structure, good.
	- One-third sediment.
~1+200	Six m of right panel have failed because of severe erosion.
1+300	Final CHO Outlet. CHO is missing gates with portions of one gate lying nearby. Cavities at headwall and left panel. Outlet structure is good but needs rubble masonry at right endwall.

Roadway maintenance needed.

Lateral R-7L (6.120 km)

0+000	Double CHO Regulator, good. Outlet structure, good.
0+065	Left CHO, good. Outlet structure has last panels dropped into eroded ditch. Surface drainage from left roadway over headwall, which can be corrected by grading.
0+090	Drop structure with inlet gate and USBR VI. Surface drainage into both abutments, which is not a serious problem, but should still be corrected. Outlet structure, good.
~0+400	Serious surface drainage problem from right bank into lateral with large cavity on right bank.
	- One-sixth sediment.
~0+450	Surface drain from right bank into lateral.

0+765	Large hole in right panel at joint. This panel and next one downstream has horizontal crack halfway up slope with vegetation growing into crack.
0+770	Bridge. Cavity on left downstream bank that could be filled in. The joint has a number of small holes that should be filled with concrete or asphalt. Large cavity on right upstream embankment.
~1+150	Left CHO, good. Outlet structure, good.
	From 0+000 to 1+215, the right bank should be designed for more effective surface drainage.
1+215	Drop structure with inlet gate and USBR VI. Inlet structure, good, except for one small cavity near headwall and one small cavity on right bank at transition inlet. Outlet structure, good structurally. Last panels in outlet transition have diagonal cracks with moss. There is a small cavity on left bank of last panel in transition outlet structure.
1+280	Right CHO, good. Outlet structure is structurally good, but filled with sediment because of surface drainage into outlet structure.
1+310	Drop structure with inlet gate and USBR VI. Inlet structure, good. Outlet structure good. There is a vertical crack at end of outlet transition.
~1+340	Vertical crack in left panel.
1+410	Two CHO's, good. Right outlet structure is good except that left side of end panel has broken off. Also, right outlet structure filled with sediment. Left outlet structure is good structurally but has sediment.
1+515	Roadway fill in lateral over left bank.
1+600	Vertical drop structure, good. No sediment.
1+700	One-sixth sediment.
1+960	Right CHO, first gate needs repair so it can be regulated. Outlet structure good, but a few cracks in left panels.
2+100	Drop structure with inlet gate and USBR VI. Outlet structure, good. Fifteen cm downstream from outlet transition is a 10 cm diameter hole near top of left panel with vegetation growing.
	- One-sixth sediment and vegetation.
2+520	Right CHO, good. Outlet structure, good.
2+630	Left CHO, good. Outlet structure has only headwall remaining and the ends are being undermined now. Needs rubble masonry to save headwall.

2+820	Vertical drop structure. There is a cavity on inlet side of each abutment. Small cavity on downstream left bank.
	- Small amount of sediment.
3+450	Bridge, good.
3+515	Drain culvert underneath lateral. Outlet structure, good. Inlet structure is nearly covered with water with an earthen dike in front to trap fish.
3+750	Right CHO, good. Outlet structure, good.
4+120	Roadway Culvert structure with gate. Culvert goes under Udon-Sakhon Nakhorn highway. Surface drainage problem from roadway on left side into lateral, which can be corrected by grading. Outlet structure is structurally good, but has small cavity at headwall.
4+200	Two CHO Regulators for Laterals R-7L-2L and R-7L-2R.
4+240	Drop structure with inlet gate and USBR VI. Inlet structure, good. There is a surface drainage problem with erosion just behind the headwall of the inlet structure, which has also resulted from water buffalo crossing here. First of all, the buffalo should be prevented from walking through here by installing a fence and forcing them to cross the lateral at 4+120. Then, backfill eroded area near inlet structure and sod. Outlet structure is good except for two large cavities on left bank of last panel in outlet transition.
4+260	Right panel is displaced and has a small hole at joint near floor. Left panel 3 m downstream has a small hole halfway up panel, because of cavity.
4+280	Right panel joint seeping water and sediment.
	- No sediment.
4+340	Cavity on right panel.
4+380	Huge cavity on right panel with displaced panels on both sides because of another cavity on left panel. Six m downstream the top part of left panel has broken off because of large cavity. Also, three cavities on right panel.
4+400	Nine m of lateral section missing with 6 m upstream and 6 m downstream with huge cavities. This problem has resulted from a parallel ditch only 6 m to right of right bank with buffalo wallow at this section. The right berm should be raised with a ditch overflow structure to carry excess water into lateral, otherwise ditch excess flow overtops right berm and runs behind lining, with eventual destruction of the lining.
4+440	Hole in right panel.
4+450	Cavity behind right panel.

~4+460	Cavities at two joints behind right panel.
~4+470	Small cavity at right panel joint.
~4+500	Large chunks of two left panels broken off.
~4+550	Joint on left panel has broken out (5 cm wide).
~4+560	Small cavity behind right panel.
	- One-sixth sediment and moss.
~4+600	One-third sediment.
4+950	Bridge. Large cavitites at right downstream and left upstream abutments. Concrete lining panels look good. Bridge structure is good.
5+000	Right CHO, good. Outlet structure is good structurally. Need more earth embankment on left side plus rubble masonry on left side.
	- Forty percent sediment and vegetation.
~5+250	One-third sediment.
~5+300	One-fourth sediment.
~5+400	Two cavitites behind right panel.
5+500	Left CHO, good. Outlet structure is good. Presently, fishermen are running water into this outlet structure.
	- One-fourth sediment and vegetation.
5+818	Bridge, very good. There is a surface drainage problem on right downstream abutment that does not affect lateral lining but could eventually result in damage to bridge wingwall.
	- One-fourth sediment and vegetation.
6+065	Overflow structure, good. Riprap has been placed at outlet floor and both abutments, which protects this structure very well from erosion.
6+065 to 6+120	Right berm is eroding. Some good soil backfill is needed plus sodding. Then, seed small barren areas on slope without disturbing the present vegetation. All work should be done by hand rather than using a machine.
6+120	Final CHO outlet, good. Large cavity behind right headwall. Outlet structure is structurally good. with a vertical crack on each side. Cavities behind right headwall and left panel. Undermining of both endwalls, so compacted backfill is required plus rubble masonry at endwalls.

<u>Sub-Lateral R-7L-1L (0.620 km)</u>

0+000	Left CHO Regulator is good structurally, but first gate frame needs some repair. Outlet structure is good.

- One-fourth sediment and vegetation.

0+300 Left CHO, good. Outlet structure is good except for left end panel, which needs some backfill plus rubble masonry at endwall.

0+310 Bridge, good.

- One-fourth sediment and vegetation.

0+340 Vertical Drop Structure, good.

0+350 Lateral completely filled with sediment because of erosion from animal crossing. Buffalo should be required to cross lateral at bridge.

- Lateral completely filled with sediment and water to final outlet structure.

0+620 Final CHO Outlet Structure with one gate. Inlet structure, good. Outlet structure is completely covered with water (good fish pond).

Sub-Lateral R-7L-1R (2.500 km)

From Tail End (2+500) to 0+000.
Road on Right Bank

2+500 Final CHO outlet. Inlet, good. Outlet structure, very good.

- Very little sediment.

~2+400 Cracks in two left panels.

2+150 Right CHO, good. Outlet structure is good. Some concrete should be placed on left endwall similar to that already done on right endwall.

2+000 Left overflow structure, good.

1+383 Bridge, good, except upstream railing has been knocked over.

- Very little sediment.

1+250 Right CHO good, except for cavity on upstream embankment. Outlet structure is good and is lined to division box 10 m downstream. Farm ditches constructed in 1980 look good.

0+800 Right CHO, good. Outlet structure is good, but could use riprap on left endwall.

0+150 Two drain culverts under lateral, good.

0+000 CHO Regulator, good. Outlet structure, good.

Lining on this lateral in excellent (Yiem) condition. Much of this is the result of having good surface drainage on both sides of lateral, with land on both sides commonly below invert elevation of lateral. This

does result in a problem for CHO Outlet structures because the drop in upstream elevation leaving the outlet would be too large and result in failure of the structure unless special measures are taken.

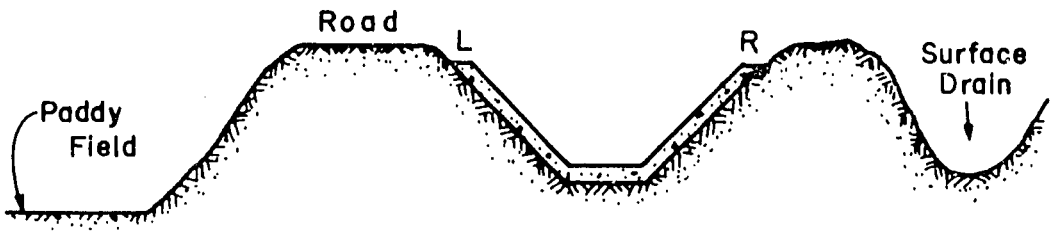
Sub-Lateral R-7L-2L (1.020 km)

0+000	CHO Regulator is structurally good. Cavities on both abutments. Outlet structure, good.
0+140	Right CHO, good. Outlet structure is good, but has jungle vegetation.
0+155	Inlet structure with gate for pipeline, good. Pipeline is 120 m long and has a manhole about every 13 m. Outlet structure is good.
	- One-third sediment.
0+300	Right CHO, good. Outlet structure, good.
0+350	Vertical drop structure is good.
	- Two-thirds sediment.
~3+90	Displaced left panel.
	Problem from 0+350 to 0+500 with surface drainage from left berm. This section should have a design and then construction to handle surface drainage.
0+500	Left overflow (wasteway) structure is good.
0+510	Drain underflow culvert structure is good.
0+600 to 1+020	Lateral completely full of sediment and water level is above lining. Completely covered with aquatic growth.
~0+700	Water in lateral is overflowing right panel and has eroded right embankment and roadway.
~0+800	Animal walkway has resulted in left panel being exposed with water behind panel.
1+020	Final CHO outlet structure is good structurally but first gate is missing. Outlet structure is good.

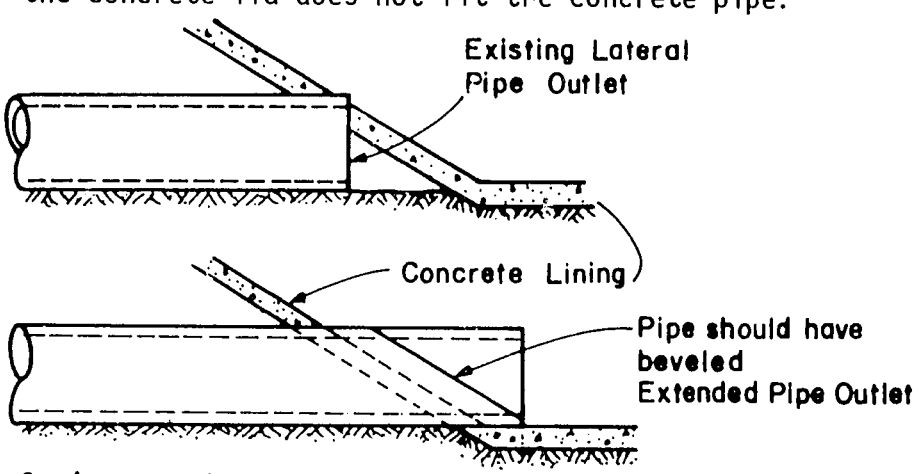
Sub-Lateral R-7L-2R (3.420 km)

0+000	CHO Regulator, good. Outlet structure, good. One-sixth sediment.
0+050	Left CHO, good. Outlet structure has headwall remaining, which is amazing because there is a 1.5 m drop from floor of outlet structure to floor of downstream channel.

0+080	Vertical drop structure is structurally good but there is a huge cavity on right abutment..
0+210	Drain Culvert under Lateral, good, both inlets and outlets (2). One-sixth sediment.
0+300 to 1+200	Lining looks very good in this area because land on both sides is lower than lateral.



1+250	Last month, a concrete pipe outlet was installed that has a circular concrete lid for a gate. Unfortunately, the concrete lid does not fit the concrete pipe.



~1+%00	Serious roadway erosion.
1+700	Left CHO, good. Outlet structure only has headwall remaining because the drop is too great, more than 1 m.
~2+000	Heavy surface drainage from right bank that has almost completely filled lateral with sediment.
	- Two-thirds sediment.
2+100	One-third sediment.
2+190	Bridge, good.
~2+300	Heavy surface drainage over right bank with lateral three-fourths full of sediment.
~2+350	One-half sediment.
2+400	Left CHO, good. Outlet structure is mostly intact except for last 20 cm of floor section. Heavily undermined because of deep scour hole. Water should not be

allowed through this CHO until this problem can be corrected. The scour hole should be backfilled and then rubble masonry installed for a length of 6 m, where a control sill should be constructed of rubble masonry with a crest elevation 5 cm below outlet floor elevation. Then, provide necessary rubble masonry to allow cascading of water to level of land below.

- One-fourth sediment.

2+420	Vertical Drop structure, good.
2+460	Heavy surface drainage from right berm has completely filled lateral with sediment.
2+540	Three-fourths sediment.
2+800	One-sixth sediment.
2+845	Bridge, good.
2+900	Left CHO with one gate, good. Outlet structure, good.

- One-fourth sediment.

3+000	Bridge, good.
3+080	Right overflow structure, good.
3+100	Drain culvert under lateral, good.
3+373	Bridge, good. No sediment.
3+420	Final CHO outlet structure, is structurally good. Cavity behind right wall. Much weed trash in CHO. Outlet structure is intact, but there is a huge cavity behind right panel and big cavity behind headwall and left panel. The berms on both sides should be cut down to level of top of concrete panels and sodded. Backfill behind panels and headwall and place rubble masonry at endwalls and provide for rubble masonry cascade of downstream channel bed.

The roadway along this lateral is not used by vehicles. As a consequence, there is good vegetation along roadway so that monsoon rains do not result in much erosion. The right berm has vegetation along most of its length, but design for surface drainage is needed.

Lateral R-8L (3.050 km)

From Tail End (Station 3+050) to RMC

3+050	Final CHO Outlet, good, except one concrete walkway panel needs to be installed. Outlet structure has a huge cavity on right side which has caused failure of right headwall and first right panel. Backfill needed plus diversion of surface drainage. Farmers ditches were constructred during 1982 dry season and look fairly good.

	- One-fourth sediment.
~2+850	Part of left panel broken off and should be repaired.
~2+800	Part of left panel broken off and should be repaired.
~2+740	Surface drainage from right bank.
2+700	Drop structure with inlet gate and USBR VI, good.
2+690	Displaced left panel, caused by grader. Upstream joint should be sealed.
2+655	Replace 6 m of right panel.
2+550	Replace 9 m of left panel.
2+500	Cavity on left bank.
~2+250	Surface drainage from left roadway.
	- One-sixth sediment.
2+175	Water seeping through floor of lining into lateral.
2+150 to 2+175	Many cavities on right bank. Water seeping into lateral from joints.
2+160	Nine m of left panel need to be replaced and surface drainage problem from left roadway corrected.
2+150	Vertical Drop Structure. At outlet, there is a cavity on the right bank and water seepage over the left panel.
2+000	Two CHO's, good. Outlet structures, good.
	- One-fifth sediment.
1+620	Drop Structure with inlet gate and USBR VI. Inlet structure has cavity on right bank and right wall displaced. Outlet has seepage from joint into lateral.
	- One-fourth sediment and aquatic growth.
	Met leader of this WUG and Sansonthi will open their meeting on December 5th at Temple Grounds of this village.
1+450	Two CHO's, good. Right outlet structure is okay, but cannot be seen because of large amounts of sediment. Left outlet structure is good except for cracks on left side.
	- One-fourth sediment and vegetation and aquatic growth.
1+300	Drop structure with gate inlet and USBR VI. Inlet structure, good. At outlet, there is a surface drainage problem from roadway into outlet structure. The road has a steep grade here because of high drop; consequently, special curbing with concrete chute is needed.
1+150	Right CHO, good. Outlet structure looks good, but heavy vegetaion growth and sediment.

1+000	Practically no sediment.
0+900	Drop structure with inlet gate and USBR VI. Inlet structure, good and outlet structure, good.
0+820	Horizontal crack two-thirds way up right panel with seepage.
0+815	Bridge, good.
	- One-fifth sediment and vegetation.
0+700	Left CHO, good. Outlet structure is good structurally, but filled with sediment.
	- One-fifth sediment.
0+500	Drop Structure with inlet gate and USBR VI. Inlet structure, good. Outlet structure, good.
0+495	Large cavity on right bank and two cavities on left bank.
0+400	Concrete spalling of right joint.
	- Very little sediment.
~0+200	Surface drainage from right bank.
~0+30	Spalling of concrete at right joint.
0+000	CHO Regulator, good. Outlet structure, good. There is a surface drainage problem from right bank that can be corrected by proper grading, plus culvert to left side of left roadway.

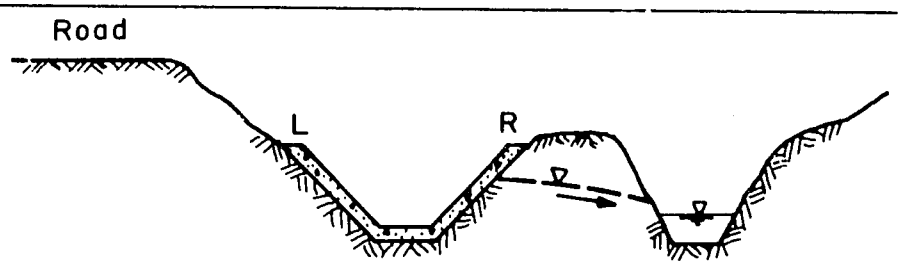
Lateral R-9L (2.655 km)

From Tail End to RMC

2+650	Final outlet structure is left CHO without gates. This structure is not used because it is too low to serve adjoining lands.
	- From 2+650 to 2+570 (CHO Regulator for Lateral R-9L-2L) is not used. There is extensive damage to the concrete lining because of extensive surface drainage into lateral. This problem does not need to be corrected unless this CHO is to be used in the future.
~2+560	Cavity in right panel. Big crack and displaced panel.
~2+500	Roadway laterite covering left panel.
~2+480	Double Surface Drain overflow structure to convey right bank surface drainage over lateral. This structure does not function, which has resulted in surface drainage under lining downstream from structure. Right bank upstream construction joint has failed on this structure and concrete wingwall fell into lateral and was removed by O&M.

~2+440 Large piece of concrete in right panel has failed and will eventually fall into lateral. Presently has groundwater inflow.

Need a surface drain on right side with bottom below top of concrete lining in order to lower groundwater levels, as well as intercept surface drainage.



Looking Downstream

- One-fourth sediment.
- Groundwater seeping through some joints.

~2+200 Three failed right panels because of surface drainage into lateral.

2+100 Village bridge. Four left panels have failed and two right panels displaced. Bridge railings near lateral road have been busted.

2+040 Left CHO, good. Outlet structure has right headwall and first right panel gone. Ditch and dyke construction did not repair this damage.

2+020 Left CHO with concrete walkway panels missing. Outlet structure is very good, but when they placed a farm inlet in left panel, the concrete around the inlet was not repaired. Ditch and dyke construction should have repaired, which was RID.

- One-third sediment to one-fourth sediment.

1+650 Concrete overflow structure, good.

1+640 Small holes in right panel.

1+630 Right concrete panel needs replacement.

- One-fourth to one-third sediment.

1+500 Left CHO, good. Outlet structure, very good.

1+480 Left CHO Regulator for Latear R-9L-1L.

From 1+480 (CHO Regulator for Lateral R-9L-1L) to RMC

1+500 Village bridge. The bridge abutments need some backfill plus some sod to prevent rainfall from seeping behind concrete panels.

1+380	Left CHO, good. Outlet structure, good.
1+150	Bridge, right panel cracked and cavities on both sides of right abutment.
1+100	Left CHO, good except concrete walkway panels missing. Outlet structure, good.
	- One-fifth sediment.
0+820	Bridge. Right abutment has cavities on both sides and failed right panel. Cavity on left downstream abutment.
0+800	Vertical drop structure, good.
	- One-fourth sediment.
0+680	Left CHO, good. Outlet structure, good.
	- One-sixth sediment.
~0+600	No sediment.
0+420	Floor uplifted in one panel. Observation wells should be placed on each side of lateral to observe groundwater levels in monsoon season and dry season. If water table is low during dry season, then install subsurface drainage. If groundwater table is high throughout year, then replace floor with weep holes.
0+411	Cavity at right joint.
0+390	Drop Structure with gate inlet and USBR VI. At exit of outlet transition structure, there is a hole in the lining on both panels just above the floor. [This is a common problem with these structures.] Inlet structure, good.
0+170	Left CHO, good. Outlet structure, good.
	- One-sixth sediment.
0+000	Double CHO Regulator, good.

Sub-Lateral R-9L-1L (1.180 km)

0+000	Left CHO Regulator, good. Outlet structure, good.
	- No sediment to 0+400.
0+400	One-third sediment and vegetation.
0+500	Right CHO, good, but one concrete walkway panel in lateral, apparently placed there by a farmer or fisherperson. Outlet structure, good.
0+530	Left concrete overflow structure, good.
0+550	Vertical Drop Structure. Steel guide on right rectangular check is missing. Cavitites on both abutments. Also, cavities on both left and right panels immediately upstream from structure. Six m downstream from structure is spalled right joint that should be repaired.

- One-third sediment and vegetation.

0+850	Left CHO, good. Outlet structure good, but needs some embankment on right side.
1+140	Left overflow structure, good.
1+180	Final CHO outlet, good, except frame on second gate is bent. Outlet structure, good. Fishermen take soil from bank for blocking water for fishing.

Sub-Lateral R-9L-2L (2.160 km)

2+112	Final outlet structure, gate frame torn from headwall and no gate. Small outlet structure, good.
2+108	Two CHO's, good. Left outlet structure has second panel on right seriously cracked and a large vertical crack in first right panel. Right outlet structure, good. Could remove sediment and vegetation.

- One-fourth sediment and vegetation.

~2+080	Cavity on right bank.
~2+045	Displaced right joint.

- Very little sediment, mostly laterite.

~1+900	Erosion of left bank for 4 m. About 10 m upstream is another 1 m of eroded right bank.
~1+750	Hole in left panel.
~1+600	Large hole in left panel with embankment underneath eroded.
~1+550	Spalled left joint.
1+400	Vertical drop structure, good.
1+300	Right CHO, good. Small outlet structure, good.
1+380	Left overflow structure, good structurally, but needs right embankment for outlet wall.
1+300	Left CHO, good. Outlet structure has headwall then 6 m of panels failed, mostly because of pond drainage into left bank. Also, the concrete in the bend is very thin, 1-2 cm. Constructed April 1982, as part of Ditch and Dyke construction. Actually, the outlet structure end panels may have failed in 1979, 1980 or 1981. Khun Charoon expected that the 6 m of end panels would have been replaced during the Ditch and Dyke Construction in April 1982.

- One-fourth sediment.

1+250	Right CHO, good. Small outlet structure is good. Downstream ditch about 60 m has farm inlet, which is presently draining paddy field and water running upstream into CHO.

	- One-third sediment.
1+002	Medium sized hole in left panel at joint.
	- No sediment, steeper slope.
0+500	Vertical drop structure, good. Small hole in lining on left bottom at outlet panel joint.
0+480	Two CHO's. Cavity on left CHO downstream embankment. Left outlet structure has headwall with cavity on right bank and remaining structure has failed. Downstream 10 m is lined bend as part of Ditch and Dyke construction in April 1982. Right CHO, good. Right outlet structure has failed with only concrete pipe outlet remaining.
	- One-sixth sediment to one-fourth sediment then one-half at 0+400 and then one-fourth at 0+350.
~0+250	One m of right panel gone and 8 m downstream is displaced joint and broken corner at top of lining on right panel.
~0+200	Large holes in both left and righ panels. Upstream 6-12 m two right panels need replacing and one left panel.
0+922	Large hole in left panel 2 m long.
0+000	CHO Regulator, good. Outlet structure, good except right joint at end of outlet is spalled and needs concrete repair.

Sub-Lateral R-9L-2L-1R (3.450 km)

Beginning at Tail End

3+485	Final CHO Outlet structure, good. Outlet structure is good, but there are cavities on both sides. Also, rubble masonry is needed at endwalls.
3+450	Heavy sediment load and grass vegetation to highway at station 1+689.
	- One-fourth to one-half sediment.
~2+800	Bridge, good.
2+750	Vertical drop structure, good.
~2+700	Right bank eroded for ~3 m.
~2+650	[Listed as 2+550, but either this structure or vertical drop structure at 2+750 are listed wrong.] Right CHO, good. Outlet structure has failed, including final length of concrete pipe. Cavity 1 m long on left bank opposite this CHO.
~2+400	Right berm [road on left] has erosion for 1 m, which should be corrected.
1+750	Right CHO, good. Outlet structure is fairly good, but cavities at headwall and right panel. Right end panel

	has lost embankment from erosion, which needs to be replaced and add rubble masonry.
1+689	Culvert structure under Udon-Sakhon Nakhorn highway. Inlet structure, good and outlet structure, good.
1+630	Right Wasteway Structure, good. This structure discharges into a drain, which is concrete lined for 600 m. This drain needs rubble masonry at end of lining to prevent undermining of end panels.
1+570	Left CHO, with cavities on both sides. Gates, good. Outlet structure has cavities on both sides and needs rubble masonry at endwalls.
	- One-third sediment and vegetation, also one-half sediment to ~1+200.
1+100	Vertical drop structure, good.
1+080	Two CHO's, good except for second gate on right. CHO does not have a sufficient width. Pipeline looks very good and concrete outlet structure looks very good, but two cavities at headwall. Left outlet structure has failed, only pipe outlet remains.
1+060	Drain culvert, good except right abutment on drain outlet needs some backfill, otherwise the right embankment will eventually erode away.
~1+000	One-fourth sediment.
~0+900	Road embankment erosion.
~0+800	No sediment because of steep slope of lateral.
~0+150	Large cavity on left bank.
0+000	CHO Regulator, good. Outlet structure, good. [Same as 1+370 on Lateral R-9L-2L.]

Lateral R-10L (1.100 km)

0+000	CHO Regulator, good. Outlet structure, good.
~0+350	Holes in right panels have previously been repaired.
	- Some sediment.
0+494 to 0+515	Damaged left panels that should be replaced.
~0+600	Thirty-six m of left panel needs to be replaced.
~0+700	Fifteen m of lateral section should be replaced.
~0+800	Twelve m of lateral left panel and 6 m of right panel need to be replaced.
~0+900	Right panel needs replacement.
~0+910	Right panel needs replacement.
~1+050	Displaced panel that needs cement in joint.

1+115	Final CHO Outlet, first gate needs repair. Outlet structure, good. Farmers ditches were constructed in 1982, and they look relatively good.
	0+500 to 1+000 needs lateral lining repair and replacement. 30 November 1982 - Needs right berm open drain from 0+000 to 1+115. Roadway encroaches on lateral and should be sloped flatter between lateral and road.

Lateral R-11L (4.800 km)

From End (4.800 km) to RMC

4+800	Final CHO outlet with only one gate, good. Outlet structure has final left panel ready to fail. Needs embankment this dry season to save this panel.
	- One-fourth sediment plus vegetation.
4+600	Canal overflow structure, good.
	- One-third sediment and vegetation.
	- One-half sediment and vegetation.
~4+440	Much of lining between here and drop structure at 4+320 is covered with sediment plus much vegetation. Must be cleaned out.
	- Three-fourths sediment.
	- Full of sediment, cannot see lining.
4+320	Drop structure with inlet gate and USBR VI. This gate was closed by farmers and water overflowed right bank and caused serious erosion, which filled this lateral downstream. About 3 m of right panel is completely exposed. Huge job of reconstruction.
4+300	Left CHO, good. Outlet structure has mostly failed. Needs lots of work to correct. Huge eroded and ponded area beyond because flow must make a 90° turn to the right. The ditch beyond, constructed by farmers, needs much improvement.
4+290	Right CHO and outlet structure in excellent condition.
4+280	Large cavity on right bank.
	- Little sediment (practically none).
3+980	Culvert under Udon-Sakhon Nakhorn Highway. Outlet, good. Inlet structure with gate has cavity on right embankment.
	- Some sediment in lateral.
3+430	Bridge, with cavities on embankments and some cracking.

	surface drainage will run off left bank of roadway. Road is left of lateral.
0+000	Double CHO Regulator. Small cavity on upstream bank. Outlet structure has some sediment that should be removed.

Sub-Lateral R-11L-1L (1.500 km)

0+000	CHO Regulator, good.
	- Some laterite.
	- One-fourth sediment and vegetation.
0+440	Left CHO, with serious embankment failure that might have been caused by leaky joint in outlet pipe. [Requires immediate attention.] Outlet structure is half failed.
	- One-fourth sediment and vegetation.
0+520	Vertical drop structure, good.
~0+560	Two left panels displaced by grader. As a minimum, should seal joints, or replace.
	- One-third sediment and vegetation.
~0+880	Three left panels, damaged by grader, should be replaced.
	- One-half sediment and vegetation.
~0+910 to 0+954	Fifty-four m of left panel needs to be replaced.
0+930	Right CHO, good. Outlet structure needs some backfill and riprapping on right endwall.
1+020	Vertical drop structure, good.
	- One-third sediment. One-half sediment with much laterite in lateral.
1+450	Cracked panels.
1+470	Wasteway, good.
1+500	Final Outlet structure, with gate missing, which has not been installed to date. Outlet structure, good.

Sub-Lateral R-11L-2L (4.500 km)

4+500	Final CHO Outlet, good, except handle on second gate is broken. Outlet structure, good, except no riprap at end of concrete basin, and there is some undermining of ends.
	- Practically no sediment and very little vegetation.
~4+400	Four panels on left bank need to be replaced.
~4+300	Two right panels with serious cracks and displacement. Probably resulted from poor compaction of right bank.

3+400	Two CHO's, good. Left outlet structure, excellent. Right outlet structure has mostly failed, but this structure should receive immediate attention to salvage the headwall, which requires heavy riprapping of floor and headwalls.
	- Little sediment.
3+200	Laterite in lateral, one-sixth full.
2+600	Vertical drop structure. Small holes in floor corners at exit of this structure.
2+590	Right CHO, good. At concrete pipe outlet, farmers have constructed concrete pipeline to convey water to rice paddies.
2+520	Left CHO, good. Outlet structure has completely failed including one concrete joint upstream from headwalls.
	- Some sediment and some aquatic growth.
~2+200	Cavity at left joint.
2+100	Right CHO, good. Outlet concrete pipe has concrete pipeline across wasteway. [This use of a pipeline has been good because the standard concrete outlet structure would have failed.]
2+060	Right wasteway, good.
	- Some sediment.
1+452	Drop structure with gate, good, except two concrete walkway bars have partly given way. USBR VI outlet structure, good.
1+440	Left CHO, good. Outlet structure has failed, except for headwall. Riprapping would save remaining structure.
	From Headgate Regulator for Lateral R-11L-1L to RMC
1+080	Right CHO, good. Outlet structure, good.
~1+050	Cracked right panel.
0+870	Right CHO, good. Outlet structure, good, except needs rubble masonry at endwalls.
0+830	Bridge. Large cavity on right upstream bank.
0+685	Two spalled left joints with cavities.
0+470	Cracked right panel.
0+440	Drop structure with gate and USBR VI. Final outlet panels have cavities. Final right panel will eventually fail in another 1-2 years. Inlet structure, good.
	- Small amount of sediment.
~0+300	Displaced joint.
0+085	Drop structure with inlet gate removed for repair. Outlet USBR VI, good. Needs road grading so lateral

~4+150	Bridge (not on list). Upstream rail broken off.
4+100	Two CHO's. Left CHO needs repair of first gate. Right outlet has large cavities behind headwall, rest of concrete structure, good. Left outlet structure, good.
4+050	Right wasteway, good.
~3+700	Three left panels need replacement. Damage was done by road grader. About 20 m upstream, there are two more left panels that need replacement, resulting from damage by grader.
	- Practically no sediment.
~3+600	Four left panels need replacement, resulting from grader damage.
~3+580	Bridge (not on list). Upstream right bank has cavity. Five m upstream the right panel has many cracks, needs repair.
~3+520	Three ~4 in. bamboo drains into lateral from paddy field.
3+500	Vertical drop structure, good.
3+450	Two CHO's, good. Right outlet has failed, with only the headwall remaining, but right headwall has huge cavity and will soon fail. Same with left outlet.
	- Right berm (road on left) could be graded to have more surface drainage away from lateral.
~3+340	Head Regulator for Sub-Lateral R-11L-2L-2L.
3+300	Two CHO's, good. Both outlet structures have right headwall okay, but rest of structure has failed, including left headwall.
3+250	Bridge, good, except for small cavity on right upstream embankment, where there is a small cavity that has resulted in a cracked panel under the bridge.
	This lateral was cleaned last month. The sediment was placed on right berm, but this sediment should be placed on right abutment.
~3+100	Three left panels have settled and left side of floor raised. The only thing that needs to be done now is to seal the joints at the ends of the three panels. Berm on right side needs shaping so loose earth cannot run into lateral from precipitation.
~3+000	Crew removing sediment but sediment is just heaped on right berm. As a consequence: (1) much of this sediment will be washed back into the sub-lateral during the next monsoon season; and (2) much of the berm vegetation will be destroyed.

2+700	Right CHO, good. Outlet structure has failed except for headwall, which has a cavity on left side. Should place rubble masonry at end of floor outlet to prevent further failure of this structure.
2+650	Small right canal overflow structure, good.
2+640	Bridge. Small cavities at all four abutments. Panels cracked.
~2+600	Badly cracked right panel that should be replaced.
2+200	Check structure, no drop, good.

From Head Regulator for R-11L-2L-1R to beginning of Regulator for R-11L-2L

- Sediment recently removed.

1+730	Two CHO's, good. Left outlet structure has two cavities on right side plus needs backfill at endwall and more embankment needed along left side. Cavity on left headwall.
1+710	CHO Regulator for R-11L-2L-1L.
1+600	Bridge, no cavities, but cracked panels. Cracked panels on right.
1+425	Culvert under Udon-Sakhon Nakhorn highway. Outlet, good. Inlet has concrete spalling at start of drop; this joint should be sealed.
~1+325	Top joint on right side needs repair.
1+300	Left CHO, good. Outlet structure, good.
~1+200	Three panels on left side need replacement. Thickness is 5 cm.
~1+150	Small cavity in left joint.
~1+120	Two left panels need replacement.
~1+100	Bridge, no cavities, good.
~1+000	Bad hole in right joint.
~0+900	Cavity on left joint.
~0+850	Cavity on right bank at joint.
~0+300	Two big cavities on left bank with one joint displaced ~5 cm.
0+200	Drop structure with gate and USBR VI. Cavity on right wall of inlet structure. Cavity on left wall of outlet structure.
0+100	Left CHO, good. Outlet structure, good.
0+000	Double CHO Head Regulator, good. Outlet structure, good.

Sub-Lateral R-11L-2L-1R (2.300 km)

0+000	Right CHO Regulator, good. Outlet structure, good.
~0+100	Bridge, top rail bent over on both sides. No cavities.
	- Some sediment.
~0+500	One right panel destroyed, needs replacement. Damage by grader.
	- Some sediment, mostly laterite.
	- One-fourth sediment and one-third sediment.
	- Lining good, but tremendous amount of laterite covering lining for approximately 30 m.
	- One-third sediment, mostly from road on right. At least 500 m from ~0+700 to 1+200 where road laterite covers right panels of lateral. Remove sediment and sod.
1+253	Roadway culvert without gate, good.
1+400	Two CHO's, good. Left outlet structure has completely failed except for outlet rectangular pipe. Right outlet structure fairly good, but needs additional embankment near endwalls.
1+450	Small drop structure with gate, good. USBR VI (smallest live ever seen) is good. Downstream channel half full of sediment for 15 m, then one-third full.
1+600	Right CHO, with second gate needing repair. Outlet structure, good.
	- One-third sediment.
~1+800	Bridge, good, except for downstream railing bent over.
	- Still much roadway laterite covering many right panels.
~2+100	Cracked right panel and spalled left joint.
	- Right roadway is much too high.
2+300	Final CHO outlet structure with first gate missing (but not gate frame and handle) and second gate completely missing. Outlet structure, good.

Reconstruct roadway to make it lower. Remove sediment from lateral. Shape roadway and sod berm between road and lateral.

Khun Charoon says that O&M will have to correct these problems, rather than being reconstructed by Construction Division.

Sub-Lateral R-11L-2L-1L (2.900 km)

0+000	CHO Regulator. One small cavity on each side of CHO. Outlet structure, good. One-third sediment and some vegetation.
	- One-third to one-fourth.
0+400	Right CHO, good. Outlet structure has failed. Soon the culvert pipe will fail because already there is a leaky joint. Erosion back to nearly half of roadway width.
0+450	Cracked left panel.
	- Little sediment.
0+618	Bridge. Cavities on two abutments, no panel cracks.
	- Two cracked panels on left and two on right.
0+903	Bridge. Large cavities at both right abutments.
1+011	Bridge. Large cavity on right downstream bank.
1+165	Culvert structure with inlet gate, good. Outlet USBR VI, good.
~1+300	Cavities along right bank. Three right panels have been displaced and need repair. There is a surface drainage problem on left bank from 1+165 to 1+470. Place culvert underneath lateral.
1+470	Two CHO's, one cavity on right CHO and two cavities on left CHO. Left outlet structure has a few cavities, but in good shape. Right outlet structure has cavities and large cracks and needs riprap at endwalls (rubble masonry).
	- Sediment and vegetation, one-third.
2+280	Left wasteway, good.
2+300	Drain culvert under lateral, good.
	- One-fourth sediment and vegetation.
2+700	Two CHO's, big cavity on both sides of left CHO. Right outlet structure has last 15 cm of floor lining gone and end panels need rubble masonry. Left outlet structure has completely failed back to CHO. Should consider not using left CHO until on-farm facilities are constructed.
	- One-third sediment and vegetation.
2+900	Final CHO outlet, inlet good Outlet structure is very good but there are two small cavities behind headwall.

Sub-Lateral R-11L-2L-2L (2.100 km)

0+000	Head regulator, (CHO), good. Outlet structure, good.
	- One-fourth full of sediment.
	- One left joint with spalling, needs repair.

Sub-Lateral R-11L-2L-1L (2.900 km)

0+000	CHO Regulator. One small cavity on each side of CHO. Outlet structure, good. One-third sediment and some vegetation.
	- One-third to one-fourth.
0+400	Right CHO, good. Outlet structure has failed. Soon the culvert pipe will fail because already there is a leaky joint. Erosion back to nearly half of roadway width.
0+450	Cracked left panel.
	- Little sediment.
0+618	Bridge. Cavities on two abutments, no panel cracks.
	- Two cracked panels on left and two on right.
0+903	Bridge. Large cavities at both right abutments.
1+011	Bridge. Large cavity on right downstream bank.
1+165	Culvert structure with inlet gate, good. Outlet USBR VI, good.
~1+300	Cavities along right bank. Three right panels have been displaced and need repair. There is a surface drainage problem on left bank from 1+165 to 1+470. Place culvert underneath lateral.
1+470	Two CHO's, one cavity on right CHO and two cavities on left CHO. Left outlet structure has a few cavities, but in good shape. Right outlet structure has cavities and large cracks and needs riprap at endwalls (rubble masonry).
	- Sediment and vegetation, one-third.
2+280	Left wasteway, good.
2+300	Drain culvert under lateral, good.
	- One-fourth sediment and vegetation.
2+700	Two CHO's, big cavity on both sides of left CHO. Right outlet structure has last 15 cm of floor lining gone and end panels need rubble masonry. Left outlet structure has completely failed back to CHO. Should consider not using left CHO until on-farm facilities are constructed.
	- One-third sediment and vegetation.
2+900	Final CHO outlet, inlet good. Outlet structure is very good but there are two small cavities behind headwall.

Sub-Lateral R-11L-2L-2L (2.100 km)

0+000	Head regulator, (CHO), good. Outlet structure, good.
	- One-fourth full of sediment.
	- One left joint with spalling, needs repair.

0+626	Two CHO's. Right CHO is Head Regulator for R-12L-1R. Left CHO, good. Outlet, good, but needs riprap at endwalls.
0+650	Right CHO, good. Outlet, good. Needs a little better riprapping on right endwall.
0+800	Final CHO Regulator, good. Outlet structure, good. First panel on left has big crack.
0+820	Begin on-farm unlined channel. Road cannot be used by Land Rover because of rains.
~1+000	Check drop structure has undermining of end panels, which need compacted backfill and riprap. Check structure, good.
	- Depth from roadway to earth channel invert is too little.
	- Concrete lining at bends.
	- Farm inlet structure usually does not have a gate, but in some cases there is a wood gate. Saw one circular shell used for gate, but it would have to leak a lot.
	- Looks good, but this is the first season of use, no maintenance to date.

Sub-Lateral R-12L-1R (3.700 km)

0+000	Head Regulator and outlet, good.
	- -y = 0.05 ymax·
~0+550	Right panel with top heavily damaged.
	- No aquatic growth or sediment.
~0+800	Bridge, downstream bridge rail knocked over.
0+095 to 1+000	Gravel and sediment in lateral, not bad, but should be removed.
1+000 to 2+000	Rocks in lateral. Some laterite from roadway [road on left].
1+300	CHO, Farm TO, very good.
1+310	Culvert structure, good. Ten m downstream from culvert is much sediment, half full.
1+400	Two CHO's. Second gates have friction stem only. Left outlet structure needs cavity filled on left side and riprap on left end. Right outlet structure, good.
	- Half full of sediment.
~1+500	Two panels missing.
1+750	Drain culvert, good.
	- One-fourth full of sediment.
2+100	Right CHO, good; outlet, good.

2+120	Left lining is covered with earth. [Should remove earth for 8 m.]
2+150	Vertical check drop structure, good.
~2+400	Lateral changes grade, becomes flatter, and enlarged; sediment in bottom.
~2+692	Head Regulator CHO for Sub-Lateral R-12L-1R-1L.
2+700	Right panel covered with soil.
2+820	Right wasteway, 2x usual crest, good.
2+858	Roadway culvert under Udon-Sakhon Nakhorn highway, good. Outlet, good. Sediment downstream one-third full.
	- Good vegetation cover on banks.
	- One-fourth to one-third full of sediment.
3+700	CHO Final Outlet structure, second gate has friction stem. Outlet has lined section for 63 m plus 5 m long culvert, then on-farm channels.
On-Farm	Right outlet after culvert has serious erosion about 4 m downstream for 10 m. Earth channel looks okay.
On-Farm	Left Outlet. Road drainage into earth channel. Many inlet gates have straw. Good concrete at culverts and bends. Crab holes about one-fourth to one-half way up earth bank.

Sub-Lateral R-12L-1R-1L (1.230 km)

0+000	CHO Regulator, good. Outlet structure, good.
	- One-half sediment.
0+073	Village highway bridge, good.
	- y = 0.1 ymax
	- One-fourth sediment.
0+250	Surface drainage overchute, good.
0+370	Left CHO, good. Outlet with right turn bend in concrete, good.
0+380	Earth over right panel.
	- One-third sediment.
	- Road needs improvement.
0+640	Bridge, good.
0+770	Inlet Culvert structure for under main highway, Udon-Sakhon Nakhorn, good.
	- One-third sediment.
	- One-half sediment.
0+850	Left CHO, good. Outlet structure, good, but full of sediment. On-farm system okay, but channel very small.

1+000	One-fourth sediment.
1+060	Left CHO, with one gate, good. Outlet structure has no concrete basin, only riprapped headwall, but looks good.
	- One-third sediment.
1+230	Final CHO Outlet structure, good. Outlet structure, good.
On-Farm	Road drainage into channel. On-farm channels are fine for first year of operation.

Lateral R-13L (3.720 km)

0+000	CHO Regulator, good.
	- y = 0.6 ymax
0+800	Left Wasteway looks good. Could not inspect concrete pipe outlet, but the invert is at least 30 cm above the ground surface.
0+915	Right CHO, good. Outlet structure concrete is very good, but end panels are partially undermined, so riprapping is required. Recommend rubble masonry.
0+940	CHO for Lateral R-13L-1R.
0+980	Left CHO, good.

Downstream End (3+720) to 1+000

3+750	End of lining.
3+700	Final outlet structure without gate. Outlet structure is about 60-70 cm above downstream water system elevation. Could provide more riprap to protect against undermining.
	- Considerable sediment and grass vegetation to drop structure.
3+490	Drop structure with USBR VI. Concrete and lining is good, but half-filled with sediment and vegetation. Inlet structure has gate removed, for repair.
	- Sediment and vegetation to next structure; needs maintenance badly.
~3+250	Pile of laterite on right bank with much going into lateral.
	- Sediment 3-5 cm deep and some places 10 cm.
2+850	Vertical drop structure, good.
2+787 to 2+799	Channel destroyed and must be replaced.
2+766 to 2+702	Lining destroyed by RID cranes slipping into channel. Must replace panels.
2+700	Right CHO, second gate covered with laterite pile and gate stem bent. Outlet structure destroyed.

2+675	Culvert structure without gate. Good structurally, but trash and weeds should be removed.
	- No water, no sediment.
	- Road needs grading badly.
2+100	Drop structure with culvert at outlet, cavity on left side. Inlet has been covered with laterite to backup water.
2+080	$y = y_{max}$ (i.e., lateral is full of water).
1+900	Two CHO's, okay. Outlet structure on right almost full of water, but okay. Left outlet is submerged.
1+870	Left wasteway, okay.
1+823	Culvert structure with gate. At inlet to broken plane transition, left panel needs some repair.
1+750	Left CHO, okay. Outlet, okay.
~1+400	Displaced right panel that must be replaced.
~1+400	Cavities on both left and right banks.
~1+380	Right panel to be replaced.
1+300	Drop structure with gate and USBR VI, okay.
	- $y = 0.6\ y_{max}$.
1+050	Two CHO's, good. Right outlet structure, good. Left outlet structure has one cavity on left side and needs riprap at endwalls.
1+035	CHO Head Regulator for Lateral R-13L-1L.

Sub-Lateral R-13L-1L (0.760 km)

0+000	CHO on left is good.
	- Very little water, with moss.
~0+100	Big cavity on right bank.
	- Very good condition, no sediment or aquatic growth, only moss.
0+760	End of lining, then much sediment.

Sub-Lateral R-13L-1R (3.050 km)

0+000 to 1+000	
0+000	CHO Regulator, good. Outlet, good. The locks are not on the two CHO gates.
	- $y = 0.5\ y_{max}$, clear water.
~0+500	Cavity behind left panel.
~0+600	Cavity behind left panel.
0+710	Culvert structure without gate, good.
0+750	Right wasteway, good, except slide gate has a flat steel stem that must be pulled up. Concrete outlet looks good, is 80 percent covered with water.

0+770 Two CHO's good, except for cavity on right downstream abutment. Left outlet structure basin is 90 percent gone. Farmers may have purposely destroyed, because there is a small culvert near right headwall for diversion to paddy. Right outlet structure, good.

0+870 Right CHO, good. Outlet structure basin has failed because there is ~10 cm drop from outlet invert to downstream water surface.

0+920 Vertical drop structure, good.

- Clear water, no sediment in lateral.

1+050 Approximately four cavities on left bank.

1+800 Right CHO, good. Outlet structure, most of the basin walls (~75 percent) have failed. The farmer(s) have constructed an earth ditch (≤ 30 lps) about 250-300 m long for irrigating fields. Looks good, could use some sediment removal and cutting of vegetation, but not essential.

~1+850 Roadway drainage problems.

- y = 0.7 ymax

2+230 Left CHO, good. Outlet structure in-place, but bad breakoff on left side. Needs rubble masonry and immediate attention.

- Sediment and aquatic growth.

2+510 Culvert structure without gate, good.

2+580 Two CHO's, good. Left outlet structure, very good, because there is a small culvert ~8 m downstream that controls water system elevation. Right outlet structure is missing half of basin, but there is very little drop (~1 cm). Preventive maintenance would have prevented failure.

2+650 Pipe drop structure with gate, good, except 1 m downstream from gate there is a huge cavity and embankment over pipe has failed. Outlet structure, USBR VI, good, but fishermen have removed riprap for damming water 1-3 m downstream. Downstream channel heavily covered with sediment. Perhaps drop pipe has failed, causing cavity and failed embankment. Check pipe, then excavate soil and backfill with compacted soil, and provide surface drainage.

3+000 Right wasteway, good. Outlet, good. Has good rubble masonry on right bank, but not left bank. Only need to place rubble masonry on left bank if erosion problem occurs.

- No sediment or aquatic growth.

3+020 CHO Final Outlet structure. Outlet structure is very good, but this structure would have failed if it had not had riprap properly placed at endwalls, because drop is ~15-20 cm.

Lateral R-14L (1.300 km)

0+000	Head Regulator. No cavities both sides, very good structure. The gates are good, needs some soil to compact at back headwall. Broken plane outlet transition is good.
	- One-eighth sediment.
0+440	Drain culvert, good condition.
0+520	Drop Structure. Upstream structure or inlet structure is good, no cavities. First gate is broken. Outlet structure is stilling basin VI, which is very good. Has cracks at panel joints on both sides.
0+530	Some sediment (practically none).
0+800	Right CHO. No cavities both sides. Gates are in good condition. Outlet stilling basin is good but has scouring at the end. Need some riprap at the end. Filled with sediment and vegetation.
	- One-tenth sediment.
0+900	Drop structure. Inlet and outlet stilling basin VI are in good condition. Many gaps between the joints but no leaking because of the method of construction.
	- One-eighth sediment.
1+300	Roadway culvert is in good condition. On-farm ditches continue on carrying water to pilot area.
	- Right road and left bank are in good condition.

Lateral R-15L (3.700 km)

0+000	Head Regulator. No cavities both sides. Gates are good. Outlet structure is good; no cavities, but some sediment should be removed.
0+400	Drop structure. Inlet structure and outlet structure are good, but there is a small cavity on left side of outlet structure. Leaking at first panel of the right side.
0+625	Roadway culvert, everything is good.
	- One-eighth sediment.
1+000	Right CHO. No cavities both sides. Outlet basin good, but have to fill soil both sides and have scouring at the end. Should place some rubble masonry at the end.
1+250	Drain culvert is very good structure.
1+570	Right CHO. No cavities both sides, needs some riprap at the end.
1+600	Left CHO. Everything is good.
1+800	Right CHO. No cavities both sides. Outlet basin has some cracks at headwall. Scouring at the end (need riprap).

1+900	Drop structure is in good condition.
	- One-eighth sediment.
2+095	Drain culvert is in good condition.
2+110	Wasteway, gate is missing. The end of outlet is scouring seriously, which should be repaired soon.
	- One-eighth sediment.
	This canal, left bank and right road are in very good condition.
2+454 to 2+500	The right of the road is eroded but not seriously.
2+680	Left CHO. No cavities. Outlet basin needs some riprap at the end because of scouring. One-eighth sediment.
2+690	The right of the road was eroded but not seriously.
3+160	Right CHO has no cavities; outlet basin, good, but have to protect scouring at the end. Left CHO has no cavities; outlet basin, good, but scouring at the end, too.
3+190	The right bank of roadway is eroded.
3+200	Drop structure, first gate missing. Inlet and outlet are good.
	- One-sixth sediment.
3+500	Right CHO. Gates are good. Outlet structure is good.
3+680	Left CHO has cavities both sides. Gates are good. Outlet is good.
3+700	Tail Regulator. No cavities at inlet structure. Gate has no hand wheel. Outlet has only headwall and has no outlet basin because of serious scouring.

Lateral R-16L (9.500 km)

0+000	CHO Regulator, good.
	- Roadway on right good.
0+032	Cracked lining on top of right panel.
0+050	Road drainage into lateral.
	- Leakage from joint in left panel.
0+060	Serious road drainage into lateral. Many places where surface road and left embankment drainage are flowing into lateral, as well as through joints. Road needs grading.
0+150	Surface drainage into cavity underneath panel. Much surface drainage into lateral.
~0+603	Drop and Culvert Structure. Entrance to inlet has hole in bottom of left panel. Downstream of USBR VI 2-3

	panels on left with serious holes in bottom of lining. Another 10-20 panels downstream are two left panels with holes, repair. Cracked panel ~0+900. Aquatic growth. Much sediment.
1+000 to 1+500	Surface drainage into lateral. Much surface drainage, joint leakage and aquatic growth.
1+500 to 2+500	Six panels on left with minor cracks.
1+700	CHO, good. Outlet structure, could use minor maintenance by placing rubble masonry against end of panels.
2+150	CHO has serious undermining on right abutment and outlet structure panels have failed; cavity in headwall.
~2+250	Cracked left panel.
2+500 to 3+000	
2+503	Two CHO's, good, with both outlet structures fair. Need to replace riprap against outlet panel and probably mortar into place so people can't move rocks.
~2+700	Right embankment of road experiencing serious erosion. Surface drainage into lateral. Much sediment and aquatic growth. Hairline cracks in panels (~8).
3+000 to 3+500	
~3+200	Eroded concrete at joint.
~3+300	Displaced joint on right.
3+400	Right CHO, good. Outlet structure very good except for road drainage over headwall.
3+440	CHO on left bank looks like it is not used.
3+480	Two surface drainage locations into lateral.
3+500 to 4+000	Many leaking joints.
	- Hairline crack on left panel.
3+822	Culvert structure with gate. One hole near inlet that should be repaired. Panel downstream from culvert broken-plane transition has a 10-cm and a 20 cm hole that <u>badly</u> needs repair. Measured thickness of lining was 3½ cm. The holes have moss, which indicated that water is always leaking here. Constructed January 1981.
4+000 to 4+500	
4+015	CHO, good. Outlet good. Looks like it is not used because no agriculture land nearby. Three right panels with hairline cracks.
~4+300	Right panel with crack.
4+375	CHO for Sub-Lateral R-16L-1L looks good.
4+400	CHO, good. Outlet, good. Not used. Aquatic growth.
4+500 to 5+000	Lateral half full of water. Aquatic growth.

5+000 to 6+000	
5+100	CHO, good. Outlet, good. Not used.
5+510	Drop structure with gate inlet and USBR VI, looks very good. Constructed January 15, 1981.
5+650	CHO, good. Outlet, good. Not used. Right panel 3 m downstream is badly damaged. Can be repaired.
~5+850	Right panel with bad hole at joint.
~5+800	Left panel with hole.
5+957	Bridge, good. Sediment. Aquatic growth. Right berm looks good.
6+000 to 7+000	Very good right berm.
6+592	Culvert structure looks good. Hairline crack on first right panel downstream.
6+640	CHO, good. Outlet, good. Some use.
~6+900	Small hole in right panel.
7+000 to 8+000	
~7+100	Roadway erosion.
7+190	Bridge, good. Surface drainage into lateral but no signs of erosion.
7+520	Culvert structure, good, but half full of water, so could not see lower half of lining. Surface drainage without erosion. Aquatic growth fairly heavy. Two leaking joints.
7+680	CHO, good. Outlet structure failed with serious bank erosion, including roadway erosion.
	- Aquatic growth.
8+000 to 9+000	
8+100	Canal overflow with single gate [very good type of structure]. Downstream two panels with cracks near top. Upstream two panels on both sides with cracks. Outlet culvert with concrete chute experiencing serious undermining under floor and two holes on left side. [In one more year, about 5 m of length will give way.] Continual lateral gate leaking is reflected by moss in chute.
	- Minor roadway erosion, which will get worse with time.
8+300	Three right panels with hairline cracks.
8+515	Head Regulator for Sub-Lateral R-16L-3R.
8+530	Large bridge, good.
8+700	CHO on left bank, good. Outlet, good.
8+800	Culvert structure, very good.
8+975	CHO on left bank, good. Floor of outlet structure has failed, but walls are in surprising good shape.
	- Sediment, water and aquatic growth.

9+000 to 9+485 (end)

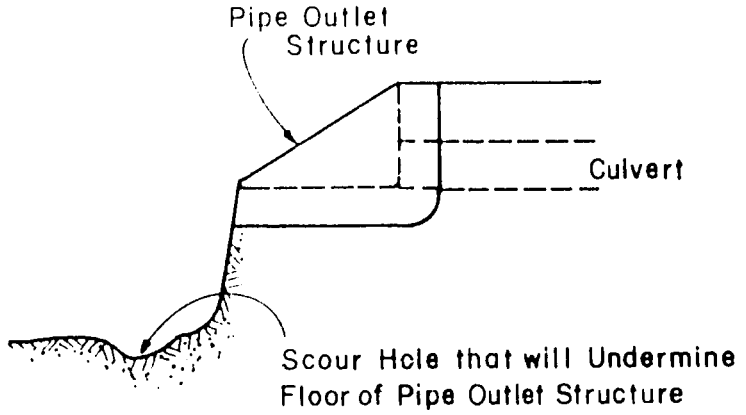
9+070	Bridge, good.
9+170	Some erosion in joint.
9+200	Left CHO, good. Outlet, good.
9+480	Left bank CHO with one gate. Outlet without basin walls.
9+485	Outlet CHO, good. Outlet structure is good.

Sub-Lateral R-16L-1L (2.068 km)

CHO Regulator located at Station 4+375 on Lateral R-16L

- Many joints on left side flowing water. Roadway on left. Berm on right, very good.

0+363	Culvert without gate, good.
0+450	Left CHO, good. Outlet, good, but needs riprap at end of walls.
0+750	Vertical drop structure, good.
1+010	Drain culvert underneath lateral. Looks very good. Outlet structure could use some touchup on riprap at end of left wall.
1+250	Left CHO, good. Outlet, good. Could use a little touchup on riprap at end of outlet basin walls.
1+490	Vertical drop structure, good.
1+505	Hole in left panel.
1+508	Leaking left joint.
~1+530	Big hole in right panel.
1+650	Left CHO, good. Outlet, good, but could use riprap touchup. Right berm very good.
1+840	Left CHO, with one gate, good. Outlet structure did not have concrete basin, only riprap.



Needs ripraping of floor and walls 0-5 m downstream from this outlet. Should mortar rocks.

2+018	Final outlet structure, good. Outlet structure, good, except end walls are being undermined. Needs better riprapping of end walls.

Sub-Lateral R-16L-1R (5.000 km)

0+000 to 1+000	Outlet Regulator Structure, good. Small amount of aquatic growth.
~0+100	Right panels with hairline crack near top.
~0+250	Small surface drainage into lateral.
0+400	Small surface drainage into lateral.
0+600	Small surface drainage into lateral.
0+800	Small surface drainage into lateral.
0+880	Right CHO. Small cavity on left abutment. Outlet structure with severe cracking, hole in headwall, and end panels being undermined. Needs corrective action now. [Concrete repair, compacted soil under end panels, riprap and raise downstream water level.]
0+890	Culvert structure with gate. Inlet floor concrete is being eroded. Roadway erosion. Culvert outlet structure, good. Sixth and eighth panels downstream have joint leakage on both sides.
0+950	Left CHO, good. Outlet structure, good, except needs riprapping with mortar because farmers have moved riprap.
	- Aquatic growth.
1+000 to 2+000	Road drainage problem into lateral.
1+200	Left CHO, good. Outlet structure, good. A few minor locations with roadway erosion into lateral.
1+600	One cracked panel on right.
1+912	Culvert structure with gate that has lock undone. Outlet structure USBR VI with cavities on both sides. Leaking joints downstream, many. Only small amount of water in lateral.
2+000 to 3+000	
2+150	Bad joint on left panel.
2+180	Drop Culvert Structure, good. Outlet structure with USBR VI. Cavity on left wingwall. Coming out of basin, the joint is bad on both sides with a cavity at top of joint on left side. Third panel downstream has significant left joint leakage.
2+200	Left CHO, good. Outlet structure, good, but could use more riprapping. Hairline cracks n right panels.
2+500	Left CHO, good, and outlet good.

2+660	Culvert structure with broken-plane transition outlet, good.
2+700	Heavy leakage in right joint halfway up wall (at W.L.). [Lateral now half full of water.]
2+850	Right CHO, good. Outlet structure, good, but erosion is occurring at end of basin panels, so riprapping is needed urgently.
3+000 to 4+000	Water depth 0.6 y_{max}. Aquatic growth, heavy.
3+300	Left CHO, good. Outlet structure, good. Left end panel could use riprap because fishermen have removed.
3+600	Vertical drop structure, good.
3+700	Water depth, $y = 0.25\ y_{max}$.
3+882	Drop Culvert Structure with USBR VI, good. [Looks like one right panel already replaced.]
3+900	$y = 0.5\ y_{max}$.
4+000 to 4+900 (end)	
4+300	Left CHO, good, except first gate handle broken. Outlet structure, good.
4+380	Right CHO, good. Outlet structure, good.
4+400	Vertical drop structure, good.
4+505	Cavity on right panel.
4+870	Two CHO's, good. Left outlet structure, good, except for undermining of endwalls. Right outlet structure has had floor failure and undermining of endwalls, which will fail after another monsoon season. The downstream water level is too low, so a solution would be build a masonry wall with downstream rubble masonry floor to dissipate hydraulic energy.
4+900	Final Outlet Structure, good. Outlet end has rubble masonry (hin rieng ya nao) which is quite good. Could do some more rubble masonry to help dissipate energy and avoid erosion.

Sub-Lateral R-16L-1R-1L (2.943 km)

0+000 to 1+000	
0+000	Regulator structure has second gate now being repaired.
0+030	Left joint leakage.
0+450	Left CHO, good. Outlet structure, good. Some riprap removed by fisherpersons.
0+550	Vertical drop structure, good.
~0+700	Bridge. Cracked panels on both sides.
1+000 to 2+000	
1+500	Two CHO's, good. Right outlet structure has end panels being undermined. Needs riprapping. Left outlet structure is good.

1+700	$y = 0.5\ y_{max}$. Aquatic growth.
1+995	Two CHO's, good. Left outlet structure, good, but cavity of left wall and headwall. Right outlet structure, good, but has sediment.

2+000 to 2+900 (end)

2+010	Vertical drop structure, good.
2+400	Right CHO, good. Outlet structure, good, except for a few cracks resulting from a cavity behind left wall.
2+720	Wasteway structure on left side, good. Outlet structure is under water, but probably no problem because of backwater effects.
2+900	Final outlet structure. Inlet is good (CHO) and outlet is good except needs a little more riprapping on left endwall.

Sub-Lateral R-16L-3R (3.430 km)

0+000 to 1+000

0+014	Head Regulator, good.
0+035	Bridge, good.
	- Aquatic growth.
~0+450	One bad joint on right, probably resulting from small fish pond on right.
0+700	Two CHO's. Left CHO, good, and outlet structure, good, but needs riprap at endwalls. Right CHO, good, and outlet good. Rock riprap was moved by farm family, so they could fish. These farm families asked for RID to turn on water for fishing.
	- Aquatic growth.
	- Channel half full of water.

1+000 to 1+500

1+145	Bridge, good.
1+250	Two CHO's, both good. Both outlet structures under water (water ~10 cm above top of concrete basin wall).
1+375	Bridge, good.
	- Aquatic growth.

1+500 to 2+000

~1+900	Left CHO, good. Outlet, good.
2+100	Right CHO, good. Outlet, good.
~2+300	Left CHO and outlet, good.
	- Aquatic growth. Half full of water. Sediment.

2+500 to 3+434 (end)

2+520	Right CHO, good. Outlet, good, with riprap in-place.

2+596	Culvert structure, good.
2+700	Two CHO's, good. Outlets, good, with riprap on both outlets in-place.
3+000	Water height about 100% full ($y = y_{max}$).
3+100	Two CHO's, good. Both outlets under water with water level ~5 cm above top of basin concrete wall.
3+150	Drop structure, vertical, okay. First panel downstream on right has two vertical cracks.
	- Two-thirds full of water.
3+400	Two CHO's, good. Both outlets, good.
3+434	Final outlet structure at end of lining. Outlet structure needs some more riprapping on left side. Also, add riprap about 5 m downstream in channel bottom to raise water surface elevation against outlet structure in order to reduce erosion. [Small problem now, big problem in future.]

Lateral R-17L (8.370 km)

0+000	The CHO has one gate lock unlocked. Motocycle wrench will unlock this gate.
0+000 to 1+000	(a) Concrete lining in excellent condition. (b) Only very minor problems. (i) A few concrete joints where soil is washing into the canal. (ii) Roadway on left bank and only a few minor locations where water is running off embankment carrying soil into lateral. (iii) Right bank does not look well compacted. A number of locations where soil is washing off embankment into canal. (iv) Aquatic weeds along full length.
1+000 to 1+500	There is one joint downstream from bridge at roughly 1+100 where much red soil is being washed into lateral. The solution would be to asphalt the joint. This could have been avoided by using a rubber dumb-bell at joint.
	- Much evidence of soil being washed into lateral because it is raining. Only a few minor cracks in the lining. Vegetation in some cracks.
1+500 to 2+000	One location without berm vegetation where much soil is washing into lateral. Needs vegetation plus roadway slope to drain rainfall away from canal. Water is collecting in tire wheel tracks.
2+000 to 2+500	About 2+600 has two panels with horizontal crack implying right embankment has settled and left lining unsupported. Lining is excellent. Has aquatic growth and soil washed into lateral.

2+500 to 3+000	Looks very good. Only visible problem is aquatic growth. W-160 CHO has two feet of concrete lining on each side of CHO that was never poured. This is presently undermining the adjacent lining, but no cracks yet. Five cm lining thickness.
3+200 to 3+500	Junction of R-17L and R-17L-1L. Just 6-9 m upstream is a bridge; on all four sides, water is washing underneath lining and causing cracking. Besides correcting this problem, embankment drainage should be directed away from lateral. At R-17L-1L CHO, water is wasting under structure and lining which is not much of a problem now if taken care of, but will grow into a significant problem. Immediately downstream from R-17L-1L CHO, there is considerable sediment for about 35 m. This is definitely reducing the discharge capacity of the lateral. Sediment actually runs to 3+550.
3+500 to 4+000	Check structure at ~3+580. Downstream from this check structure at end of wingwall, there is considerable water going under the lining with a 10 cm x 20 cm hole in the bottom of the lining, which is washing sand into the lateral. Another hole 3 m downstream at joint.
3+800	CHO. There is a 1 m long crack immediately downstream of the CHO, which is on the right bank.
3+833	Bridge. All four sides have minor problems of leakage under the lining. Solution: More fussy job of grading embankments away from lateral and concrete protection of bridge abutments. There is very little drainage area (a few ft^2) but it is enough to cause serious problems in a few years. Small amounts of sediment along lateral with vegetation growth and some aquatic growth. Removing sediment, which would not be a big job, would alleviate future aquatic growth problems.
4+000 to 5+000	There is a USBR Stilling Basin VI about 4+200. Six m downstream there are serious holes in the lining, which is only 3 cm thick (designed for 5 cm). There is a fair amount of sediment upstream from this drop structure. A few of the joints downstream are washing soil into the lateral. CHO downstream ~200 m (4+700) has a few minor cavities, but the handle on the inside gate is broken, but operable.
5+000 to 5+500	
~5+150	Drop structure with USBR Stilling Basin VI. Six m downstream and 9 m downstream there is washing under the panel. From 7-15 m downstream a fair amount of sediment with grass.
~5+240	Bridge has washing under panels and signs of embankment settlement with serious cracking on left side.
~5+350	Drop structure with USBR Stilling Basin VI. Again, the lining panel 6-9 m downstream has cavities forming behind the joints. Also, sediment downstream for ~15 m.

5+500 to 6+000	
~5+700	Bridge with surface rail top beam knocked off. Cavities on upstream side of bridge and right panel cracked with hole. Third panel upstream on left side with serious cracking. Lining looks very thin ~2 cm (design, 5 cm). Some sediment in lateral.
6+000 to 7+000	
6+400	Two CHO's. No problem. About 20 m upstream is a panel with hairline crack.
6+800	Two holes in panels
6+840	Panel with hairline crack. One joint with soil and grass.
7+000 to 8+000	
7+160	Two CHO's. Leaky gate.
7+520	Bad joint. Lining looks excellent, only problem is methodof construction that resulted in the wide joints.
8+000 to End	
8+105	Two CHO's, with only one cavity; but, the outlet on the other side of the embankments have lost their erosion control concrete and some of foundation eroded away. The right CHO outlet has failed with only one joint sticking out from CHO and remaining concrete pipe is in eroded hole and outlet structure lies in eroded hole. CHO 20 m from end of R-17L lateral has a cavity on downstream side. The outlet structure left of roadway has underwashing on left side that needs correction. Final outlet structure has cracking on left sidewall at inlet and outlet structure has foundation being undermined. Needs more riprap. The earth channel runs approximately 1 km.

Sub-Lateral R-17L-1L (5.580 km)

0+000 to 0+500	TO structure is mentioned for Lateral R-17L. Cavities on both abutments and concrete damage behind inlet gate. Outlet structure is good. The panel on right downstream from outlet structure is cracked (needs asphalt).
~0+250	CHO on left bank has two cavities on left embankment.
~0+350	Drop structure with USBR V. Panel on right leaving stilling basin has undermining and water is running into lateral. Fifteen m downstream there is water running through joint into lateral. Many joints downstream have leaking with much sediment flowing into lateral. Also, there is considerable undermining. Terrific aquatic growth. Much sediment.

0+500 to 1+500	
~0+600	Two CHO's. Roadway has a cavity and outlet structure for left CHO is badly damaged. Right CHO has a cavity and so does outlet structure.
	Design - Do not construct CHO outlets where there is much fall afterwards, because they quickly erode.
~1+000	Bridge has cavities at all four abutments.
1+200	Vertical Drop Structure, good. Much aquatic growth. Water in bottom portion of lateral, so bottom cannot be seen.
1+500 to 2+000	
~1+600	Two CHO's, each with abutment cavities. Right outlet structure has serious problem with cavities and cracking, with eventual failure likely. In contrast, the left outlet structure is very good because it is set at ground level.
~1+700	Vertical Drop structure looks good except for small cavity on left abutment.
2+000 to 3+500	
2+400	Drop structure, good. [These structures have substantial concrete.] All of the six panels immediately downstream have joints leaking soil and small holes in the lining.
~2+800	Two CHO's, look good. Sediment downstream and aquatic weeds. Lots of vegetation growth in joints.
3+500 to 4+000	
~3+600	Two CHO's, left outlet structure has end panels that have failed and more will fail in future. Correcting problem now would help. Right outlet structure also has broken panels. Downstream there is considerable sediment and vegetation from right embankment.
~3+700	Drop structure with USBR VI. Right panel and basin outlet has a hole in the bottom and a crack. Bottom has sediment but only a few cm deep.
4+000 to End	Small amounts of sediment and vegetation.
4+550	Two CHO s with cavity on one abutment of right CHO. Right outlet structure has failed. Left outlet structure, good. Same reasons as before, fall after outlet.
~4+675	Roadway Culvert structure [has a slide gate at inlet]. Cavity in left abutment. Floor has a hole.
	- Lots of sediment downstream from culvert and vegetation must be cleaned for 350 m. Then, much less problem to end.
~5+265	Bridge. Left panel broken in upper corner. Cavities at all abuments.

5+360	Wasteway, good.
~5+400	CHO, good. Outlet structure has downstream panels that have failed.
5+465	Final CHO. Outlet structure has undermining of final panels. Immediate maintenance will save this structure.

Sub-Lateral R-17L-1L-1L (3.670 km)

	Outlet from Lateral R-17L-1L is at station 2+990. CHO structure has small cavities on both sides. CHO outlet structure has a small problem with first joint being offset from broken-plane transition. CHO on right side at ~0+200 with cavity on each abutment. Sediment in CHO.
~0+300	Bridge looks good.
~0+350	CHO has cavity on each abutment. Outlet structure has one cavity at headwall. Very little sediment and aquatic growth.
0+500 to 1+000	CHO at 0+600 is good. Good outlet structure with fish trap.
~0+650 to 0+700	Many cavities along right wall that need immediate attention. A few panels have already been displaced.
~0+800	A panel needs to be replaced. Lining thickness is mostly 5 cm except at top (3½ cm).
0+900	CHO has cavities. Lining upstream has cavities at joints. Only minor amounts of sediment and aquatic growth.
1+000 to 1+500	
~1+100	CHO with cavity and outlet structure with cavity at headwall.
~1+250	Outside road embankment needs repair.
~1+450	Serious road erosion. Need immediate attention. Needs an asphaltic ridge on right side of roadway with rigid berm drop structure to drop water, plus have vegetation planted on slopes.
1+500 to 2+500	
1+620	CHO looks good but outlet structure has serious damage. Some pieces of wall have fallen off and headwall and sidewalls undermined.
~1+800	Lining cavity.
1+850	One cavity at culvert outlet.
~1+900	CHO has medium size cavities on both abutments. Outlet structure has failed.
	- Aquatic growth.

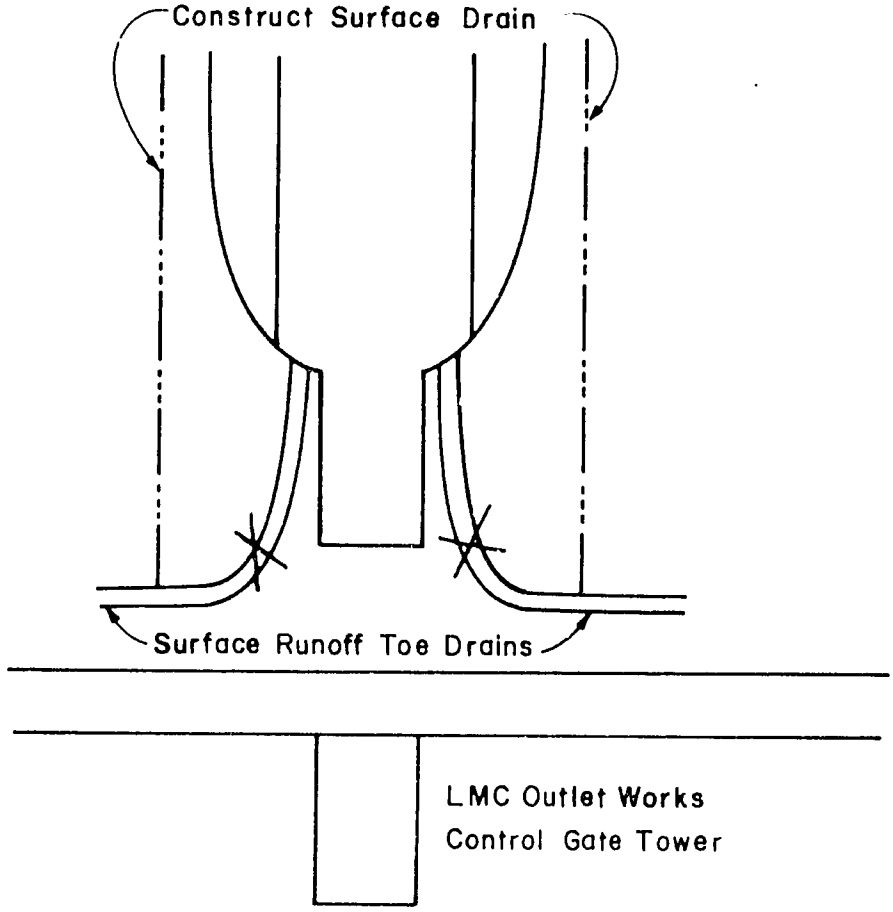
2+500 to 3+000	
~2+600	CHO has a cavity on each abutment. Outlet structure, good.
~2+750	Road culvert with headgate, last concrete panels before inlets are seriously undermined. The gate rod was in the water, so the gate is not working. Culvert outlet structure is good. CHO about 100 m downstream from culvert has a cavity on each abutment.
3+000 to End	Aquatic growth and sediment.
~3+600	CHO with medium cavity on downstream abutment. Outlet structure has failed.
~3+700	Wasteway on left bank looks good. Immediately downstream is serious vegetative growth in lateral bottom for 80 m. Final outlet structure serves a small diameter (~15-20 cm) pipeline across a small river.

Sub-Lateral R-17L-2L (2.469 km)

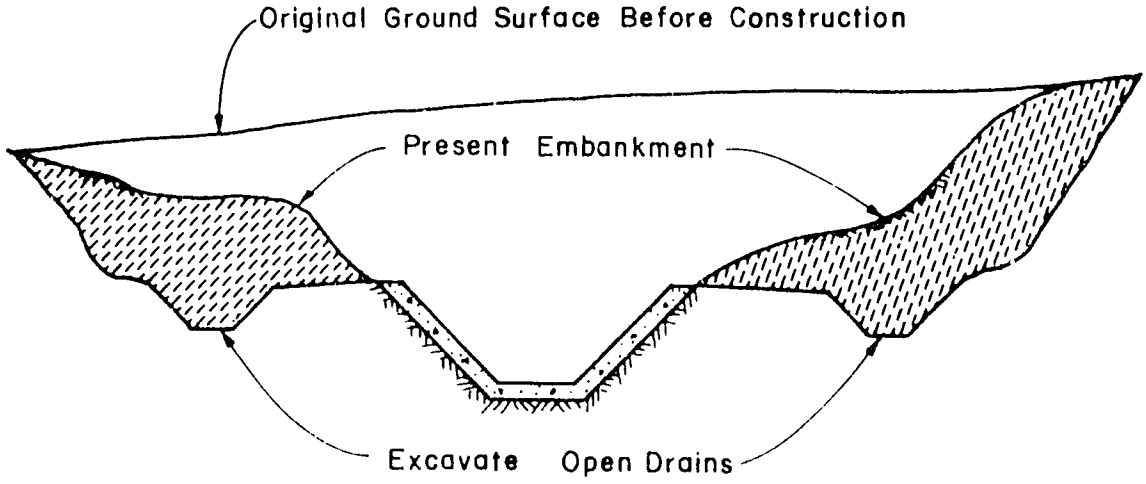
0+000 to 500	
0+000	CHO and Broken-plane transition are good. CHO at 0+300 has only one cavity, which may be a rodent hole. Much vegetation, some 1'-2' high, and fair amount of sediment.
0+500 to 1+000	Much vegetative growth with fair amount of sediment. Vegetation growth frequently as high as concrete lining.
1+000 to 1+500	Two CHO's at ~1+200. Left CHO to have a problem in future with outlet too high for surrounding land, which will result in serious erosion, but will probably be a good elevation when on-farm facilities are constructed.
1+500 to 2+000	Small drop structure (~2') with USBR Stilling Basin VI. No visible problems, but water on both abutments can seep into backwall.
~1+700	CHO with outlet structure. Right wall of outlet basin with huge hole that needs correction.
~1+750	Bridge with cavity on upstream right side and right panel cracked.
	- Much sediment and vegetation in this entire reach.
2+000 to End	
2+100	Bridge looks good.
2+300	Bridge looks good.
~2+350	CHO with lateral overflow, looks very good.
2+445	End of lateral R-17L-2L. Structure looks very good.

LEFT MAIN CANAL (28.040 km)

Dam Outlet Works Control Gates for LMC. Leak about half of RMC Dam Outlet Works Control Gates. No problems with aquatic weeds. There have been no major problems with RMC or LMC outlet works control gates to date.

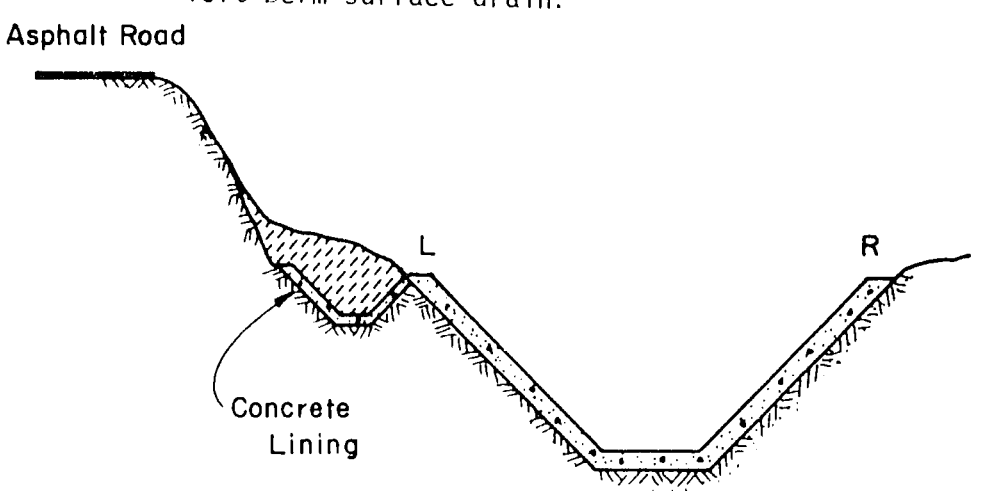


NOTE: Right berm is bedrock with some soil, and not much sediment comes from right side, so only construct left berm to station 0+275.



0+000 End of LMC Outlet Works. First left panel downstream has much water leaking from joint. There are small holes in panel joints downstream.

0+035	Hole in right panel.
~0+125	Concrete drain that discharges onto left panels. An alternative means of discharging this water and sediment should be found.
~0+200	Water is seeping over left panels and there are many small holes in left panels, but right panels are very good.
	- Some aquatic growth.
~0+250	Large holes in six left panels. Should repair these panels so they will not fail.
~0+275	Cavity behind right panel with small hole in lining near floor, which will get larger with time. Begin right surface drain at station 0+275. Beginning at roughly station 0+275 the right panels start showing much damage at joints.
~0+300	Large holes in six right panels and two left panels.
~0+325	Large hole in left panel.
~0+525	Large holes in left panels. Many right panels have erosion at joints.
~0+650	Large hole in two right panels.
0+700	Large right wasteway structure. This wasteway can be used for right bank surface drain outlet.
	- From ~0+500, the road is very high and quite close to LMC, so there will be some difficulties in constructing left berm surface drain.



~0+725	Holes in left panels.
~0+800	Large hole in left panel that should be repaired to avoid failure in near future.
	- Very little sediment.
	- Very little aquatic growth.

~0+900 to ~1+000 Holes in left panels.

- From 0+700 to 1+200 the right panels look good, so that right surface drain would not be necessary. In this reach, the joints should be sealed with asphalt.

~1+000 Large holes in four left panels. Two of these holes should be repaired soon.

~1+070 Large hole in left panel.

~1+085 Holes in two left panels.

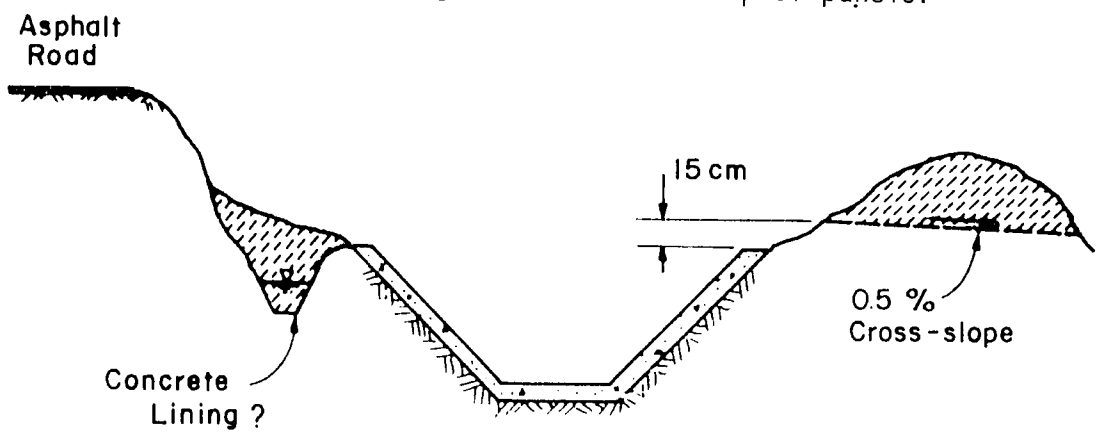
- Begin right berm surface drain at approximately 1+200 because this is where three right panels have holes.

~1+150 Two large holes in left panel.

~1+300 Large hole in left panel. From 1+300, there is room between LMC and asphalt road for open earthen surface drain.

1+345 Drain culvert. Inlet structure is good.

- From 1+345, instead of constructing right berm surface drain, since the adjacent land is below LMC invert, out berm to just 15 cm above top of panels.



- Lining looks good.

~1+500 Some erosion of right panels at floor joint. Cavity behind left panel with small hole in joint at floor level and panel cracked. Cracked left and right panels.

- Many panels with cavities and small holes, which need surface drains.

- Left panel with large cavity and bulging displaced panel that will soon fail.

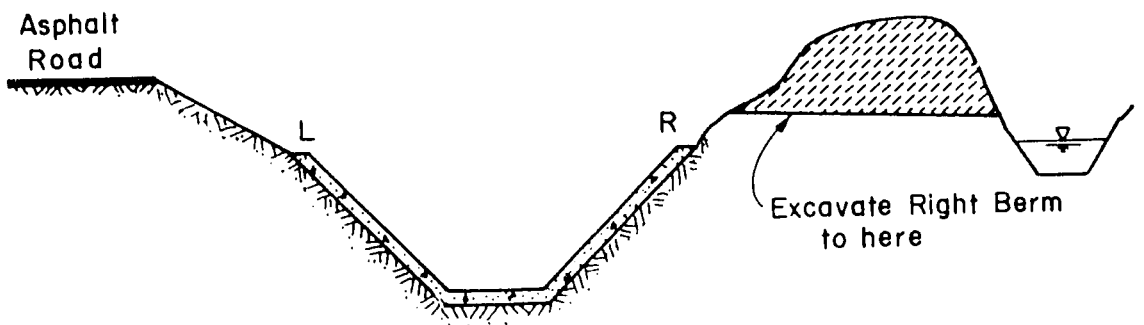
~1+600 Left berm is saturated and seepage going over left panel for a length of 6 m. Large hole in left panel near joint.

~1+750 Large hole in right panel.

1+830 Concrete Bridge is good, but rails have been knocked off.

1+850 Two CHO's are good, but concrete walkway panels are missing and right CHO has cavity along downstream wall. Left pipe outlet structure is good. Right outlet structure is good.

1+900 Drop Chute Structure with gate. Inlet structure is good. Upstream left panel has two cavities. There is ponded water to right of right berm which can be used for right surface drain. Outlet structure is good but right bank is saturated and water seeping over right wall.



2+000 Many cracked left and right panels, but only a few small holes in panels. Cracked floor panels. Therefore, subsurface drainage is needed, which can be accomplished by having invert of surface drains as low as possible, but at least below F.S.L. of LMC.

~2+300 Lining looks good.

~2+450 Holes in right panels at floor joint. Left panels look good. Cracked right panels with small holes near floor joints. Left panels are good, probably because the asphalt road is near the level of the top of the lining.

2+595 Inverted Siphon without gate. Inlet structure is good. Parallel concrete bridge has cavities at upper corners of right concrete abutment panel. At downstream end of bridge there is a huge cavity at right corner that needs to be fixed soon. Also, there is a cavity in left abutment panel just below the cavity at downstream end of bridge.

- Adjacent land is below LMC invert. However, right berm needs to be cut down a small amount and graded to convey water away from LMC.
- Cracked right panels, but no holes. Left panels look good.

2+890 to 2+925 Right panel with large hole and right panels with small holes.

2+900 Left CHO is good, except concrete walkway panels are missing. Outlet structure is good.

2+950 Large hole in right panel and many panels with small holes.

- Many right panels with cracks and small holes, but left panels have only a few holes.
- Very little sediment.

3+200 Right CHO is good and outlet structure is good.

3+300 Concrete Bridge is structurally good, but railings have been knocked off. Cavities behind left and right panels with panels underneath being cracked. Highway is only a short vertical distance above top of lining and land left of highway is lower than LMC invert, so surface drainage is not needed. Land to right of right berm is lower than LMC invert, so surface drainage is not required, but right berm should be cut down and graded.

3+450 Drain Culvert. Could not find because inlet structure is under water.

3+600 Right CHO is good, except concrete walkway panels are missing. Outlet structure is good, except cavity behind headwall and cracked left panels.

- Some cracked right panels and some small holes, but lining is fairly good. Left panels look good.

~3+700 Cracked left and right panels halfway up.

3+800 Right CHO looks good, but concrete walkway panels are missing. Did not inspect outlet structure. Cracked right panels show the need for surface drainage and cutting down right berm.

~4+200 Many holes in left and right panels with bulging of left panels. Need left surface drain between LMC and asphalt road.

- Need right berm surface drain from station 4+280 to 4+380.

4+400 Right CHO is good, except concrete walkway panels are missing. Outlet structure is good.

~4+550 Large hole in right panel.

~4+650 Large hole in left panel. Many cracked left panels.

~4+700 Drain Culvert. Outlet structure is good, except for last meter of floor has failed, so that compacted backfill and rubble masonry is needed at end of outlet structure.

- Adjacent land is below LMC invert.

4+800 Right CHO is good, except concrete walkway panels are missing. Pipe outlet structure feeds concrete pipeline, all of which looks good.

- Many cracked left panels and some holes.

~5+100 Drop Chute Structure with gate. Inlet structure is good. Outlet basin looks good. Large and small holes in downstream left panels. Holes in downstream right

panel joints. Needs left and right surface drains. Right berm surface drain needed for only 100 m. Left berm is concrete lined to prevent erosion, which is very good, but there are many cavities that need to be filled.

- Aquatic growth.
- Asphalt road is much higher (~3 m) than top of panels.

~5+300 Huge cavity behind right panels.

~5+325 Cavities behind right panel and three badly cracked right panels. Five cracked left panels.

~5+360 Six cracked left panels with seepage and moss.

5+420 Concrete Bridge is structurally good, but rails have been knocked off. Badly damaged left panels under bridge.

~5+475 Hole in right panel.

~5+500 Cavities behind right panels and cracked panels.

- Need left and right berm surface drains because highway on left is much higher than top of panels and so is land on right.
- Some cracked left panels.

5+600 Right CHO is good, except cavity along downstream wall. Outlet structure is good.

5+630 Concrete bridge is good. Large cavity on right upstream abutment and right panel has settled. Can end right berm surface drain at station 5+630; then, only right berm needs to be cut down and graded. Continue left surface drain.

~5+850 Cavity behind right panel and bad horizontal crack.

5+865 Cavity behind right panel which is displaced.

5+880 Displaced right panel.

5+900 Right CHO is good, except concrete walkway panels are missing. Outlet structure is good, but cavities and holes where downstream lining connects to outlet structure.

- Many cracked left panels. Many cavities behind right panels.
- Many cavities behind left panels.

6+000 CHO Regulators for Laterals L-1L and L-2R.

- Cracked left panels.
- Hole in right panel.

6+040 Concrete bridge is structurally good, but railings are gone. Large cavities on upstream abutments, but panels are not cracked.

6+050 Check structure with two gates is good.

- Most right panels are cracked.

6+150 Drop chute structure without gate. Inlet structure is good. Walls at end of chute have huge cavities with large hole in right vertical wall. Another large cavity along right vertical wall. Holes in outlet transition structure. Holes in joints in downstream left and right panels.

- From 6+150, right berm surface drain is needed.

~6+200 Large holes in left panels. Many joints with small holes.

~6+250 Large hole in right panel. Many cracked right panels.

- Adjacent land is much higher than top of lateral lining.

~6+300 Two failed left panels.

- There are many cracks and holes in left and right panels, but more in left panels in this reach, primarily because adjacent land is much higher (~1 m) than top of lining panels.

~6+800 Failed left panels.

7+200 Four left panels failed. There is some surface drainage to left of asphalt road and right of right berm, but it should perhaps be deeper. Right berm needs shaping to convey rainfall runoff away from LMC.

~7+250 The surface drains to left of highway and right of right berm look deep enough to provide adequate subsurface drainage. The right panels look very good. Left panel has big hole, but downstream left panels look good.

~7+700 Concrete bridge [not listed] is structurally good. No cavities.

- Much aquatic growth.

- Lining looks good.

~8+200 Cavities behind left panels.

8+750 Left CHO is good except for cavities along upstream sidewall and headwall. Concrete walkway panels are missing. Outlet structure is very good.

- Adjacent land is below LMC invert. Lining is very good.

~8+800 Cavities behind left panels.

~9+000 Some cavities behind left panels. A few small holes and some large holes in lining.

~9+400 Cavities behind left panels (15).

9+620 Concrete bridge is structurally good, but top pipe rails have been removed. Cavities behind right panels and left panels cracked.

- Thirty-nine cavities behind right panels. Thirty-three cavities behing left panels.
- There is no road from 9+700, so both left and right berms need shaping.

10+200 Concrete bridge is structurally good, but rails have been knocked off. Cavities at left abutment, but panels are not cracked.

~10+300 Left berm eroded away and compacted backfill needed.

~10+500 Hole in left panel.

- From 10+200 to 10+825 there were twenty-two cavities behind left panels and seventy cavities behind right panels.
- Lining looks good. Adjacent land is well below LMC invert.
- Left and right berms need shaping.

10+825 Inverted Siphon without gate. Inlet structure is good. Right wall of rubble masonry embankment protection has cavities. Outlet structure is good. Right embankment protection has a few cavities. Trash in outlet structure should be removed.

- Ten cavities behind right panels and seventeen cavities behind left panels from 10+825 to 11+300.
- Lining looks very good. Adjacent land at 10+800 about same elevation as LMC invert.

11+300 Concrete bridge is structurally good, but top pipe rails are gone. Cavities on upstream abutments, but panels are good.

11+310 Left CHO is good, but concrete walkway panels are missing. Outlet structure is excellent design, but has cavities along right panels.

- Many cracked right panels because adjacent land is high. Needs right surface drain from 11+310 to 11+450.
- Left panels are good.

11+450 Concrete Bridge [listed as 11+640] is structurally good, but half of upstream top rail is missing. Cavities at all abutments, but no cracked panels.

~11+475 Six cracked right panels.

~11+500 Four cracked right panels.

~11+525 Cracked right panel. Some sediment.

- Many cracked right panels and some panels have small holes.

11+700 Cracked left panels and bulging in one panel.

- Both left and right surface drains could be made deeper.

~11+800 Large hole in left panel near floor.

~11+900	Four cracked right panels.
12+126	Drain Culvert. Inlet and outlet structures are under water.
12+135	Overflow spillway is good.
	- Seven cavities behind left panels from 11+450 to 12+145.
12+145	Wasteway Structure (Tail Regulator) is good, except for huge cavity behind headwall.
12+280	Hole in right panel.
	- Only a few cavities.
12+300	Concrete Bridge is structurally good. Small cavity on left downstream abutment.
	- Left berm is in bad need of cutting and shaping.
12+360	Right CHO is good except concrete walkway panels are missing. Pipe outlet structure is good.
~12+460	Bottom portions of four right panels have failed and bottom portions of three left panels.
~12+500	Huge hole (1 m x 2 m) in left panel.
~12+550	Huge holes in two adjacent left panels.
~12+600	Cracks in horizontal joints in four right panels.
~12+650	Huge holes in two nearby left panels. Adjacent land below LMC invert.
~12+700	Cavities behind many adjacent right panels and cracked panels.
~12+850	Failed bottom portions of two left panels with bulging, which means more of these and adjacent panels will fail.
~12+900	Large holes in two nearby left panels.
~12+950	Beginning at this station, the adjacent land on left is ~1 m below top of panels and land on right of LMC is about 70 cm higher. Extensive failure of five right panels and three left panels. This area had just been rebuilt this last summer. There is heavy seepage at bottom of left panel.
	- Many heavily cracked and bulging right panels for 50 m.
	- Need left and right surface drains.
	- Some of the right panels will soon fail because of large cavities, cracks and bulging.
	- Extensive panel damage due to lack of left and right surface drains, which would also provide subsurface drainage.

There are very few drain culverts through this reach of LMC, so providing adequate drainage will be expensive.

13+600 to 13+800 At least 20 right panels have completely failed. Providing left and right surface drains is a major priority for construction because the extent of damage will increase rapidly each year. Many left panels will soon fail as a result of large cavities and heavy bulging. At least 15 failed left panels.

13+859 Concrete bridge is structurally good. Cavities behind left and right panels with cracking and bulging.

Beginning from Concrete Bridge at 13+859 to End

- Seven right panels need to be replaced.
- Seven right panels need to be replaced. Five left panels need to be replaced.
- Two right panels need to be replaced. Six right panels need to be repaired.
- Two left panels need to be repaired.
- Three left panels are bulging and will soon fail.
- Two left panels need to be replaced. Three left panels need to be repaired.
- Sixteen right panels need to be replaced. Two left panels need to be replaced. Six left panels need to be repaired.
- Five right panels and seven left panels will soon fail.
- Fifteen right panels and seven left panels have failed.
- Four right panels and three left panels need to be repaired.

~14+020 Left surface drain inlet to LMC. The structure is good, but there is a hole in the lining with underlying cavity at lip of outlet.

- Four right panels need cavities filled.
- Three left panels need cavities filled, but bulging has begun and these panels will fail in another year or two.
- Two right panels need cavities filled.
- Three left panels need cavities filled, but bulging has already begun.
- Nine left panels need cavities filled, but bulging has already begun.
- Many cavities on both left and right sides that need filling.

First priority on LMC should be filling of cavities behind panels in reaches not having surface and sub-surface drainage.

- Three bulging left panels need repair by filling cavities.
- Two displaced left panels that need cavities filled.
- Four left panels are bulging and cavities should be filled.
- Hole in left panel.
- Right panels are very good and there are no cavities over much of this reach.
- Huge cavity behind left panel and panel is broken.
- Right and left berms should be cut down and shaped.

14+520 Concrete Bridge is structurally good. No cavities, but left and right panels under bridge are cracked.

14+560 Right surface drain inlet to LMC is good, but there is a hole in right panel underneath the drain inflow crest.

14+570 Inlet channel for Lateral L-3L.

- Five cracked right panels.
- Upper corner (2 m wide by 1 m high) of right panel broken off because of surface drainage into LMC.
- Left and right berms 1.5 m above top of lining.

~14+750 Left surface drain into LMC. Surface drainage has caused failure of four left panels.

~14+760 Left panel has two cavities and hole in panel. Right panel has cavity.

- From 14+520 to 14+850 there are only a few cavities behind left and right panels and lining is very good.

~14+850 Concrete Bridge (near entrance to RID Road Construction Division) is structurally very good.

- Right panels immediately downstream from bridge have seepage flowing over the top.
- Left and right surface drains are needed.

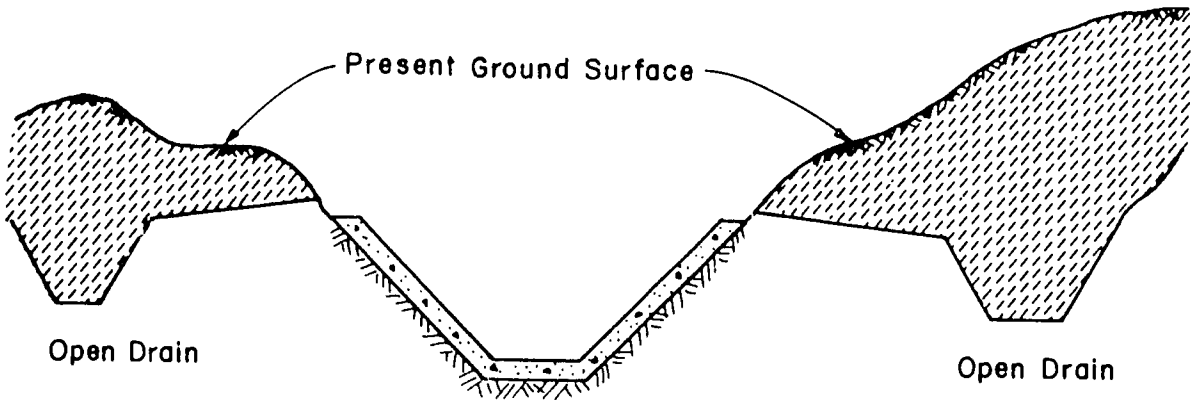
Might have been better to place pumping station at km 10 or 12.5 rather than km 16, so that LMC would be elevated above land. This could have eliminated the pumping plant at Lateral L-3L, but the total discharge capacity would have been the same.

- Surface erosion from left berm has resulted in sediment in LMC.
- Seepage over right panels at many locations between 14+850 and 16+000, as well as many locations on left panels. All signs here would indicate that there should be cavities and cracked, broken and failed panels; but the lining looks good. One reason may be that the lining construction joints are tighter.

15+800

Left Concrete Surface Drain Inlet to LMC is structurally good, but has resulted in failure of underlying left panel and adjacent left panels may also fail.

- Lots of earth to be removed from 14+850 to 16+000 because both left and right berms are generally 1.5 m above top of lining.



~15+900

Saturated left berm fill at least 1 m above top of lining. Normally, this condition would lead to failure, but there are no cavities. Also, this indicates that the construction had to be very good.

Note: During construction of panels, alternate panels are poured. Wood strip is removed before pouring in-between panels, but sometimes some pieces of wood are left. Many times, the joints are 2-4 mm wide. The construction technique should assure that the concrete panels are poured in such a manner that the joints are as tight as possible. Present practice is to pour the in-between panel against the previously poured adjoining panels, then using a triangular-shaped board cut a surface joint approximately 4 mm deep. Thus, the width of construction joint frequently seen is the result of concrete contraction from drying. Recommend use of dumb-bell hard rubber joints on an experimental basis. Should definitely do a better job of concrete curing.

- Thirty-nine measurements of lining thickness were made between 12+500 and 16+000. The thickness varied from 5-13 cm and averaged 7.6 cm.

16+000

Pump Lift Station with two pumps. Pumps usually operate satisfactorily, but there are some problems with control unit. Water is lifted 8.375 m. There is also a right overflow concrete structure downstream from outlet structure, which is in good condition.

- Adjacent land is below LMC invert.

~16+100

Hole in floor panel. Lining is very good.

~16+250	Hole in right panel near floor. Left and right berms are at proper elevation, but need grading. Left berm has cross slope so that rainfall runs into LMC rather than away from LMC.
16+500	Right CHO is good, but there is a cavity along upstream wall and concrete walkway panels are missing. Outlet structure is good, but large cavity behind right panel.
~16+600	CHO Regulator for Lateral L-4R.
	- From 16+000 to 16+741, the lining looks extremely good and there were no visible cavities.
16+741	Roadway Culvert without gate under Udon-Sakhon Nakhorn highway. Inlet structure is good, but large amount of sediment needs to be removed. Outlet structure is good, but sediment needs to be removed.
	- From 16+800, right berm surface drain is needed. Land on left is below LMC invert.
16+860	Left CHO is good, except concrete walkway panels are missing. Outlet structure is good, but much shrubbery.
~16+900	Small holes in right panels at floor level.
~16+950	Holes in righ panel.
	- Some aquatic growth.
	- Some rocks in LMC.
~16+975	CHO Regulator for Lateral L-4L.
~17+100	There is surface drainage on right side of right berm. Provide surface drainage outlet and cut down right berm ~1 m.
	- Road has been constructed too high.
17+290	Left CHO is good, except second gate frame and gate is missing. Outlet structure is good.
17+650	Left CHO is good, except concrete walkway panels are missing. Outlet structure is good, but some compacted backfill could be used on left side and shrubbery removed.
17+675	Right CHO is good, except for cavities along both sides and concrete walkway panels are missing. Outlet structure is good, but much sediment and shrubs.
17+840	Concrete bridge [not listed] is structurally good. Cavity behind left upstream abutment and right downstream abutment, but panels are not cracked.
	- Lining looks very good.
17+960	Right CHO is good, but concrete walkway panels are lying in LMC. Pipe outlet structure is good, but has cavity near headwall and floor is undermined for 1 m.

18+020 Concrete bridge is structurally good. Cavities at downstream abutments, but panels are not cracked.

- Practically no sediment.

18+350 Left CHO is good, except concrete walkway panels are missing. Outlet structure is good.

18+400 Concrete bridge is structurally good. Cavities behind right panels and left upstream abutment, with left and right panels cracked.

18+410 CHO Regulator for Lateral L-5R.

- Adjacent land is below LMC invert.

18+650 Right CHO is good, but concrete walkway panels are missing. Outlet structure is good, but cavity behind left panel and outlet walls and floor are being undermined, so compacted backfill plus rubble masonry is needed.

18+853 Roadway Culvert without gate. Inlet structure is good. Outlet structure is good.

- Lining looks very good.

19+000 Right CHO is good, except for cavity along upstream wall and concrete walkway panels are missing. Outlet structure has broken left and right panels and undermining, so repair of left and right panels, compacted backfill and rubble masonry are needed.

19+100 Left CHO is good, except concrete walkway panels are missing. Outlet structure is good.

19+400 Left CHO is good, except concrete walkway panels are missing. Outlet structure is good. Cavities at right abutments and left downstream abutment, but no cracks in underlying panels.

- Right berm needs cutting down and shaping.
- Adjacent land on both sides lower than LMC invert.

19+980 Left CHO is good, except concrete walkway panels are missing. Outlet structure is so covered with shrubbery that it could not be seen.

20+036 Right CHO is good, except for small cavity along downstream wall and concrete walkway panels are missing. Outlet structure is good.

20+145 Concrete bridge [not listed] is structurally good. No cavities, but cracked left panel.

20+200 Two CHO's are good, except concrete walkway panels are missing. Right outlet structure is good. Left outlet structure is good, but could use rubble masonry at endwalls.

20+250 Drop structure with inlet gate and USBR VI. Inlet structure is good, but has two large cavities near

headwall. Outlet structure is good, but needs compacted backfill along right wall. Joints, both left and right, at end of outlet transition is broken on left side and leaking on right side.

- Sediment has been piled along right berm at edge of lining.
- About eight cracked right panels.

20+500 Right CHO is good. Outlet structure is good.

- Right berm needs cutting down and grading.
- Left roadway is too high.

20+850 Drain Culvert. Outlet structure pipeline is completely covered with sediment. Could not find inlet structure because of vegetation.

~20+900 Large hole in left panel.

- Some cracked left panels.

~21+100 Four cracked and bulging left panels.

- Many cracked right panels.
- Right berm needs cutting down and grading.

21+130 Drain Culvert could not be found. Farmer said it does exist, but covered with sediment.

21+400 Concrete bridge is structurally good, except left downstream top rail has been knocked over. No cavities.

21+500 Left CHO is good, except for cavity along downstream wall. Outlet structure has eight holes in panels, but headwall is good.

21+620 Drain culvert could not be found. Farmer said it does not exist.

~21+670 Large hole in right panel. Cracked left panels.

21+700 Right CHO and outlet structure is good.

- One-eighth sediment.

~22+100 Three broken right panels. Beginning at this station, right surface drain needs to be constructed.

22+200 Two CHO's are good, except concrete walkway panels are missing. Both outlet structures are good.

22+300 Concrete bridge is structurally good. Cavities behind right panels, but no cracks in panels.

22+500 Drain Culvert Inlet structure is so full of vegetation that it cannot function as an effective drain.

22+800 Two CHO's are good, except concrete walkway panels are missing. Left outlet structure is good, except for cavity near right headwall. Right outlet structure is good.

- One-sixth sediment.

22+950	Left CHO is good, except concrete walkway panels are missing. Outlet structure is good.
23+260	Two CHO's are good except for missing concrete walkway panels on right CHO. Left outlet structure is good. Right outlet structure is good.
~23+500	Three broken left panels as a result of roadway erosion. Roadway needs cross-slope away from LMC.
	- Many cracked right panels.
	- Need right berm surface drain to next drain culvert and grading of roadway.
23+950	Left CHO is good. Outlet structure appears good, but there is roadway erosion, sediment and vegetation.
24+000	Roadway Culvert without gate. Inlet structure is good. Outlet structure is good.
	- Land on right is higher than top of lining, so right surface drain is needed. Left side of road is lower than top of lining, but higher than LMC invert, so left surface drain probably not needed.
24+100	Right CHO is good. Outlet structure is good.
24+300	Drain Culvert. Inlet structure is good. Outlet structure is under water.
24+520	Two CHO's are good, except concrete walkway panels are lying in LMC. Both outlet structures are good.
25+100	Drain Culvert. Inlet structure is good. Outlet structure is good.
25+450	Concrete bridge is structurally good. No cavities.
25+500	Two CHO's are good, except concrete walkway panels are lying in LMC. Both outlet structures are good.
~25+700	Huge hole in right panel.
	- Need right berm surface drain for ~200 m because land is much too high and have cracked right panels and holes in lining.
25+905	Concrete bridge is structurally good. No cavities.
25+920	Left CHO is good, but cavity along downstream wall and concrete walkway panels are lying in LMC. Outlet structure is good, but much sediment.
25+980	Right CHO is good, except concrete walkway panels are missing. Outlet structure is good.
	- One-eighth sediment.
26+060	Concrete bridge is structurally good. Cavities behind left panels and some small cracks in left and right panels.
26+250	Drop structure with inlet gate and USBR VI. Inlet structure is good. Outlet structure is good, but left

and right banks are much too high and should be cut down ~3 m. Second right panel downstream has large hole.

- Many small holes in right panels.
- Very little sediment.

~26+700 Two right panels with many cracks.

~26+800 CHO Regulator for Lateral L-5L.

26+900 Two CHO's are good, except left CHO has no concrete walkway panels. Left pipe outlet structure is good. Right outlet structure is good.

27+000 Drop structure with inlet gate and USBR VI. Inlet structure is good. Outlet structure is good. Left panel at end of outlet transition structure has a large hole. Downstream left and right panels have holes because road is too high on left and right surface drain is needed from here to 27+600.

- Many holes in right panels and cracked right panels.

27+550 Right CHO is good, except for a cavity along each sidewall. Outlet structure is good.

- Very little sediment.

~27+750 Hole in right panel.

28+000 Two CHO's are good. Right outlet structure is good. Left outlet structure is good.

28+040 Tail Regulator with gate. Inlet structure is good. Pipe outlet structure is good.

Lateral L-1L (9.310 km)

0+000 Double CHO Regulator, good. Small cavities behind abutment panels on both sides. Outlet broken-plane transition structure is good. The first and second left panels downstream have large cavities, which has displaced the second left panel.

- One-eighth sediment.

~0+200 Cracked left panel.

0+250 Right berm has surface drainage into lateral that has resulted in large cavities behind right panels and horizontal cracks on three right panels.

~0+275 Hole in right panel. A number of joints show evidence of leaking water and sediment.

~0+300 Cracked right panels resulting from large cavity behind right panels. Serious bulging and cracks in three left panels that will eventually fail. There is a cavity at one joint, but this problem is probably also due to roadway (left) settlement.

~0+390 Cavity behind left panel.

~0+400	Ten to fifteen cm hole in left panel. Two right panels have cracks.
~0+420	Some panels on right are cracked.
~0+475	Four right panels have a continuous crack that will become worse with time. There are many cavities.
~0+480	Cavity behind left panel joint.
~0+490	Cavity behind left panel that has caused cracks in two left panels.
0+500	Right CHO is good except for cavity alongside upstream wall and concrete walkway panels are missing. Outlet structure has cracked right panel and cavity behind right panel. Farmer has knocked an outlet through the right side and used a wood plug for control. On opposite side of CHO there is a cavity behind left panel.
~0+600	Large cavity behind right panel with big horizontal crack one-third way below top.
	- One-six sediment.
0+650	Concrete bridge is structurally good but top pipe rails are missing on both sides. Very large cavities behind both left and right panels and left panel displaced.
~0+700	Displaced left panel.
~0+725	Failed left panel and upstream left panel is ready to fail.
~0+750	Ten left panels have horizontal cracks one-third way up panels and are bulging. In a few years, these panels will fail. There is no visible evidence of cavities. This problem has likely resulted from roadway settlement.
~0+800	Two cracked left panels.
~0+825	Two cracked left panels.
~0+850	Three cracked right panels.
~0+900	Drain Culvert. Inlet structure is good. There is no outlet structure. Serious roadway erosion. The pipe outlet should be extended about 8 m and a concrete outlet structure constructed. Then, compacted backfill should be placed so that the road way is reconstructed. There is also serious erosion of right berm, which should be corrected.
	- About 200 m of laterite erosion into lateral.
	- One-sixth sediment.
1+050	Right berm erosion.
1+200	Right CHO is good except concrete walkway panels are missing and sediment in CHO. Outlet structure is good and feeds concrete pipeline.
1+200	CHO Regulator for Lateral L-1L-1L.

Beginning at CHO Regulator for Lateral L-1L-1L at Station 1+200

~1+200 to 1+300	Some cracked right panels. Sediment from lateral has been piled on left edge of right berm, so it will easily be washed back into the lateral during the monsoon rains. One-tenth sediment.
~1+350	Large cavity behind left panel and adjacent left panels are cracked. Cracked right panels.
1+500	Abandoned right CHO.
1+510 to 1+560	Most right panels are cracked, with some small holes. This condition will get worse with time. The right berm should be graded and sodded. All cavities should be filled.
~1+600 to 1+670	Cracked right panels. Right berm needs grading and sodding and cavities filled. Also, some cracked left panels. One-tenth sediment.
2+200	Drain Culvert. Outlet is concrete pipe, which looks good because there is no erosion.
1+300 to 2+500	Most right panels are cracked and some cracks are getting wider. Also, some cracks in left panels. The main problem is the right berm, which is quite high, so that soil settlement has occurred, in addition, there are cavities behind the right panels. This entire reach needs serious attention by grading and sodding right berm and filling cavities.
2+800	Two CHO's, both are good, except concrete walkway panels are missing. Left CHO has cavity at endwall. Left outlet structure is good except for 10 m long crack in floor that should be sealed with asphalt. Right outlet structure has cavity at headwall. Some cracks in panels.
3+000	Concrete Bridge is structurally very good. Huge cavities behind left panels and left panels are cracked.
	- Right berm needs grading.
~3+160	Three right panels cracked.
~3+300	Eight right panels are cracked with vegetation growing in three panels.
~3+400	About 20 m and then 15 m of cracked right panels. Right berm needs grading.
~3+500	Left CHO [not listed]. First gate and frame missing. Concrete walkway panels missing. Large cavity on upstream wall. Outlet structure has cavities behind left and right panels, which are badly cracked and has holes in the panels.
	- Right berm needs grading and sodding.
3+635	Roadway Culvert Inverted Siphon. Inlet has double gates. Inlet is good, but needs sediment removed.

	Outlet structure is good. [Udon-Sakhon Nakhorn highway].
3+700	Two CHO's, both good. Right outlet structure is good. Left outlet structure has large cavities behind left and right panels and under floor. This needs correction to prevent eventual failure of the structure.
	- One-twentieth sediment.
~4+200	[Listed as 4+000] Left CHO has huge cavity on downstream wall and small cavities on upstream wall and endwall. Concrete walkway panels are missing. Outlet structure has cavities and holes that need repair.
~4+400	[Listed as 4+200] Right CHO is good except concrete walkway panels are missing. Outlet structure has failed except for headwall.
4+780	Wasteway Structure. This structure has a large gate in center flanked by overflow weirs. Looks very good. Could use some compacted backfill behind right wingwall of outlet structure.
5+100	Left CHO is good, except concrete walkway panels are missing and there is a cavity along upstream and downstream walls. Outlet structure is good, but has a few small holes on left and right panels.
5+110	Concrete Bridge is good. Cracks in right panel underneath bridge.
5+400	Right CHO is good except concrete walkway panels are missing. Outlet structure is good.
	- One-tenth sediment and aquatic growth.
~5+800	Thirty m of cracked right panels. Four left panels are bulging, with two having already failed, and another three left panels with cracks.
5+850	Concrete Bridge [not listed] is structurally good but has huge cavities behind left panels under bridge.
5+850 to 5+870	Many cavities behind left panels.
5+900	Pump Lift Structure with three pumps. Could not discuss pump operation because there was no attendant. At end of pump outlet structure transition, there is an overflow weir. Concrete structures look good.
~5+950	Double CHO Regulator for Lateral L-1L-2L.
6+150	New CHO being constructed.
6+160	Concrete Bridge is structurally good. Small cavities on upstream abutments with crack in right panel.
6+275	Right CHO is very good. Outlet structure has failed endwalls because of serious erosion. Needs new panels plus rubble masonry at endwalls.
6+300	Roadway Culvert with inlet gate. Inlet structure is good. Outlet structure is good.

~6+310	Two failed left panels.
~6+450	Right CHO [not listed]. CHO is good. Outlet structure is good, but could use rubble masonry at endwalls.
	- One-fifteenth sediment.
6+725	Concrete Bridge is structurally good. Right abutments have cavities.
6+800	Vertical Drop Structure is good, but railing is missing. Cavity and eroded concrete joint on left side at end of this structure. Practically no sediment for 30 m.
	- One-tenth sediment and vegetation.
7+000	Right CHO is good. Outlet structure is good, but needs compacted backfill behind endwalls and rubble masonry at endwalls.
~7+150	Hole in right panel joint.
7+225	Concrete Bridge is structurally good. No cavities and no panel cracks.
7+300	Left CHO is good, but concrete walkway panels lying in lateral. Outlet structure is good, but needs rubble masonry at endwalls.
	- Right berm needs grading.
	- One-tenth sediment.
7+450	Cracked left panel.
7+700	Right CHO is good. Outlet structure is good, but needs rubble masonry at endwalls.
	- One-fifteenth sediment.
8+050	Drain Culvert. Both inlet and outlet structures are good.
8+189	Concrete Bridge is good.
8+200	Two CHO's are good. Right outlet structure is good. Left outlet structure is good, but needs rubble masonry at endwalls and rubble masonry for cascading floor to dissipate excess hydraulic energy.
8+240	Drop structure with inlet gate and USBR VI. Inlet structure is good. Outlet structure is good.
	- Practically no sediment (one-twelfth).
8+360	Drain Culvert. Inlet structure is good, but could use more compacted backfill around headwall. Outlet structure is very good.
	- One-tenth sediment.
8+700	Two CHO's are good. Right outlet structure has 1 m of right endwall and floor that has failed. About 40 cm drop, so failure will continue. Replace failed sections, place compacted backfill behind walls and under floor, and place rubble masonry at endwalls and install

cascading floor. Left outlet structure has failed except for headwall.

- One-sixth sediment.

~8+800 Concrete Bridge is structurally good. Cavity on right upstream abutment.

- One-fourth sediment.

9+000 One-sixth sediment.

9+200 Two CHO's are good, except concrete walkway panels are lying in lateral and used by fisherpersons. Right outlet structure has last 1 m of lining failed and endwalls are being undermined. Needs compacted backfill and rubble masonry at endwalls and cascading floor. Left outlet structure has same condition as right outlet structure, plus a cavity near headwall.

9+310 End of concrete lining. There is no Tailgate Regulator or Final Outlet Structure. The water runs from the end of lining and bends right to cascade to lower lying lands to right of lateral.

Note: Most of the lining from the Lift Station has lower lying land on both sides of lateral, so as expected, the lining is very good.

Sub-Lateral L-1L-1L (3.400 km)

0+000 CHO Regulator has first gate and frame missing, otherwise structurally good.

- One-third sediment.

~0+025 Cracked left and right panels.

- Road on right.

~0+040 Cavity behind right panel.

~0+075 Large cavity behind right panel.

~0+080 Large cavity behind two right panels with cracked lining and displacement.

0+100 Right CHO is good except for cavity on downstream wall and concrete walkway panels missing. Outlet structure is good except for 10 x 20 cm hole in left panel near floor.

- One-third sediment.

~0+130 Vegetation growing in joints. Apply asphalt.

~0+160 Cavity behind right panel.

0+308 Drain Culvert. Could not see because covered with ponded water. Farmers said there is no drain culvert.

~0+650 Concrete Bridge. Cavity behind left panel [not listed].

~0+750	Cracked left panels.
~0+775	Cavity behind left panel and hole in lining that will continue to get worse.
0+800	Hole in left joint.
0+850	Right CHO has first gate and frame missing and concrete walkway panels missing. Outlet structure is good.
1+000	Cavities behind left panels and holes in lining. Also hole in right panel. Two-thirds water.
~1+050	Hole in left panel and cavity behind right panel.
~1+100	Holes and cavities in right panels.
~1+150	Many cavities and holes in lining on both sides for 40 m. Left berm needs to be cut down for 200 m and surface drainage provided on right side of right roadway for 200 m. Animal crossing has added to erosion problems and two-thirds sediment for 40 m. Concrete bridge would alleviate this problem.
~1+200	Large hole in two left panels. Sixty percent sediment.
~1+250	Three failed left panels resulting from surface drainage from paddy fields. Reconstruct left berm, pond water, and provide surface drainage outlet. One-half sediment.
~1+275	Many cavities behind left panels.
~1+300	[Listed as 1+100] Right CHO has concrete walkway panels missing. Broken panels on both sides of CHO. Outlet structure is good except for hole in downstream bend. CHO has much sediment.
	- One-half sediment.
~1+400	Cavities behind both left and right panels.
1+500	One-third sediment.
~1+550 to 1+650	Many cavities, many cracked panels, and many bulged panels which will eventually fail.
~1+750	Drain Culvert [not listed]. Outlet has pipe outlet structure that can be partially seen under the water. Inlet is also covered with water.
~1+900	Cavities behind left panels and cracked panels.
2+000	Right CHO has first gate and frame missing. Also, second gate is missing. Concrete walkway panels are missing. Outlet structure is good.
	- One-third sediment.
	- One-half sediment for 60 m.
	- One-third sediment.
2+425	Displaced left panel.
2+450	Left CHO has first gate and frame missing and concrete walkway panels are missing. Outlet structure has

serious erosion near headwall so that concrete pipe is exposed. Some of left panel is broken.

2+465 Top half of left panel has cracked and settled.

2+600 Vertical Drop Structure is good except for cavity at left upstream wall.

- One-third sediment.

~2+700 Cavities behind two right panels and one right panel has been displaced. No water.

~2+740 Cavity behind right panel. Left berm needs grading.

~3+100 Roadway erosion.

~3+200 Cavities behind two right panels that have become displaced. One-third sediment.

3+300 Two CHO's have concrete walkway panels missing. Cavity on upstream wall of left CHO. Right outlet structure is good. Left outlet structure has concrete pipeline, which is good, except for cavity near pipe outlet.

3+420 Left concrete overflow structure is good, but needs more rubble masonry at bottom of outlet chute.

3+425 Final outlet structure with single gate. Inlet structure is good. Outlet structure has headwall in place, but rest of structure has failed because of 20 cm drop.

From 0+900 to 2+000 open drain is needed to right of right roadway. From 0+900 to 2+400 an open drain is needed adjacent to left berm because this land is as high as the top of the concrete lining. This will be relatively easy construction. Left berm should be cut down ~50-80 cm.

Sub-Lateral L-1L-2L (6.500 km)

0+000 Double CHO Regulator, good. Outlet structure is good.

- Small amount of sediment (one-fifteenth).

~0+090 Concrete Bridge is good.

~0+100 Left CHO is good. Outlet structure is good, but could use rubble masonry at endwalls.

0+200 Right CHO is good. Outlet structure is good, but needs compacted backfill along left panel and endwalls. Needs rubble masonry at endwalls.

- One-eighth sediment.

0+700 Two CHO's. Right CHO needs second gate frame repaired. Right outlet structure is good, but could use rubble masonry at endwalls. Left CHO and outlet very good.

- One-sixth sediment.

1+200	Two CHO's are good. Left outlet structure is good but has sediment and shrubbery. Right outlet structure is good, but has sediment.
1+220	CHO Regulator for Lateral L-1L-2L-1R.

- One-eighth sediment.

~1+400	Concrete Bridge is structurally good. Has a large cavity on left downstream abutment and two left panels are cracked.
~1+475	Large cavity behind left panel.
1+550	Two CHO's are good except for cavity on left CHO on downstream wall. Left outlet structure has broken right panel, failed floor 1.5 m long, and needs rubble masonry at endwalls and floor. Right outlet structure is good.
1+675	Drain Culvert. Inlet and outlet structures are good.
1+925	Concrete Bridge is structurally good. Cavity of right upstream abutment, but no cracks in lining. One-eighth sediment.
1+950	Two left panels with cracks.
2+100	Left CHO is good. Outlet structure has broken left panel that has failed. This structure needs rubble masonry at endwalls and cascading floor to prevent further failure.
2+355	Roadway Culvert with double inlet gates, good. Outlet structure is good.
2+400	Left CHO is good except for cavity on left upstream wall that has caused vertical crack in left panel. Outlet structure is good, but needs rubble masonry at outlet floor.

- One-eighth sediment.

~2+550	Right CHO is good except concrete walkway panels are missing. Outlet structure is good.
2+625	Concrete bridge is structurally good. Cavity on right downstream abutment which has caused crack in right panel.
2+750	Drain Culvert. Both inlet and outlet structures are good.
2+900	Left CHO is good. Outlet structure has failed except for pipe outlet structure, which may also fail.
2+985	Concrete Bridge is good. No cavities.
3+200	Left CHO is good. Outlet structure is good, but much sediment and shrubbery.
3+300	Left turnout structure with one gate. Outlet structure is good, but needs rubble masonry at endwalls.

- Sediment placed on right edge of left berm.

3+605 Roadway Culvert with double inlet gates. Inlet structure is good. Outlet structure is good.

- One-eighth sediment.

3+900 Right CHO has cavity on upstream wall and concrete walkway panels in lateral. Outlet structure is good.

3+916 Left CHO is good. Outlet structure is good, but could use some compacted backfill and rubble masonry at endwalls.

~4+250 Concrete bridge is good. No cavities and no cracks in panels.

4+350 Left CHO is good. Outlet structure is good.

4+400 Right CHO is good. Outlet structure is good, but could use rubble masonry at end of structure.

~4+650 Constructing new left CHO.

~4+700 Concrete Bridge [not listed] is structurally good. No cavities.

4+850 Left CHO is good. Outlet structure has failed.

- Left berm has sediment piled on edge, which is eroding back into lateral.

- Sediment is 10 cm deep.

~4+950 Constructing new right CHO.

~5+100 Constructing new left CHO.

5+290 Drain Culvert. Could not find at this listed station.

5+320 Roadway Culvert with inlet gate. Inlet and outlet structures are good.

5+550 Right CHO is good. Most of outlet structure has failed because of 30 cm drop.

~5+600 Cavity behind left panel. One-sixth sediment.

~5+700 Cavities behind left panels and holes in left panels.

5+940 Concrete Bridge is structurally good. No cavities.

5+950 Two CHO's are good except concrete walkway panels are in lateral. Right outlet structure is good. Left outlet structure is good, but needs rubble masonry at endwalls.

6+050 Drain Culvert. Inlet structure is good, but outlet needs sediment removed.

~6+175 Holes in two left panels.

6+280 Concrete Bridge is structurally good. No cavities and no cracks.

6+520 Left CHO is good. Outlet structure has left panel broken and cracks in left and right panels and needs rubble masonry at endwalls.

6+525	Right CHO is good, but has no concrete walkway panels. Outlet structure is good, but has huge cavity behind headwall and endwalls are being undermined. Needs compacted backfill and rubble masonry at endwalls.
	- One-sixth sediment.
~6+700	Erosion of left berm that has not damaged left panel yet.
6+850	Two CHO's have concrete walkway panels in lateral and on bank. Small cavity on upstream wall of left CHO. Both outlet structures are good, but need rubble masonry at endwalls.
	- Sediment piled on left berm.
~7+250	Cavities behind five right panels.
	- Grade roadway for surface drainage.
7+380	Final CHO outlet structure is good, but concrete walkway panel is in CHO. Outlet structure is good, but needs rubble masonry at endwalls.
	Most of this lining is very good because land on both sides is below lateral.

Sub-Lateral L-1L-2L-1R (1.500 km)

0+000	CHO Regulator is good. Outlet structure is good.
	- One-fourth sediment.
0+070	Concrete bridge is structurally good. No cavities and no cracks.
0+300	Concrete Bridge is good.
~0+450	New left CHO being constructed.
~0+520	New right CHO being constructed.
0+550	Vertical Drop Structure is good, except railing is missing.
	- One-fourth sediment and vegetation.
0+700	Drop structure without inlet gate. Huge cavity near headwall. USBR VI is good.
	- One-half sediment for 30 m, then one-fourth sediment.
0+850	Drain Culvert. Both inlet and outlet structures are good.
0+900	One-third sediment.
0+950	One-fourth sediment.
1+000	Two CHO's have concrete walkway panels in lateral. Right CHO needs first gate repaired. Right outlet

structure has mostly failed, but drop in W.S. only 10-15 cm. Left outlet structure has also mostly failed.

1+100 One-third sediment.

1+200 One-fourth sediment.

1+300 One-third sediment.

1+450 Left CHO is good. Outlet structure has half failed because of too much drop.

1+500 Tail Regulator without gate. Both inlet and outlet structures are good.

Lateral L-1R (6.624 km)

0+000 CHO Regulator good but has cavities on both sides at corner of lining panels. Outlet broken-plane transition has LMC roadway erosion into structure; otherwise, very good.

- Very little sediment, but some aquatic growth.

~0+150 Hole and crack in right panel.

0+200 Right CHO, good. Outlet structure, good, but could use rubble masonry at endwalls.

0+300 Drop structure with inlet gate and USBR VI. Inlet structure, good and outlet structure, good. [Note: There is no hole in the joints at last joint of outlet transition structure.]

- One-eighth sediment and aquatic growth.

~0+400 Erosion from right berm at a number of locations. Surface drainage needs to be designed and constructured for ~100 m.

0+700 Drain Culvert has serious erosion of right berm over inlet structure headwall so that right panel is exposed for 1 m. Outlet structure, good.

- One-eighth sediment, mostly laterite, plus some aquatic growth.

1+000 Drop structure with inlet gate and USBR VI. Inlet structure, good, but has cavities alongside both walls. Outlet structure, good. [No holes in joints at end of outlet transition.] Right panel 6 m downstream is cracked.

1+200 Drain Culvert. Inlet structure is okay, but could use some compacted backfill behind the headwall and wing-walls. Outlet structure has erosion around headwall, so compacted backfill is needed.

1+220 Horizontal cracks with holes and holes in joints in three left and right panels.

~1+300 Horizontal crack in six left panels.

- One-eighth sediment and aquatic growth.

1+600	Two CHO's. Right CHO, good, except for small cavity on upstream wall and large cavity at endwall. Left CHO, good, except for cavity on upstream wall. Both outlet structures are very good.
1+850	Drop structure with inlet gate and USBR VI. Inlet is structurally good but has cavities on both sidewalls and endwalls. There are large cavities over concrete pipe between inlet and outlet structures. Outlet structure, good.
	- Practically no sediment.
2+100	Two CHO's, good, except for small cavity at left CHO endwall. Right outlet structure has large cavity at headwall and hole in headwall lining. Left outlet structure is good except for cracks in right panel.
2+350	Drop structure with inlet gate and USBR VI. Inlet structure is good except for a small cavity behind headwall. Serious problem of huge cavities over concrete pipe between inlet and outlet structures; suspect they are caused by leaky joints in concrete pipe. Outlet structure is good. Hairline cracks in right panels.
2+500	Drain Culvert. Inlet structure looks good, but difficult to inspect because of heavy shrubbery. Outlet structure is good.
2+650	Left CHO, good, except concrete walkway panels missing. Outlet structure has failed left panel.
2+800	Left CHO is structurally good but second gate is missing. Outlet structure has large cavity behind headwall and structure has completely failed.
2+825	Right CHO, good, but concrete walkway panels missing. Outlet structure has large holes in left panels.
	- Very little sediment.
3+025	Drop structure with inlet gate and USBR VI. Inlet structure, good, but a small cavity near headwall. Cavities over concrete pipeline between inlet and outlet structures. Outlet structure is very good.
	- One-third sediment and aquatic growth.
~3+100	Surface drainage from paddy field over right panel.
~3+200	Hole and cracks in right panel.
~3+250	One-fourth sediment.
3+400	Inlet structure conveying surface drain into lateral, good. [However, I don't like this type of structure.]
3+680	Roadway culvert without inlet gate. Inlet structure, good. Outlet structure, good.
	- One-third sediment.

3+750	Two CHO's. Left CHO is good and left outlet structure is good. Concrete walkway panels missing on both CHO's. Right CHO and outlet structure is good.
3+900	Left CHO is good. Outlet structure has cavity behind headwall and 10 cm diamater hole in left panel.
	- One-fourth sediment.
4+200	One-third sediment and vegetation.
4+400	One-fourth sediment.
4+500	Left CHO needs first gate replaced. Outlet structure is gone except for pipe outlet structure because of large downstream drop.
4+600	Concrete bridge is structurally good, but there are cavities behind the right panels and there is a small hole in the left panel.
	- One-fourth sediment and aquatic growth.
4+620	Hole in right panel.
4+700	One-third sediment and vegetation.
4+800	One-fourth sediment and aquatic growth.
5+200	Left CHO has cavity along downstream wall and missing second gate, but gate frame in-place. Serious roadway erosion behind outlet structure headwall. Pipe outlet structure is in place but rest of outlet structure is gone.
	- One-fourth sediment.
5+600	One-fifth sediment.
5+700	Two CHO's. Left CHO is good, but has cavity on downstream wall. Left outlet structure has serious erosion above headwall and concrete outlet basin has failed. Right CHO is good. Right outlet structure consists of a pipe outlet structure that is in good condition.
5+713	Check structure, good.
5+723	Failed right panel that needs replacement.
5+800	One-third sediment and vegetation
6+100	Left CHO is good. Outlet structure is good except for holes along right panels. Heaviest damage due to excavation of soil behind right panel by farmer.
	- One-third sediment.
6+410	Tailgate Regulator is good including pipe outlet structure. Holes in nearby concrete panels.
~6+500	Final outlet structure without gate, good. Outlet structure is good except for a hole in both left and right joints. [Note: Inlet of final outlet structure has painted in black and yellow 6+500 km.]

Note: ~6+250 is CHO Regulator for Lateral L-1R-1L.

Note: Lining is very good, mostly because the land on both sides of lateral is usually lower than the elevation of the lateral.

Sub-Lateral L-1R-1L (1.170 km)

0+000	CHO Regulator, good, except second gate and frame is missing. Outlet structure is good.
	- One-fourth sediment.
0+100	Drain Culvert [could not find].
0+180	Drain Culvert. Inlet structure is good, but dammed by fisherperson and outlet structure almost completely covered with sediment. Roadway erosion. Extend pipe.
0+200	Two CHO's. Right CHO is good. Pipe outlet structure looks good, but cannot see bottom half because of ponded water. This right outlet feeds same pond that is inlet to drain culvert. Left CHO and outlet structure, good.
0+300	Concrete bridge [not listed] is good except for busted upstream railing, which looks like someone wanted the two pipe rails. Small hole in right panel. One-fourth sediment.
0+400	One-third sediment and vegetation.
~0+650	Drain Culvert [not listed].
	- One-half sediment.
~0+800	Right berm erosion into lateral.
	- Sixty percent sediment.
0+900	Three-fourths sediment.
1+000	Right CHO is good except concrete walkway panels not installed. Pipe outlet structure is good. Twenty meters downstream is roadway culvert with failed length of concrete pipe.
1+162	Tail Regulator. Inlet structure is good. Outlet structure is good, but much sediment.
1+170	CHO Regulator for Lateral L-1R-1L-1R.

Sub-Lateral L-1R-1L-1R (1.569 km)

0+000	CHO Regulator has no gates. Outlet structure, good.
	- Three-fourths sediment.
0+300	Two CHO's, good, but second gates and frames are missing. Left outlet structure is probably good but completely filled with sediment. Right outlet structure

has crack along top of right panel and half filled with sediment.

- Ninety percent sediment.
- Water level above top of lining.

1+000 Two CHO's with concrete walkway panels and second gates and frames missing. Both outlet structures in-place but covered with sediment. Water level in lateral is above lining and ~ 10 cm below top of CHO walls. [Note: A few cavities behind panels can be observed. Undoubtedly there will be many cavities since the water level is above the lining.]

~1+300 Failed left panels.

1+450 Roadway culvert. Inlet structure is good. Outlet structure is good, but has sediment and vegetation.

1+569 Final Outlet Structure. CHO without second gate, needs compacted backfill along walls to prevent cavities behind lining. Pipe outlet structure can be seen below water.

Lateral L-2L (3.500 km)

0+000 Open channel inlet to Regulator at 0+060. Cavities behind right panels.

0+060 Regulator for Lateral L-2L. Cavity behind right panel at inlet to transition structure, otherwise inlet structure with single large gate is good. Regulator includes culvert under Udon-Sakhon Nakhorn highway. Outlet structure is good, but many cavities behind left wall.

- One-fourth sediment.

~0+300 Crew is presently constructing CHO.

0+500 Left CHO is good except concrete walkway panels are missing. Outlet structure is very good structurally, but has cavity at headwall and left panel.

0+825 Large cavity behind left panels and top portion of left panel is broken.

0+850 Right CHO is good, except for small cavity on upstream wall and concrete walkway panels are missing. Outlet structure is very good.

- One-fifth sediment.
- Roadway needs grading so surface drainage will flow to right away from lateral.

1+300 Concrete Bridge is structurally good, but has cavity on right downstream abutment with cracking of right panel.

1+310 Hole in left panel.

1+340	Hole in left panel. One-fifth sediment.
~1+490	Left CHO [not listed]. Cavities on both abutments and huge cavity over concrete pipeline. Concrete walkway panels are missing. Outlet structure is good structurally, but has cavities.
1+500	Floor of lateral badly broken and should be fixed soon.
1+510	Concrete Bridge is good. Cracked left panel.
~1+850	CHO Regulator for Lateral L-2L-1R.
~1+860	Badly cracked left panels.
~1+900	Cracks in left panels.
1+919	Check structure is good, but walkway panels are missing.
	- One-fourth sediment.
~2+300	Concrete Bridge [not listed] is structurally good except top pipe railing on upstream side is missing and there is no downstream railing. No cavities.
~2+600	[CHO's listed, but not there.]
~2+600	Holes in left panels.
~2+800	New pipe outlet in left panel, not very appropriate.
	- Need surface drainage channels on left and right sides.
3+100	Two CHO's are good, except first gate missing on each CHO and concrete walkway panels are missing. Left CHO has cavity on upstream abutment. Left outlet has hole in lining in left and right panels. Right outlet structure is good.
	- One-fourth sediment.
~3+200	Right CHO is good except first gate is missing. Outlet structure has failed floor and inal left panel failed. This structure could be easily salvaged with rubble masonry.
~3+239	Left Tail Regulator is good, but has huge cavity over concrete pipeline, which has failed. Pipe outlet structure is good.
	- One-fifth sediment.
3+500	Final CHO outlet structure with first gate missing and concrete walkway panels missing. Large cavity near headwall. Outlet structure is good.

<u>Sub-Lateral L-2L-1R (2.880 km)</u>

0+000	CHO Regulator has second gate missing and cavities on both abutments. Outlet broken-plane transition structure is good.
	- Roadway and berm erosion. Needs surface drainage channels on both sides.

0+095	Concrete Bridge is good. Left panel is cracked, with cavity behind left panel.
~0+110	Cavity behind left panel.
~0+120	Cavity behind left panel and panel joint is displaced.
	- One-sixth sediment.
~0+170	Cavity behind left panel and small hole in left panel.
~0+180	Cracked left panel.
~0+185	Holes in left panel joint.
~0+250	Cracked right panel. One-eighth sediment.
~0+275	Hole in right panel.
0+300	Two CHO's have concrete walkway panels missing. Left CHO has large cavity on downstream wall and headwall. Left outlet structure is good. Right outlet structure has large broken piece in left panel and cavities along left panels.
	- There is surface drainge on both sides.
0+395	Have excavated hole in right side, probably for new CHO.
0+450	Right CHO is good, but concrete walkway panels are missing. Pipe outlet structure feeds concrete pipeline, which is good, but pipeline outlet and downstream lining has badly failed.
0+485	Surface erosion from left berm has left panel exposed.
0+500	Drop structure with inlet gate and USBR VI. Inlet structure is good, but has cavities along both sidewalls. Near inlet, compacted backfill is needed on right side. Outlet structure is good, but has a cavity near right corner of headwall.
	- One-half sediment with much of lining covered with vegetation.
~0+825	Left overflow structure is good, but could use rubble masonry at end of structure.
0+928	Concrete bridge is structurally good, but three of the four pipe railings are gone. Needs roadway fill on left side. No cavities.
	- One-half sediment.
~1+000	Roadway needs grading to provide surface drainage away from lateral. There is surface drainage on both sides.
1+500	Two CHO's are good, but concrete walkway panels are missing. Left outlet structure has failed, including last three lengths of concrete pipe. Right pipe outlet structure feeds concrete pipeline; there is considerable need for compacted backfill around concrete pipe upstream from outlet and lined channel downstream, which has much exposed lining and many cavities.

1+600	Vertical Drop Structure is good, but railing is missing.
	- One-half sediment.
2+000	Left CHO is good, but concrete walkway panels are missing. Outlet structure has completely failed. Only first length of concrete pipe is attached to CHO. Large cavities along downstream CHO wall and headwall.
	- Left berm needs grading. One-third sediment.
~2+400	One-half sediment.
2+630	Tail Regulator with single gate is very good. Outlet structure is under water and cannot be seen.
	- One-fourth sediment.
2+880	Final CHO Outlet Structure. CHO is good, but concrete walkway panels are missing. Outlet structure is very good.

Lateral L-3L (0.835 km)

	Note: There is no control structure at the entrance to Lateral L-3L. Instead, the Pump Lift Station at 0+211 serves as the control and the distance 0+000 to 0+211 is a forebay.
0+065	Roadway Culvert under Udon-Sakhon Nakhorn highway. Inlet and outlet structures are good.
	- One-sixth sediment for 20 m.
~0+125	Double concrete pipe culvert inflow into lateral.
~0+160	About one-fourth of left panel gone.
0+000 to 0+180	Three places presently having water seep over top of left panels.
0+211	Pump Lift Station (three pumps). Only Pump No. 3 can presently operate. Pumps No. 2 and No. 1 have a problem with the transformer as stated by Assistant Pump Operator, who reported this condition to LNO O&M on Nov. 1. Only once in awhile does a serious problem occur with the pumps, usually there are only minor problems. Inlet and outlet structures are good.
	- Lining looks very good and land on both sides of lateral is approximately 10 m below lateral invert.
	- Road on right. Right bank has some erosion.
~0+300	Six left panels have horizontal cracks.
~0+500	One-twelfth sediment.
0+560	Right CHO is good except concrete walkway panels are missing. Outlet structure has failed except for pipe outlet structure, which will probably fail soon.
	- Right road bank erosion.
0+570	Small holes in left panel.

~0+650	Large cavity behind left panel with bulging in one panel and two panels will fail.
0+745	Cavity behind left panel and hole in left panel.
0+750	Failed left panel resulting from pond drainage into lateral. Right panel has a large hole at joint floor.
0+755	Cavity behind right panel.
0+760	Concrete Bridge is structurally good but has large cavities on left upstream and downstream and right downstream abutments. Right panel is badly cracked near top.
0+770	Cavity behind left panel. Two left panels are badly cracked. Hole in another left panel with vegetation growing.
0+790	Huge cavity behind two right panels with bulging of both panels and a hole in one right panel. Both panels will eventually fail completely unless these cavities are filled soon and cracks sealed.
0+800	Double CHO Regulators for Laterals L-3L-1L and L-3L-1R.

Sub-Lateral L-3L-1R (3.173 km)

0+000	Double CHO Regulator is good. Outlet broken-plane transition structure is good.
0+040	Right CHO is structurally good but concrete walkway panels are missing and the panels on both sides have large cavities and lining is broken. Outlet structure has completely failed including last two lengths of concrete pipe.
0+043	Top third of left panel is gone and needs repair.
	- One-eighth sediment (measured as 9.5 cm).
0+050	Left berm erosion (road on right).
0+200	Left berm erosion.
	- One-sixth sediment.
0+450	Right CHO is good except concrete walkway panels are missing. Outlet structure has failed except for pipe outlet structure, which will also likely fail.
0+500	Drain Culvert. Inlet and outlet structures are good.
0+650	Right CHO is good except concrete walkway panels are missing. Outlet structure has serious erosion problem, which will eventually cause failure of the concrete pipe and pipe outlet structure.
	- One-eighth sediment.
~0+850	Erosion over left panel and sediment boil at bottom of left panel joint.
~1+000	One-sixth sediment.

1+050	Right CHO is good except concrete walkway panels are missing. Outlet structure has failed except for pipe outlet structure. Rubble masonry at end of pipe outlet structure would be sufficient.
	- One-eighth sediment.
1+400	Right CHO is good except concrete walkway panels are missing. Pipe outlet structure is good.
	- One-sixth sediment.
~1+700	Hole in left panel.
1+800	Vertical Drop Structure is good but railing is missing.
	- One-eighth sediment for 50 m.
1+850	Drain Culvert. Both inlet and outlet structures are good, except for left berm erosion [listed as 1+950].
	- Practically no sediment.
~1+920	Hole in left panel.
2+000	Left berm erosion.
2+100	Right CHO is good except concrete walkway panels are missing. Pipe outlet structure is good.
2+270	Roadway Culvert with double gates. Inlet and outlet structures are good.
2+300	The lateral grade downstream must be much flatter than upstream because there was practically no sediment upstream, but there is 13 cm of sediment downstream.
2+350	Right CHO is good except concrete walkway panels are missing. Pipe outlet structure is good, but being undermined, so rubble masonry is needed.
2+360	Left CHO is good except concrete walkway panels are missing. Pipe outlet structure is good.
2+430	Drop structure with gate and USBR VI. Inlet and outlet structures are good.
	- Fifteen cm of sediment.
2+500	Ten cm of sediment
2+600	Twelve cm of sediment.
2+820	Wasteway [could not find].
3+170	End of Sub-Lateral L-3L-1R and Regulator for Sub-Lateral L-3L-1R-1L and Sub-Lateral L-3L-1R-1R.

<u>Sub-Lateral L-3L-1R-1R (3.500 km)</u>

0+000	CHO Regulator is good. Outlet broken-plane transition structure is good.
	- One-eighth sediment.

0+100 Right CHO is good except concrete walkway panels are missing. Outlet structure is good.

0+120 Drop structure with inlet gate and USBR VI. Inlet structure is good. Outlet structure is good.

- Lateral is presently being cleaned.

0+200 Left CHO needs second gate repaired and concrete walkway panels are missing. Outlet structure has failed except for pipe outlet structure.

0+330 Drain Culvert. Inlet structure difficult to see because of vegetation. Outlet structure is good, but has much sediment.

0+535 Roadway Culvert without inlet gate. Inlet structure is good, but needs sediment removed. Outlet structure is good.

- One-sixth sediment.

0+800 Drain Culvert. Inlet and outlet structures are good.

1+060 Two CHO's are good except concrete walkway panels are missing. Left outlet structure has cracks and erosion at endwalls. Right outlet structure also has erosion at endwalls. Needs rubble masonry at endwalls.

- One-eighth sediment.

1+500 Two CHO's are good except concrete walkway panels are missing. Left outlet structure has half of structure failed because drop is too much. Right outlet structure is good, but endwalls need rubble masonry and 1 m of floor has failed, which needs rubble masonry cascading floor. There is a cavity in center of road (right) over concrete pipe.

- One-sixth sediment.

1+600 Vertical Drop Structure is good, but rails are missing and both downstream berms need shaping.

- Very little sediment.

1+715 Drain Culvert. Inlet and outlet structures are good, but inlet has too much vegetation.

2+100 Two CHO's. Right CHO needs second gate repaired. Right outlet structure has failed earlier, but maintenance has salvaged this structure; also needs compacted backfill under floor and rubble masonry cascading floor. Left CHO has no outlet structure. CHO walkway panels are missing. Huge block of concrete in lateral should be removed and transported away.

2+270 Drain Culvert. Both inlet and outlet structures are good.

- Removed sediment on left berm and placed on edge of lateral.

- One-sixth sediment.

2+500 Two CHO's are good but concrete walkway panels are missing. Left outlet structure is good except for two cavities behind headwall and right endwall needs compacted backfill and rubble masonry. Right outlet structure has failed except for pipe outlet structure. There is a large cavity over right concrete pipeline.

- One-sixth sediment.

~2+750 Animal crossing. Could install small bridge.

2+850 Roadway erosion that needs repair.

2+900 Left CHO is good except concrete walkway panels are missing. Outlet structure has many cavities along headwall, otherwise structure is very good. Filling these cavities soon will leave this structure in good condition.

- One-eighth sediment.

3+080 Roadway Culvert without gate. Inlet structure is good. Outlet structure is good.

- One-eighth sediment.

3+475 Two CHO's are missing concrete walkway panels. Left CHO has second gate missing. Left outlet structure has erosion along headwall and right panel, left panel has broken from headwall, and endwalls need compacted backfill and rubble masonry or entire left panel will fail soon. Right CHO is good. Right outlet structure can be salvaged if compacted backfill is placed behind left and right panels and rubble masonry is placed at endwalls and floor.

3+500 Tail Regulator with one gate. Inlet structure is good. Outlet structure is good.

This lining is very good because, in general, the land on both sides is below the lateral invert. However, this situation results in the CHO outlet structures having too great of a drop and then failing.

Sub-Lateral L-3L-1R-1L (1.920 km)

0+000 Double CHO Regulator is good and outlet structure is good, but needs sediment removed.

0+100 Two CHO's. Right CHO has cavities behind adjacent panels with broken panels and concrete walkway panels are missing. Right pipe outlet structure is good. Left CHO is good but concrete walkway panels are missing. Left pipe outlet structure is good.

- One-sixth sediment.

0+200	One-eighth sediment.
	- Left joints are leaking.
0+400 to 0+900	Sediment piled on left berm and much of it will be washed back into lateral.
0+535	Concrete Bridge is good.
	- One-tenth sediment.
~0+800	Top third of right panel gone and hole in nearby left panel.
~0+820	Hole in left panel.
0+930	Two CHO's are good except concrete walkway panels are missing. Pipe outlet structures are good.
	- Practically no sediment.
0+990	Erosion behind left panels for 5 m that should have compacted backfill.
1+000	Drop Structure without gate and USBR VI. Inlet and outlet structures are good.
	- One-eighth sediment.
1+100	Two CHO's are good except concrete walkway panels are missing. Left pipe outlet structure is good, but has erosion that is serious and needs correction. Right pipe outlet structure also has serious erosion problem that will result in eventual failure of the structure.
1+175	Drop structure with inlet gate and USBR VI. Inlet structure is good. Roadway erosion that must be corrected. Outlet structure is good.
1+200	Right CHO is good except concrete walkway panels are missing. Endwalls of outlet structure are being undermined and will fail if rubble masonry is not placed at the end of this structure.
	- One-twelfth sediment.
1+300	Left berm erosion.
	- Practially no sediment.
1+500	Drain Culvert. There is much vegetation growing in inlet structure. Outlet structure is good.
	- One-twelfth sediment.
1+800 to 1+850	Much erosion of left berm which will leave left panels exposed, so that they will crack and break. If corrected now, the lining will remain intact.
1+900	Two CHO's are good except concrete walkway panels are missing. Left pipe outlet structure has erosion above

headwall and serious erosion below. Right pipe outlet structure also has erosion erosion because of large drop (60 cm).

1+920 Tail Regulator with one gate. Inlet structure is good and pipe outlet structure is good, but it would be helpful to place rubble masonry in pool floor.

Sub-Lateral L-3L-1L (2.020 km)

0+000 Double CHO Regulator, good. Outlet structure is good.

- One-tenth sediment.

~0+150 Hole in right panel.

~0+200 Hole in right panel joint.

~0+220 Huge hole 1.5 m long in two left panels with cavities behind left panels.

~0+226 Hole in right panel joint.

~0+250 Five failed left panels resulting from cavities and roadway surface runoff.

~0+260 Hole in left panel joint.

0+270 Concrete Bridge. Huge cavities in upstream left panels that need immediate attention so that they will not fail. Bridge is good and no panels underneath are cracked. Huge cavities behind left panels downstream from bridge. Many broken and failed panels for 50 m. Major repair and replacement needed of panels plus surface drainage along right berm and cutting road to be lower and grading for surface drainage away from lateral.

- One-fourth sediment.

- Need right berm surface drainage from 0+150 to 0+600 and left of road drainage from 0+150 to 0+500.

0+500 Roadway cross slope causes rainfall to flow into lateral rather than away from lateral.

0+600 Left CHO is good. Outlet structure has failed over last 3 m because of 20 cm drop. Needs backfill and rubble masonry to save remaining structure.

0+620 Roadway Culvert with inlet gate and outlet structure. Cavity 4 m long on left panels upstream from inlet structure that should be filled before panels fail. Same is true on right panels. Outlet broken-plane transition structure is good. First right panel downstream has failed.

- One-half sediment.

- Land on both sides is below lateral.

1+100 Right CHO is good. All but headwall of outlet structure has failed, which will also fail.

- 0.4 sediment.

~1+200 Drain Culvert [listed as 1+120]. Inlet and outlet structures are good.

- One-third sediment.

1+350 Left CHO is good. Outlet structure has failed floor for 2 m and undermined endwalls. Compacted backfill and rubble masonry needed.

1+510 Vertical Drop Structure is good, but railing is missing.

- One-third sediment.

1+600 Drain Culvert. Inlet and outlet structures are good, but need more backfill around headwalls.

1+620 Left Wasteway with gate. Structure is good. Cavities in roadway over outlet barrel. Concrete pipe with concrete cradle is undermined at outlet, which requires compacted backfill plus rubble masonry.

1+630 Serious roadway erosion that needs correction.

- One-third sediment.

1+750 Left CHO is good. Hole in right panel opposite CHO. Outlet structure is good except for erosion at end of structure that needs rubble masonry work.

1+900 One-fifth sediment.

2+020 Final CHO Outlet Structure is good. Outlet structure has failed except for pipe outlet structure. Most of the outlet structure could be salvaged because large pieces are intact.

Sub-Lateral L-3L-1L-1L (1.900 km)

0+000 CHO Regulator is good. Outlet structure is good.

- Leaky panel joints.

~0+160 New left CHO, which is good, but rubble masonry should be placed at endwalls of outlet.

- Very little sediment.

0+285 Drop structure without inlet gate and USBR VI. Inlet and outlet structures are good.

- Sediment from lateral has been placed on left berm near edge of lateral.

0+400 Vertical Drop Structure is good except for cavities on both walls.

0+520 Two CHO's are good. Right pipe outlet structure is good, but could use rubble masonry. Left pipe outlet structure has erosion and needs rubble masonry.

0+550 Vertical Drop structure is good, but no railing.

- Practically no sediment.

- Land on both sides below lateral.

~0+900 Left berm eroded for 3 m and left panel exposed.

~0+950 Roadway erosion.

1+000 Drain Culvert. Inlet and outlet structures are good.

- Roadway erosion.

~1+100 Concrete Bridge [not listed] is structurally good. No cavities.

1+380 Right Wasteway with gate missing, and concrete walkway panels in structure. Outlet Culvert is good.

1+400 Two CHO's. Left CHO has second gate missing, but pipe outlet structure is good. Right CHO is good. Right pipe outlet structure is good.

~1+825 Cavities along right panels.

1+900 Final CHO outlet structure is good. Pipe outlet structure is good, but has cavities and erosion that should be corrected.

Sub-Lateral L-3L-1L-2L (6.320 km)

0+000 Double CHO Regulator, good. Outlet broken-plane transition structure is good.

0+020 Right CHO needs both gate frames firmly attached to the headwalls. Outlet structure has 1.5 m drop, so there is tremendous erosion, but most of outlet structure is intact. Large boulders should be temporarily placed in the pool bottom to prevent further erosion.

- Very little sediment.

- Sediment removed from lateral has been placed on right berm adjacent to lining, so that much of this sediment will be washed into the lateral during the monsoon rains.

0+500 Drain Culvert. Both inlet and outlet structures are very good.

0+550 Hole at joint in two left panels.

- One-twelfth sediment.

0+950 Drain Culvert. Outlet structure is good, but some sediment could be removed. Inlet structure is good.

1+300 Left CHO is good, but concrete walkway panels are missing. Pipe outlet structure is good.

- One-tenth sediment.

- Right berm needs grading.

1+310 Right CHO is good, but concrete walkway panels are missing. Outlet structure is good, but needs immediate attention to placement of rubble masonry at endwalls and

rubble masonry cascading floor before further downstream erosion results in failure of the outlet structure.

1+770 Left CHO is good except for cavity along downstream wall and concrete walkway panels are missing. Pipe outlet structure is good.

1+880 Road Culvert with double inlet gates. Inlet structure is good. Outlet structure is good.

- Sediment removed from lateral has been placed on right berm adjacent to lateral.
- One-tenth sediment.

From 0+000 to 2+000, the adjacent land has been lower than the lateral, so the lateral lining looks very good.

~2+150 Large cavity behind left panels.

2+350 Two CHO's are good, except concrete walkway panels are missing. Outlet is structurally good, but floor and walls are undermined for 1 m. There is approximately a 60 cm drop. Rubble masonry at endwalls and floor will prevent failure of this structure.

- Lateral is above adjacent land.

2+700 Drain Culvert. Outlet structure is good. Inlet structure on right side of lateral is structurally good, but capacity is reduced because of too much sediment.

3+000 Two CHO's, but have concrete walkway panels missing. Left CHO has cavity along downstream wall, which has caused hole in left panel. Left outlet structure has pipe outlet structure with much erosion. Right outlet structure is good, except left endwall needs compacted backfill and rubble masonry.

~3+200 Three cracked right panels.

- Roadway needs grading and laterite.

3+450 Drain Culvert. We could not find. Farmer said that it does exist. Retured later and found drain culvert. Both inlet and outlet structures are very good.

3+470 Wasteway. We could not find.

3+650 Left CHO is good, except concrete walkway panels are missing. Pipe outlet structure is good, but some erosion, so rubble masonry is needed.

3+695 Cracked right panel with small hole.

3+725 Concrete Bridge is structurally good. Large cavity on left upstream abutment.

3+735 Right Inlet structure for Sub-Lateral L-3L-1L-2L-1R. This inlet has a wood gate, but no metal gates.

~3+900	Right pipe outlet. Again, the inlet on right panel does not extend sufficiently into lateral for placement of a concrete lid, so that whenever there is water in the lateral, there will be water passing through this concrete pipe. At outlet end, the pipe should be extended and rubble masonry placed at outlet.
	- Practically no sediment.
~3+950	CHO Regulator Sub-Lateral L-3L-1L-2L-1L.
~4+000	Small pipe outlet with no control gate.
4+050	Left CHO is good except for very large cavity on roadway over concrete pipe. Pipe outlet structure is good.
4+145	Roadway Culvert. Inlet structure has no gate control, but is good structurally. Outlet structure is good.
	- Right berm needs grading.
	For most of the length of this lateral, the adjacent land is below lateral.
4+530	Two CHO's are good, except the concrete walkway panels are missing. Both pipe outlet structures are good.
4+555	Cavities behind left panels.
4+770	Drain Culvert. Both inlet and outlet structures are good.
	- One-fourth sediment, lateral has not been cleaned.
5+000	Two CHO's are missing concrete walkway panels. Right CHO needs first gate repaired and second gate is missing. Right pipe outlet structure is good. Left pipe outlet structure is now good, but there is serious erosion and this structure will fail unless compacted backfill and rubble masonry are placed around structure.
5+140	Check structure is good, except one concrete walkway panel is loose.
	- One-fourth sediment.
~5+400	Cavities behind left panels.
5+700	Two CHO's are good except concrete walkway panels are missing on right CHO. Left pipe outlet structure is good. Right pipe outlet structure is good, but there is some erosion near headwall.
	- Contractor is removing sediment in this reach, which just began this morning.
	- One-fourth sediment.
~5+900	Lateral has been cleaned.
~5+925	Pipe outlet on right side.

6+000	Left CHO is good, but cavity on upstream wall. Concrete walkway panels are lying in lateral. Pipe outlet structure is good.
6+300	Two CHO's are good, except right CHO has no concrete walkway panels and second gate is missing, while concrete walkway panels for left CHO are lying on bank. Right outlet structure is good, but there is erosion at end of structure that needs rubble masonry soon. Left pipe outlet structure is good, but floor is being undermined, so rubble masonry is needed.
6+320	Final Outlet structure is a Tail Regulator with a single gate. Inlet structure is good. Outlet structure is intact, but needs immediate attention because of serious erosion downstream which will soon result in failure of the structure. Also, there is a cavity at the headwall.

Over most of the length of this sub-lateral, the adjacent land is below lateral invert, so the lining has been very good.

Sub-Lateral L-3L-1L-2L-1R (2.155 km)

0+000	Regulator has no metal gate, only a temporary wood gate. Inlet structure is good. Outlet structure is good. Sediment in outlet structure and pipeline.
	- One-third sediment.
~0+100	Small pipe through left panel that drains paddy fields.
~0+350	One-fourth sediment.
~0+400	Cavity behind left panel.
0+500	Two CHO's are good, except concrete walkway panels are missing. Both outlet structures are very good.
~0+600	Practically no sediment.
~0+700	One-third sediment.
~0+900	Left berm erosion that will soon expose left panel.
1+000	Drop structure with inlet gate and USBR VI. Inlet structure is good. Roadway erosion needs attention. Outlet structure is good, but could use some compacted backfill plus sodding along both walls.
	- One-third sediment.
~1+025	Cavity behind right panel.
~1+040	Cavities behind left panels.
1+100	Two CHO's are good, except concrete walkway panels are missing. Right pipe outlet structure is good. Left outlet structure is good, except for some undermining at endwalls, which needs rubble masonry.

- One-third sediment.
- Left berm erosion, which needs grading.
- Roadway bank erosion.

1+330	Drop structure with inlet gate and USBR VI. Inlet structure is good. Outlet is structurally good, but completely full of sediment. Serious bank erosion. Water should not be allowed from this point on until this problem is corrected.
1+400	Three-fourths sediment.
1+500	One-third sediment.
1+570	Drain Culvert. Inlet structure is good. Outlet structure is good.
1+640	Roadway Culvert without inlet gate. Inlet structure is good. Outlet structure is structurally good, but 90 percent full of sediment.
1+700	One-half sediment.
1+770	Right CHO is good except concrete walkway panels are missing. Outlet structure is good except for cracks in left and right panels and downstream erosion. Needs rubble masonry at end of outlet structure.
1+860	Drain Culvert. Inlet structure is good, but could use some compacted backfill behind headwall. Outlet structure is good, but much sediment, including sediment in pipeline.

- One-third sediment.

2+000	One-sixth sediment.
2+025	Pipe outlet through left panel.
2+030	Right CHO is good, except concrete walkway panels are missing and a small cavity on downstream wall. Outlet structure has left and right panels failed and headwall but pipe outlet structure is intact.
2+050	Roadway Culvert. Outlet structure is good. Inlet structure without gate is good.

- One-third sediment.

2+155	Final CHO Outlet Structure. Inlet structure is good. Outlet structure is good.

<u>Sub-Lateral L-3L-1L-2L-1L (2.000 km)</u>

0+000	CHO Regulator is good, but concrete walkway panels are missing and one of them is in lateral. Outlet broken-plane transition structure is good. There is a hole in left joint at end of outlet structure.

- One-third sediment and vegetation.

0+185	Concrete Bridge is structurally good, but has no railing. Would be good to have a concrete curb on both sides of bridge.
0+360	Left CHO is good, except concrete walkway panels are missing. Outlet structure is good, except for cavity behind right panel and needs rubble masonry at end of structure.
0+400	Drop structure with inlet gate and USBR VI. Inlet structure is good. Outlet structure is good. There is a cavity at end of outlet transition structure behind left panel and a hole in left joint.
	- 0.4 sediment.
~0+500	Cavities behind left panels.
0+800	Two CHO's are good, but concrete walkway panels are missing. Left outlet structure has large cavities behind headwall and right panel, with some cracks. Right outlet structure also has cavities behind headwall and right panel.
1+130	Drain Culvert [listed as 1+190]. Both inlet and outlet structures are good.
	- One-third sediment.
1+390	Drop Structure with inlet gate and broken-plane outlet transition. Both inlet and outlet structures are good.
	- One-half sediment.
1+550	Left CHO is good, except second gate and concrete walkway panels are missing. Pipe outlet structure is good.
1+675	Surface drainage, erosion, and cavity behind right panel.
1+740	Concrete surface drainage inlet to lateral on right side.
1+730	Drain Culvert.
1+980	Two CHO's are good, except concrete walkway panels are missing. Left outlet structure is good, except large cavity behind left panel and rubble masonry needed at endwalls. Right outlet structure is good.
	- One-half sediment to 2+000.
2+000	Tail Regulator inlet structure and gate is good. Pipe outlet structure is good, but needs compacted backfill and sodding behind headwall.

<u>Lateral L-4L (0.530 km)</u>

0+000	CHO Regulator is good, except concrete walkway panels are missing. Outlet structure is good.

	- Very little sediment.
0+050	One-half sediment.
	- Roadway erosion.
0+300	One-third sediment.
0+350	One-fourth sediment.
	- Left berm grading needed.
	- Right road needs maintenance.
0+410	Drain Culvert. Inlet structure is good, but has cavities along both walls. Outlet structure is good, but needs compacted backfill.
	- One-eighth sediment.
0+530	Tail Regulator, does not exist. End of concrete lining is being undermined on left side, so needs rubble masonry.

Lateral L-5L (1.600 km)

0+000	CHO Regulator is good except for cavity along downstream wall. Concrete walkway panels have been placed in LMC by fisherpersons. Outlet structure is good. First left and right panels after outlet transition are slightly displaced.
	- Very little sediment.
0+030	Cavity behind left and right panels.
0+035	Left CHO is good, except concrete walkway panels are missing. Pipe outlet structure is good.
0+040	Drop structure without inlet gate and USBR VI. Inlet structure is good. Outlet structure is good.
	- One-twelfth sediment.
0+550	Drain Culvert. Inlet and outlet structures are good.
~0+650	Two cracked right panels.
0+750	Concrete Bridge is structurally good. No cavities, but right panels under bridge have cracked.
0+800	Two CHO's are good, but have cavities along both sidewalls. Right CHO has concrete walkway panel in lateral. Pipe outlet structures are good. Adjacent left and right panels near CHO's are cracked.
1+090	Left CHO is good, but has small cavity along each sidewall. Pipe outlet structure is good.
1+560	Right CHO is good. Pipe outlet structure is good.
1+600	Tail Regulator. Inlet structure is good, but there is a cavity on right side. Pipe outlet structure is good.

	This lining is very good, because adjacent land is usually below lateral invert.

Lateral L-2R (3.010 km)

0+000	CHO Regulator is good and outlet structure is good. Note: Asphalt has been used in joint at end of outlet transition structure.
	- One-eighth sediment.
	- Road on left.
	- Land adjacent to lateral is slightly lower than lateral invert.
0+300	Left CHO is good and outlet structure is good.
0+400	Right CHO is good. Outlet structure has cracks and a hole on left side, but is in fairly good condition.
	- One-sixth sediment.
0+600	Vertical Drop Structure is very good, except railing is missing.
	- Very little sediment.
~0+800	Two cracked right panels.
	- One-eighth sediment.
	- Right berm needs grading.
1+350	Left CHO is structurally good, but has cavities along both sidewalls and large cavities near endwall. Outlet structure is good, but needs compacted backfill along left panels.
1+425	Roadway Culvert with inlet gate. Inlet is structurally good, but has cavity behind right wall. Outlet broken-plane transition structure is good. Roadway erosion. Gate frame lying alongside outlet structure.
	- Adjacent land is below lateral invert.
	- One-tenth sediment.
1+850	New CHO being constructed.
1+875	CHO Regulator for Sub-Lateral L-2R-1L.
1+875	Right CHO is good, but concrete walkway panels are missing. Outlet structure is good and has only one crack on left panel.
2+000	Left CHO is good. Outlet structure is good, except for cavity behind left panel over farmer outlet to pond.
2+026	[Listed as 2+467]. Roadway Culvert without inlet gate. Inlet structure is good. Outlet structure is good.

- One-tenth sediment.

~2+200 Cavity behind right panel over small pipe outlet to farmer. Cavity has resulted from farmer or fisherperson taking soil from right bank adjacent to lining.

~2+400 Right berm surface drainage erosion into lateral.

- One-eighth sediment.

2+590 Concrete Bridge is structurally good, but one railing pipe has been broken off. No cavities or cracks in underlying panels.

2+600 Two CHO's. Right CHO has first gate missing. Right outlet structure is good, but downstream lining has been busted in many places. Left CHO is good, but has one concrete walkway panel lying in lateral and another inside CHO structure. Left outlet structure is good.

- One-tenth sediment.

3+000 Tail Regulator. Inlet structure is good. Outlet structure is good.

3+010 Final CHO Outlet Structure. CHO is very good. Pipe outlet structure is good.

This was an excellent design. The lateral invert is above the adjacent lands along nearly the full length. As a consequence, this lining, which was constructed nine years ago, is in excellent condition.

Sub-Lateral L-2R-1L (1.250 km)

0+000 CHO Regulator is structurally good, but first gate is missing and concrete walkway panel is lying inside CHO structure. Outlet structure is good.

- Six cm sediment.
- Right berm erosion. Right berm needs grading.

~0+200 Hole in right panel.

~0+300 Fifteen cm sediment.

~0+400 One-half sediment.

0+620 Left CHO is good, but concrete walkway panel is lying in lateral and there is a small cavity along downstream wall. Outlet structure is very good.

- Right berm erosion.
- ~ Fifteen cm sediment.

~0+900 Overflow structure has recently been constructed and outlet earthen channel needs to be completed.

- 0.4 sediment.

1+200 Two CHO's are structurally good. Right CHO has cavity along downstream wall. Right pipe outlet structure is good. Left pipe outlet structure is good, but needs rubble masonry at outlet.

1+250 Tail Regulator. Inlet structure is good, but gate needs repair. Outlet structure is very good with one cavity along left headwall.

Note: Check grade on this sub-lateral because of large sediment deposits. If more grade is needed, then the drop structure at 0+600 on Lateral L-2R should have had less drop so the elevation of the CHO Regulator for Lateral L-2R-1L would have been higher and the grade for this sub-lateral increased.

L-2R	0+000 to 0+600	1:4000
	0+600 to end	1:8000
L-2R-1L		1:4000

Therefore, the difference in sedimentation between L-2R and L-2R-1L was not affected by the grade (slope).

Lateral L-3R (2.500 km)

0+000 CHO Regulator has not had second gate installed and concrete walkway panels are missing. Outlet structure is good.

0+025 Surface drainage from paddy field over right roadway needs correction, otherwise this road location will become impassable.

- One-sixth sediment.
- Adjacent land is higher than lateral. Would be good to lower roadway and left berm, then provide good surface drainage on both sides between 0+000 to 0+300.

0+300 Right CHO is good, except concrete walkway panels are missing. Outlet structure is good.

- One-fifth sediment.

0+565 Concrete Bridge is structurally good, but upstream top pipe rail is gone. Cavity on left downstream panel, but there are cracks in left panels under bridge.

- One-third sediment.

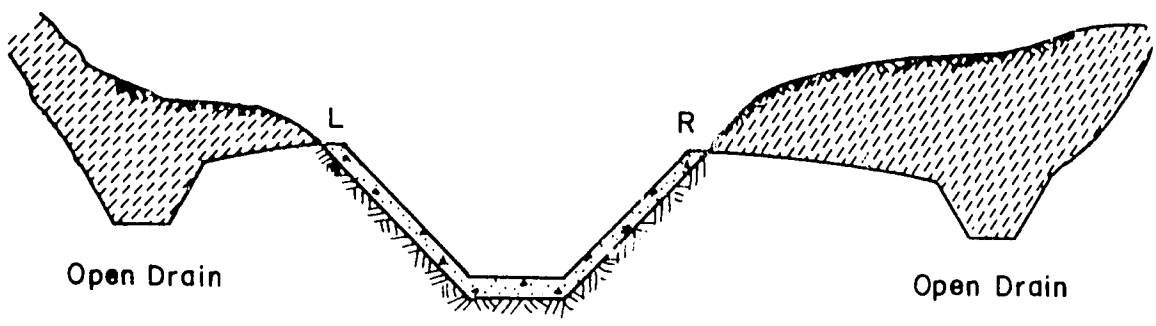
0+600 One-fifth sediment.

0+850 Right CHO is good, but concrete walkway panels are missing. Outlet structure is good, but has cavity behind right panel and two holes in right panel.

- Road is too high.
- One-fifth sediment.

1+050 One-fourth sediment.

1+120	Left CHO is good, but concrete walkway panels are missing. Outlet structure has hole in right panel and cracks in left panels, but is fairly good.
	- One-third sediment.
1+200	One-fourth sediment.
1+335	Concrete Bridge is structurally good. Cavity on left upstream abutment, but no cracks in lining panels.
1+340	Two large holes in left panel.
1+400	Right CHO is good, but concrete walkway panels are missing. Outlet structure is good except for large cavities behind headwall.
1+450	Eleven cm sediment.
~1+600	Cavity behind left panel and hole in left panel and broken panel.
~1+700	Cavity behind right panel and 10-15 cm hole in lining.
~1+800	Two cracked left panels and small hole in next downstream panel. Wood strips have been left in joint after construction.
~1+825	Pipe outlet from lateral.
	- One-sixth sediment.
~1+875 to 2+150	Cracked left panel. Needs surface drainage on left and right sides for 275 m.



~1+950 to 2+000	Many cavities at right panel joints.
2+000	Two CHO's are good, but concrete walkway panels are missing. Left pipe outlet structure is good, but has cavity near headwall. Right CHO has a cavity along each sidewall. Right pipe outlet structure is good.
2+025	Cavity behind left panel.
2+050	Badly broken left panel that needs repair.
2+170	Left CHO is good, but second gate needs repair and concrete walkway panels are missing. Outlet structure is good.
	- One-sixth sediment.
~2+300	Vertical crack in left panel with small hole.

2+360	Drain Culvert. Inlet structure is good. Two left panels cracked. Large cavity behind right panel. Outlet structure is good.
2+460	Overflow Structure [not listed] is good, but needs rubble masonry at bottom of chute.
2+470	Tail Regulator. Inlet is good, but has cavity near headwall. Pipe outlet structure is good, but could use rubble masonry at outlet.
2+500	Final CHO Outlet Structure. CHO is good except has large cavities along left wall that needs correction. Also, concrete walkway panels are missing. Pipe outlet structure is good.

Lateral L-4R (1.500 km)

0+000	CHO Regulator is good structurally, but has large cavities along both walls and concrete walkway panels are missing. Outlet structure is good.
	- One-fourth sediment.
0+100	One-sixth sediment.
0+230	Drain Culvert. Both inlet and outlet structures are good.
~0+300	One-eighth sediment.
0+400	Two CHO's are good, except concrete walkway panels are missing. Left pipe outlet structure and downstream lining is good. Right outlet structure has left headwall failed and big hole in right panel; this could be repaired and the structue salvaged.
	- Land on both sides is lower than lateral.
0+600	Concrete Bridge is good. Cavity on left upstream abutment but panels are not cracked.
	- One-sixth sediment.
0+800	[Listed as 0+850]. Drain Culvert has failed along right edge of road on right of lateral.
1+005	Concrete Bridge is structurally good, but downstream railing is broken off. No cavities or cracks.
	- One-eighth sediment.
1+100	One-fourth sediment.
1+400	Right CHO is good, but concrete walkway panels are missing. Pipe outlet structure is good. Need compacted backfill over concrete pipeline before joint gets worse and leaks even more.
	- One-sixth sediment.
1+450	Tail Regulator is structurally good, but gate frame and gate are lying in lateral. Outlet structure is good.

Note: There are lots of shrubbery and weeds along lateral banks that should be cut.

Note: Generally, the land on both sides of the lateral is lower than the lateral invert.

Lateral-L-5R (1.650 km)

0+000	CHO Regulator is good, but has cavities along both walls and concrete walkway panels are missing. Outlet structure is good. First right panel downstream has crack.
	- One-fifth sediment.
	- Sediment removed from lateral has been placed on left berm at edge of lateral, therefore, much of this sediment will be washed back into the lateral by monsoon rains.
	- Left berm needs cutting down and shaping.
0+340	Drain Culvert. Inlet structure is good Outlet structure is under water and cannot be seen.
~0+630	Newly constructed CHO. Concrete walkway panels have purposely been left off, which is good. Pipe outlet structure is good.
0+780	Drain Culvert. Inlet structure is good. Outlet structure is under water and cannot be seen.
0+775	Cavity behind right panel and panel is cracked.
	- One-sixth sediment.
0+854	Concrete Bridge is structurally very good. Huge cavity on left upstream abutment, but no cracks in panels.
	- One-eighth sediment.
0+950	Right CHO is very good. Outlet structure is good.
1+110	Roadway Culvert without gate. Inlet structure is good. Outlet structure is good.
1+270	Concrete Bridge is structurally good. No cavities and no cracks in panels.
1+400	Two CHO's are very good. Right outlet structure is good with one crack in right panel. Left outlet structure is good except for hole in left panel by farmer in order to get water.
1+600	Tail Regulator is good, but has a cavity at headwall. Outlet is a concrete pipeline and earthen outlet pond is a buffalo wallow.
1+650	Final CHO Outlet Structure. CHO is good, except second gate is missing. Outlet structure is very good.