11.9 Observation about Water Right

I. GENERALIDADES

1. AMBITO DEL TRABAJO : La Legislación sobre derechos de agua, está constituída por el Código de Aguas, por normas del Código Civil y por leyes especiales, a saber : N° 3.133, sobre neutralización de los residuos provenientes de establecimientos industriales; reglamento de esta ley; D.F.L. N° 237, de 1931, sobre fuentes termales; ley N° 14.536, sobre construcción de obras de regadío por el Estado; D.L. N° 1.172, sobre la Comición Nacional de Riego; reglamento de esta ley; y D.L.N° 3.557, de 1981, sobre protección de aguas en pro de la agricultura y la salud de los habitantes.

En este trabajo nos referimos únicamente al Código de Aguas, cuyo texto vigente fue fijado por el decreto con fuerza de ley N° 1.122, de 1981, publicado en el Diario Oficial del 29 de octubre de dicho año, y pretendemos dar una visión resumida del mismo.

2. LAS AGUAS Y SU CLASIFICACION : Las aguas se clasifican en superficiales y subterráneas, y las superficiales se subclasifican en corrientes y detenidas.

Aguas superficiales son aquellas que se encuentran naturalmente a la vista del hombre.

Aguas corrientes son las que escurren por causas naturales o artificiales.

Aguas detenidas son las que están acumuladas en depósitos naturales o artificiales, tales como lagos, lagunas, pantanos, charcas, aguadas, ciénagas, estanques o embalses.

Finalmente, aguas subterráneas son las que están ocultas en el seno de la tierra y no ha sido alumbradas. La exploración de estas sólo puede hacerla el dueño del suelo respectivo; en suelo ajeno, sólo se puede explorar aguas subterráneas previo acuerdo con el dueño del predio,y en bienes nacionales con la autorización de la Dirección de Aguas. (Artículos 2° y 58°).

3. EL DERECHO DE DOMINIO SOBRE LAS AGUAS : Las aguas son bienes nacionales de uso público.

Esto quiere decir que las aguas en Chile pertenecen al Estado, que son del exclusivo dominio de éste.

Pero la ley entrega a los particulares el derecho de aprovechamiento de las aguas, el cual debe ejercerse en conformidad a las disposiciones del Código de Aguas (Artículo 5°).

4. EL DERECHO DE APROVECHAMIENTO SOBRE LAS AGUAS : El derecho de aprovechamiento es un derecho real que recae sobre las aguas y consiste en el uso y goce de éllas de acuerdo con la ley. Es de dominio de su titular,quién podrá usar, gozar y disponer del derecho en conformidad a la ley (Artículo 6°).

5. CARACTERISTICAS DEL DERECHO DE APROVECHAMIENTO : Las características del derecho de aprovechamiento de aguas son las siguientes:

a) Es un derecho real, es decir, se ejerce sobre el agua sin respecto a determinada persona, sino que frente a todo el mundo. Otros derechos reales son el de propiedad, el de herencia, el de usufructo, el de prenda y el de hipoteca. Lo contrario a derechos reales son los personales, que son los que sólo pueden reclamarse de ciertas personas, que han contraído la obliga -

ción correlativa, como el que tiene el prestamista contra su deudor por el dinero que le prestó;

b) Se expresa en volumen por unidad de tiempo; y

c) Es de libre disposición, es decir, el titular del derecho de aprovechamiento, puede hacer lo que quiera con él. Así, puede venderlo total o parcialmente; puede venderlo solo o con el predio; puede dividirlo como quiera; puede arrendarlo con o sin el predio; puede darlo en hipoteca, etc.

(Art. 6°, 7° y 69° y siguientes).

6. CLASIFICACIONES DEL DERECHO DE APROVECHAMIENTO : Los derechos de aprovechamiento se clasifican de la siguiente manera:

a) Consuntivos y no consuntivos. Derecho de aprovechamiento consuntivo es el que faculta a su titular para consumir totalmente las aguas en cualquiera actividad. Derecho de aprovechamiento no consuntivo es aquel que sólo permite emplear el agua sin consumirla y obliga a restituirla.

b) De ejercicio permanente y de ejercicio eventual. Derecho de aprovechamiento de ejercicio permanente es el que faculta para usar el agua en la dotación que corresponda, salvo que la fuente de abastecimiento no contenga la cantidad suficiente para satisfacerlo en su integridad, en cuyo caso el caudal se distribuirá en partes alícuotas. Derecho de aprovechamiento de ejercicio eventual es el que sólo faculta para usar el agua en las épocas en que el caudal matriz tenga un sobrante después de abastecidos los derechos de ejercicio permanente. Los derechos de ejercicio permamanente se otorgan en fuentes no agotadas. Las aguas lacustres o embalsadas no son objeto de derechos de ejercicio eventual. El ejercicio de los derechos eventuales queda subordinado al ejercicio preferente de los derechos eventuales otorgado con anterioridad.

c) De ejercicio contínuo, de ejercicio discontínuo y de ejercicio alternado. Derecho de aprovechamiento de ejercicio contínuo es el que permite usar el agua en forma ininterrumpida durante las veinticuatro horas del día. Derecho de aprovechamiento de ejercicio no contínuo es el que sólo permite usar el agua durante determinados períodos de tiempo. Derecho de aprovechamiento de ejercicio alternado es aquel que permite usar el agua por turno con otra o más personas con igual derecho, distribuyéndose el recurso en forma sucesiva (Artículos 12 a 19).

7. CAUCES DE LAS AGUAS : El Código se refiere a los álveos o cauces naturales, a los álveos de aguas detenidas y a los cauces artificiales y embalses.

Alveo o cauce natural de una corriente de uso público es el suelo que el agua ocupa y desocupa alternativamente en sus creces y bajas periódicas y que es de dominio público.

Alveo o lecho de los lagos, lagunas, pantanos y demás aguas detenidas, es el suelo que ellas ocupan en su mayor altura originaria y que es de dominio privado, salvo cuando se trate de lagos navegables por buques de más de cien toneladas, caso en que el suelo es de dominio público.

Canal o cauce artificial es el acueducto construído por la mano del hombre, formando parte de él las obras de captación, conducción, distribución y descarga del agua, tales como bocatomas, canoas, sifones, tuberías, marcos partidores y compuertas, obras y canales que son de domi nio privado.

Embalse es la obra artificial donde se acopian aguas. La construcción de embalses de una capacidad superior a cincuenta mil metros cúbicos o cuyo muro tenga más de cinco metros de altura y los acueductos que conduzcan más de dos metros cúbicos por segundo, requieren la aprobación previa del Director General de Aguas, de acuerdo al procedimiento de los artículos 130 y siguientes.

(Art. 30 y siguientes y 294).

8. <u>LOS DERRAMES Y LOS DRENAJES DE AGUAS</u> : Los derrames son las aguas que quedan abandonadas después de su uso, a la salida del predio. Su producción no es obligatoria ni permanente, quedando sujeta a las contingencias del caudal matriz y a la distribución o empleo que de las aguas se haga en el predio que los origina.

Drenajes son los cauces u obras que extraen aguas con el objeto de recuperar terrenos que se inundan periódicamente, desecar terrenos pantanosos o vegosos o deprimir niveles freáticos cercanos a la superficie.

(Art. 43 y siguientes).

II. *ADQUISICION DEL DERECHO DE APROVECHAMIENTO*.

1. <u>MODOS DE ADQUISICION; CLASIFICACION</u> : Los modos de adquirir el derecho de aprovechamiento de aguas, se clasifican en originarios y derivativos. Son originarios el acto de autoridad, la ley y la prescripción. Son derivativos la tradición, la sucesión por causa de muerte y la ley.

Por su importancia práctica y por el objeto de este trabajo, nos referiremos solamente a los modos de adquisición denominados acto de autoridad, tradición y ley.

2. ADQUISICION POR ACTO DE AUTORIDAD : La autoridad encargada para constituir originariamente el derecho de aprovechamiento de aguas, es la Dirección General de Aguas, que lo hace mediante la dictación de una resolución y previo el cumplimiento del procedimiento que se va a indicar.

La dirección General de Aguas está obligada a constituir el derecho cuando hay aguas disponibles.

No es necesario, como ocurría antes, acreditar la necesidad del agua para obtener el derecho de aprovechamiento.

La autoridad constituirá este derecho sobre aguas existentes en fuentes naturales y en obras estatatales de desarrollo del recurso, no pudiendo perjudicar ni menoscabar derechos de terceras personas.

Si el acto de constitución del derecho de aprovechamiento no expresa otra cosa, se entenderá que su ejercicio es contínuo.

El derecho de aprovechamiento envuelve la facultad de imponer todas las servidumbres necesarias para su ejercicio, sin perjuicio de las indemnizaciones que correspondan.

El procedimiento para la constitución del derecho de aprovechamiento es el siguiente:

a) El interesado debe presentar una solicitud que debe contener las siguientes menciones :

1) El nombre del álveo de las aguas que se desean aprovechar; su naturaleza, esto es, si son superficiales o subterráneas, corrientes o detenidas, y la provincia del país en que están ubicadas o que recorren;

2) La cantidad de agua que se desea extraer, expresada en medidas métricas y de tiempo;

3) El o los puntos en que se desea captar el agua y el modo de extraerla;

4) Si el derecho es consuntivo o no consuntivo, de ejercicio permanente o eventual, contínuo o discontínuo o alternado con otras personas.

b) La solicitud debe ser publicada en el Diario Oficial, dentro de quince días contados desde la fecha de su presentación, los días 1° ó 15 de cada mes.

c) Los que se crean perjudicados con la solicitud y la junta de vigilancia respectiva, podrán oponerse dentro del plazo de treinta días. Se entenderá, además, que hay oposición cuando, en el mismo plazo, se hubieren presentado dos o más solicitudes sobre las mismas aguas, caso en el cual, si hay aguas disponibles para constituir nuevos derechos sobre ellas, éstos se sacarán a remate entre los solicitantes, salvo que se trate de aguas subterráneas, respecto de las cuales no puede haber remate.

d) Si no hay oposición a la solicitud, y siempre que exista disponibilidad del recurso y fuere legalmente procedente, la Dirección de Aguas constituirá el derecho solicitado mediante la resolución correspondiente. En caso contrario, rechazará la solicitud.

e) La resolución que otorgue el derecho se reducirá a escritura pública y ésta se inscribirá en el respectivo Registro de Propiedad de Aguas. (Arts. 20 y siguientes y 140 y siguiente).

3. ADQUISICION DEL DERECHO DE APROVECHAMIENTO POR LA TRADICION : La tradición "es un modo de adquirir el dominio de las cosas y consiste en la entrega que el dueño hace de éllas a otro, habiendo por una parte la facultad e intención de transferir el dominio, y por la otra la capacidad e intención de adquirlo".

"Para que valga la tradición se requiere un título translaticio de dominio, como el de venta, permuta, donación, etc.".

Este título translaticio de dominio, es decir, este acto o contrato translaticio de dominio, debe otorgarse por escritura pública.

Ahora bien, la tradición del derecho de aprovechamiento se hace por la inscripción del título en el Registro de Propiedad de Aguas respectivo.

En otras palabras, la escritura pública en que debe constar el título translaticio de dominio (por ejemplo , el contrato de venta), debe inscribirse en dicho Registro, y esta inscripción es la tradición del derecho de aprovechamiento. (Arts. 112 y siguientes).

4. LA LEY COMO MODO DE ADQUIRIR EL DERECHO DE APROVECHAMIENTO : En forma originaria, se puede adquirir el derecho de aprovechamiento por la sola disposición de la ley (sin necesidad de acto de autoridad) en los cuatro casos que se indican en los artículos 20 inc. 2°, 44,56 y 57 y 310 del Código.

En forma derivativa, la ley permite adquirir el derecho de aprovechamiento mediante la expropiación por causa de utilidad pública.

(Arts. citados y, además, los arts. 27 y 129).

III. LAS ORGANIZACIONES DE USUARIOS

1. CUALES SON ESTAS ORGANIZACIONES : El Código establece cuatro tipos de organizaciones de usuarios de derechos de aguas, que son: las Comunidades de Aguas, las Comunidades de Obras de Drenaje, las Asociaciones de Canalistas y las Juntas de Vigilancia.

2. LAS COMUNIDADES DE AGUA : Estas entidades se constituyen por la sola circunstancia de que dos o más personas tengan derechos de aprovechamiento en las aguas de un mismo canal o embalse, o usen en común la misma obra de captación de aguas subterráneas.

Pueden quedar así, esto es, sin organizarse, o bien organizarse por escritura pública suscrita en la Dirección General de Aguas e inscribirse en el respectivo Registro de Propiedad de Aguas.

Las comunidades de agua pueden también organizarse por sentencia judicial, lo que ocurrirá cuando no hay acuerdo entre todos los interesados. El juez cita a un comparendo en el cual los interesados pueden hacer valer sus derechos. La sentencia debe reducirse a escritura pública, que debe registrarse e inscribirse en la forma ya señalada.

Las comunidades de agua son dirigidas por un directorio y funcionan sobre la base del derecho de voto de los co muneros que las constituyen.

Se diferencian de las asociaciones de canalistas y de las juntas de vigilancia, principalmente, en que no son, como estas últimas, personas jurídicas.

3. COMUNIDADES DE OBRAS DE DRENAJE : Estas entidades se forman por el hecho de que dos o más personas aprovechen obras de drenaje o desagüe en beneficio común.

   Pueden organizarse en la misma forma prescrita para las comunidades de agua.

   Los comuneros tendrán derecho a un voto por cada hectárea de dominio afecta al sistema, salvo acuerdo en contrario.

4. ASOCIACIONES DE CANALISTAS : Estas asociaciones son personas jurídicas, cuya constitución o formación y la de sus estatutos debe hacerse por escritura pública suscrita por todos los titulares de derechos de aprovechamiento en las aguas de un mismo canal artificial o de un embalse, escritura que debe ser informada por la Dirección General de Aguas y aprobada por el Presidente de la República.

   Son aplicables a estas asociaciones las normas que regulan las comunidades de aguas, en cuanto sean compatibles con su naturaleza y no contradigan lo dispuesto en sus estatutos, y las normas del Código Civil sobre las personas jurídicas, con algunas pocas excepciones.

5. JUNTAS DE VIGILANCIA : Estas entidades también son personas jurídicas, están formadas por las personas naturales o jurídicas y las organizaciones de usuarios que en cualquier forma aprovechen aguas de una misma cuenca u hoya hidrográfica, y su constitución, conjuntamente con

los estatutos respectivos, debe hacerse por escritura pública que se someterá a la aprobación del Presidente de la República, previo informe de la Dirección General de Aguas.

Tienen por objeto administrar y distribuir las aguas a que tienen derecho sus miembros en los cauces naturales, explotar y conservar las obras de aprovechamiento común.

En lo no modificado por las normas dictadas especialmente para las juntas de vigilancia, son aplicables a éstas las disposiciones dictadas para las comunidades de agua y las asociaciones de canalistas, en lo que sean compatibles con su naturaleza.

Además de poder constituirse por escritura pública,en la forma señalada anteriormente, las juntas de vigilancia pueden también constituirse por sentencia judicial, para lo cual debe citarse a comparendo, a solicitud de cualquiera de los interesados o de la Dirección General de Aguas. La sentencia debe reducirse a escritura pública, conjuntamente con los estatutos, si hubiera acuerdo sobre estos.

Como las asociaciones de canalistas, las juntas de vigilancia están dirigidas por un directorio y funcionan sobre la base del derecho a voto que corresponde a todos sus miembros. El Directorio, entre sus numerosas atribuciones, tiene la de designar a los repartidores de agua, los cuales, a su vez, designan a sus celadores, con acuerdo del directorio.

IV. LA DIRECCION GENERAL DE AGUAS

1. Concepto : La Dirección General de Aguas es un servicio público dependiente del Ministerio de Obras Públicas cu-

ya misión es planificar, dirigir, manejar y coordinar todo lo referente al recurso agua.

Su jefe superior se denomina Director General de Aguas y es de la exclusiva confianza del Presidente de la República.

2. ATRIBUCIONES Y FUNCIONES : Tiene las atribuciones y funciones que el Código le confiere, algunas de las cuales ya han sido mencionadas en este trabajo, y, en especial, las siguientes :

   a) Planificar el desarrollo del recurso en las fuentes naturales, con el fin de formular recomendaciones para su aprovechamiento ;

   b) Investigar y medir el recurso, en la forma que el Código señala ;

   c) Ejercer la policía y vigilancia de las aguas en los cauces naturales de uso público e impedir que en éstos se hagan o destruyan obras sin la autorización correspondiente ;

   d) Supervigilar el funcionamiento de las juntas de vigilancia, de acuerdo con lo dispuesto en el Código ;

   e) Aforar las corrientes si con motivo de la construcción de obras hidráulicas se alterasen los caudales en cauces naturales y artificiales, y dirimir las dificultades que se presenten en su distribución entre los dueños de derechos de aprovechamiento de dichos cauces ;

   f) Vigilar las obras de toma en cauces naturales con el objeto de evitar perjuicios en las obras de defensa, inundaciones o el aumento del riesgo de futuras crecidas, pudiendo ordenar que se modifiquen o destruyan aquellas obras provisionales que no den seguridades ante las creces; asimismo podrá ordenar que las bocatomas de los canales permanezcan cerradas ante el peligro de grandes avenidas; y

g) Exigir a los propietarios de los canales la construcción de las obras necesarias para proteger caminos , poblaciones u otros terrenos de interés general , de los desbordamientos.

V. "CONSIDERACIONES GENERALES EN TORNO A LA NUEVA POLITICA DE AGUAS "

O DEL ACTUAL CODIGO .

Por su importancia, queremos terminar estos apuntes refiriéndonos a un trabajo que con el título señalado hizo don Eugenio Lobo Parga, en su calidad de Director General de Aguas . Lo haremos extractando del mismo las siguientes ideas.

" *Creo que una de las primeras ideas que habría que destacar* es la separación que se traduce de toda la nueva legislación entre el manejo de agua y los usos a que se puede destinar el agua. Ha quedado muy bien definido en la nueva legislación lo que es manejo del agua propiamente tal y las normas y conceptos para manejar este recurso agua, independizándolo de otras ideas u otras disposiciones que estuvieron en legislaciones anteriores y que más bien se referían a cómo se debía usar el recurso o a consejos o a políticas sobre cada uno de los usos".

" Conjugando el concepto de riesgo (si se va a contar con el agua o no, de acuerdo con las variaciones del clima) con el concepto de eficiencia (relación entre el recurso asignado y el recurso que finalmente se incorpora al proceso productivo), la legislación anterior entraba a discernir sobre cual sería la eficiencia conveniente para asignar el agua y entra ba por la vía de la asignación misma a determinar los niveles convenientes de eficiencia, y, en cierta forma, también el nivel de riesgo que cada productor debería abordar".

" La idea matriz del actual Código, es dejar al propio usuario,al particular que está usando el agua, que decida cual es la eficiencia que le conviene, y cual es el riesgo que está dispuesto a afrontar".

" En la idea matriz en este aspecto de la nueva legislación es que la asignación del agua se refiera exclusivamente al recurso agua en sí, a la cantidad de agua que hay, a la gente que lo quiere usar, sin que junto a la asignación se selle el destino futuro de esa agua ni se defina cuál es la forma de utilizarlo que le va a convenir a quién lo va a usar, ni tampoco cuál es el riesgo que debe asumir. El propietario de un derecho de aprovechamiento tiene la libre disposición de él, puede hacer con él cualquier cosa; puede venderlo (conjunta o separadamente del predio), arrendarlo (con o sin el predio), regalarlo, destinarlo a lo que él quiera".

" Para que funcione esta idea ... tiene que producirse un mercado fluído, conocido, informado ...".

" Otro tipo de idea que tiene mucha relación con la asignación del recurso (por el Estado) es la convervación y planificación del desarrollo del mismo en sus fuentes naturales. En una política de planificación central, el Estado y la autoridad que asigna toma todas las decisiones y planifica todos los usos. La idea del actual Código es dejar a cada usuario y a cada particular que decida lo que le conviene más. Pero llegamos al probelma de las fuentes. El recurso parte de fuentes, en las cuales es necesario conservar el recurso ... El nuevo Código le encarga a la Dirección General de Aguas planificar el desarrollo del recurso en sus fuentes naturales. Ha quedado establecido que no se desea que los funcionarios del Estado entren a planificar el uso del recurso, a imponer determinada técnica o a vigilar que hace cada propietario con su derecho de aprovechamiento. Pero si le encarga planificar el recurso en sus fuentes naturales...".

" La nueva legislación establece que cuando dos o más personas están solicitando el mismo recurso de agua, la forma que tiene el Estado, de dilucidar la cuestión es a través de una licitación pública" (no se da importancia al destino del agua, a si se va a usar o no, a si uno de los interesados la va a usar en algo provechoso o no para la comunidad). O sea, no es el Estado quién decide por sí a quién se lo entrega, sino que a través de una licitación el que mayor utilidad pueda sacar del recurso, se supone que ofrecerá más, que estará dispuesto a invertir más, a exponer más para obtenerlo...".

" La tercera idea que es importante destacar dentro del Código, es que todas las cuestiones que se susciten en la aplicación del mismo, son materia de la justicia ordinaria; que no hay un tribunal administrativo como podría haber sido la Dirección de Aguas en cierta forma con las atribuciones que antes tenía; que es el derecho común, la justicia ordinaria quién dilucida en ultima instancia todo, y que la administración del agua radica fundamentalmente en las organizaciones de usuarios, o sea el Estado se mete solamente en la asignación del recurso, en la medición, en la conservación para defender derechos de terceros, pero que la administración del agua debe radicar fundamentalmente en los propios usuarios".

Para la exposición de estas ideas, el autor de estas "Nociones del Derecho de Aguas Chileno" ha querido demostrar los graves errores en que ha incurrido el actual Código de Aguas, los cuales, según se ha dicho en esferas sociales, están siendo estudiados para ser remediados. El principal de todos, a nuestro juicio, es "el haber adecuado el derecho de aguas a la implantación progresiva de una economía social de mercado".

Table A-11-1 Present Irrigation Area

(unit: ha)

Block	Irrigation Area (A)
1	1,760
2	3,730
3	2,300
4	8,600
Total	16,390

Table A-11-2 Summary of Estimated ETcrop (Combined)

(unit: mm/day)

Month / ETcrop	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1. For Single Cropping	0.3	0.2	0.3	0.2	0.9	1.3	2.1	2.5	3.1	3.3	2.1	0.7
2. For Double Cropping	1.4	0.7	0.4	0.4	1.4	1.7	2.4	2.8	3.8	5.1	4.4	2.3

Note : Table A-11-6 Shows the Breakdown

Table A-11-3 Conveyance (EC), Field Canal (Eb), Distribution (Ed) and Field Application Efficiency (Ea)

Conveyance Efficiency (Ec)			ICID/ILRI
Continuous supply with no substantial change in flow			0.9
Rotational supply in projects of 3,000 - 7,000 ha and rotational areas of 70 - 300 ha, with effective management			0.8
Rotational supply in large schemes (>10,000 ha) and small schemes (<1,000 ha) with respective problematic communication and less effective management:			
based on predetermined schedule			0.7
based on advance request			0.65
Field Canal Efficiency (Eb)			
Blocks larger than 20 ha: unlined			0.8
lined or piped			0.9
Blocks up to 20 ha: unlied			0.7
lined or piped			0.8
Distribution Efficiency (Ed = Ec x Eb)			
Average for rotational supply with management and communication adequate			0.65
sufficient			0.55
insufficient			0.40
poor			0.30
Field Application Efficiency (Ea)	USDA	US (SCS)	
Surface methods			
light soils	0.55		
medium soils	0.70		
heavy soils	0.60		
graded border		0.60-0.75	0.53
basin and level border		0.60-0.80	0.58
contour ditch		0.50-0.55	
furrow		0.55-0.70	0.57
corrugation		0.50-0.70	
Subsurface		up to 0.80	
Sprinkler, hot dry climate		0.60	
moderate climate		0.70	0.67
humid and cool		0.80	
Rice			0.32

Source: Crop Water Requirements
FAO Irrigation and Drainage Paper 24 (revised in 1977)

Table A-11-4 Maximum Present Gross Duty of Water

Block	A (ha)	ETcrop (mm/day)		Re (mm/day)	Ep	Qdmas (m^3/s)	
		Single crop	Double crop			Single crop	Double crop
1	1,760	3.3	5.1	0	0.4	1.7	2.6
2	4,030 1/	3.3	5.1	0	0.4	3.8	5.9
3	2,300	3.3	5.1	0	0.4	2.2	3.4
4	8,600	3.3	5.1	0	0.4	8.2	12.7
Total	16,690 1/	3.3	5.1	0	0.4	15.9	24.6

Table A-11-5 Balance of Existing Irrigation Water

A: Single Cropping Pattern

Block	Main Canal	① (ha) A	② (m^3/s) Qd	③ (m^3/s) Qa	④ (m^3/s) Qc	⑤ (m^3/s) ③ or-② ④	⑥ (ha) Ai
1	Esperanza Canal	1,760	1.7	1.4	7.5	Δ0.3	1,470
2	Zanjón de la Aguada	4,030 1/	3.8	6.6	12.8	2.8	4,030
3	Punta Canal	2,300	2.2	7.4	3.2	2.0	2,300
4	Carmen Canal	8,600	8.2	8.2	7.0	Δ1.2	7,330
Total	-	16,690 1/	15.9	15.6	-	3.3	15,550

B: Double Cropping Pattern

Block	Main Canal	① (ha) A	② (m^3/s) Qd	③ (m^3/s) Qa	④ (m^3/s) Qc	⑤ (m^3/s) ③ or-② ④	⑥ (ha) Ai
1	Esperanza Canal	1,760	2.6	1.4	7.5	Δ1.2	950
2	Zanjon de la Aguada	4,030 1/	5.9	6.6	12.8	0.7	4,030
3	Punta Canal	2,300	3.4	7.4	3.2	Δ0.2	2,170
4	Carmen Canal	8,600	12.7	8.2	7.0	Δ5.7	4,740
Total	-	16,690 1/	24.6	15.6	-	Δ6.4	12,160

① A : irrigation area (present upland field)
② Qd : gross duty of water
③ Qa : existing available water
④ Qc : canal capacity
⑤ : balance of irrigation water
⑥ Ai : irrigable area in existing conditions

1/ An upland field of 300 ha owned by the University of Chile is included.

Table A-11-6 Estimation of ETcrop Combined

(1) For single cropping (existing)

(Unit : mm/day)

Crops	Combination of cropping (%)	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Wheat	36	-	0.2	0.5	0.5	1.9	2.4	3.1	2.2	0.3	-	-	-
Maize	24	0.3	-	-	-	-	0.4	1.6	3.4	6.3	7.4	5.1	2.1
Fruit	10	0.9	0.1	-	-	0.1	1.0	2.0	3.1	4.3	4.7	3.5	1.6
Winter vegetable	12	0.9	0.9	0.7	0.5	1.6	0.9	-	-	-	-	-	-
Summer vegetable	18	-	-	-	-	-	0.9	2.1	3.3	5.6	6.0	3.0	-
Mean		0.3	0.2	0.3	0.2	0.9	1.3	2.1	2.5	3.1	3.3	2.1	0.7

(2) For double cropping (planned)

Crops	Combination of cropping (%)	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Wheat + vegetable	45	2.4	0.9	0.5	0.5	1.9	2.4	3.1	2.2	1.9	3.7	4.5	2.9
Maize + vegetable	30	1.2	0.9	0.7	0.5	1.6	1.3	1.6	3.4	6.3	7.4	5.1	2.1
Fruit	25	0.9	0.1	0	0	0.1	1.0	2.0	3.1	4.3	4.7	3.5	1.6
Mean		1.4	0.7	0.4	0.4	1.4	1.7	2.4	2.8	3.8	5.1	4.4.	2.3

Table A-11-7(1) Calculation of ETcrop (1/3)

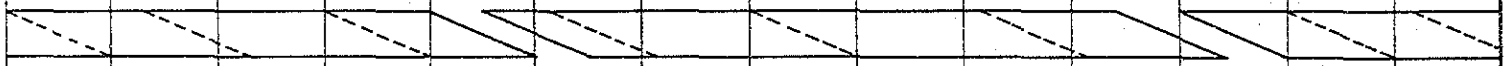
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
(1) Cropping Pattern														
(2) Cropping Intensity	1.0	1.0	1.0	1.0	0.63	0.63	1.0	1.0	1.0	1.0	0.63	0.63	1.0	1.0
(3) Crop Coefficient (Kc)	0.55	0.90	1.07	0.97	0.61	0.59	0.91	1.05	1.10	0.95	0.49	0.30	0.55	0.90
(4) Re . Crop Evapotranspiration (ETo) mm/day	6.7	5.0	2.7	2.5	1.4	0.9	0.6	1.8	2.2	3.3	4.4	6.2	6.7	5.0
(5) Crop Evapotranspiration (ETcrop = Kc×ETo)	3.7	4.5	2.9	2.4	0.9	0.5	0.5	1.9	2.4	3.1	2.2	1.9	3.7	4.5

Table A-11-7(2) Calculation of ETcrop (2/3)

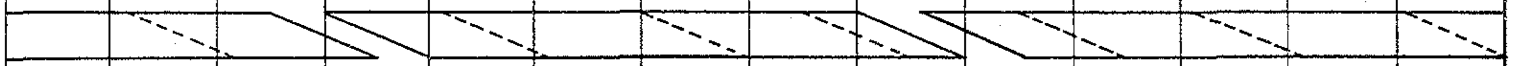
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
(1) Cropping Pattern														
(2) Cropping Intensity	1.0	1.0	0.63	0.63	1.0	1.0	1.0	1.0	0.63	0.63	1.0	1.0	1.0	1.0
(3) Kc	1.10	1.02	0.79	0.46	0.63	0.76	0.90	0.8	0.61	0.47	0.78	1.01	1.10	1.02
(4) ETo	6.7	5.0	2.7	2.5	1.4	0.9	0.6	1.8	2.2	3.3	4.4	6.2	6.7	5.0
(5) ETcrop = KcxETo	7.4	5.1	2.1	1.2	0.9	0.7	0.5	1.6	1.3	1.6	3.4	6.3	7.4	5.1

Table A-11-7(3) Calculation of ETcrop (3/3)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
(1) Cropping Pattern														
(2) Cropping Intensity	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
(3) Kc	1.1	1.05	0.67	0.26	0.2	0.2	0.2	0.3	0.53	0.98	1.06	1.1	1.1	1.05
(4) ETo	6.7	5.0	2.7	2.5	1.4	0.9	0.6	1.8	2.2	3.3	4.4	6.2	6.7	5.0
(5) ETcrop = Kc×ETo	7.4	5.3	1.8	0.7	0.3	0.2	0.1	0.5	1.2	3.2	4.7	6.8	7.4	5.3

Table A-11-8 Estimation of ETo

month	1974									1975		
Item	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Epa 1/ (mm/day)	3.1	1.7	1.1	0.7	2.1	2.6	3.9	5.8	8.3	8.9	6.6	3.6
Kp 2/	0.8	0.85	0.85	0.85	0.85	0.85	0.85	0.75	0.75	0.75	0.75	0.75
ETo (mm/day)	2.5	1.4	0.9	0.6	1.8	2.2	3.3	4.4	6.2	6.7	5.0	2.7

1/ Observation values at Station No 24, Santiago, which correspond to 6.7 return period values based on the records of 1961/62 to 1981/82

2/ Refer to the FAO manual

Table A-11-9 Existing Irrigation Canals

Canal	Distance from Intake (km)	B (m)	H (m)	Slope (I)	A (m^2)	P (m)	Q (m^3/s)	Remarks
Esperanza Alto	(0.10)	6.0	2.5	1/ 670	13.20	10.3	26.1	
"	(2.80)	2.6	4.0	1/1480	9.62	10.2	10.6	Irrigation water is drawn from the Mapocho river.
"	(4.30)	4.0	1.8	1/ 620	6.00	7.0	9.4	
"	(16.30)	2.5	1.2	1/ 180	2.25	4.3	4.7	
Esperanza Bajo	(2.00)	5.5	1.0	1/2100	3.85	6.9	2.5	
Ortuzano	(0.05	5.0	3.0	1/1000	13.50	10.4	22.1	
Lat. 1 Ortuzano	(0.10)	1.6	0.6	1/ 400	0.48	2.2	0.4	Irrigation water is drawn from Zanjón de la Aguada.
Rinconada	(0.05)	4.5	2.0	1/ 230	7.65	7.9	21.4	
"	(0.55)	2.5	0.9	1/ 230	1.47	3.7	2.3	
Loma Blanca	(0.00)	0.5	1.2	1/ 180	0.45	2.3	0.5	
Encañado	(0.10)	0.6	1.2	1/ 210	0.54	2.4	0.6	
Punta	(1.00)	3.3	2.5	1/ 800	7.26	7.7	15.4	
"	(9.50)	3.0	1.5	1/ 270	3.60	5.4	7.3	Irrigation water is drawn from the Maipo river through the Mapocho river
"	(19.60)	1.0	1.5	1/ 500	2.64	4.4	5.3	
Boza	(0.70)	2.5	1.4	1/ 320	2.75	4.7	4.7	
Noviciado	(4.00)	3.4	1.2	1/1800	3.06	5.6	2.1	
Lat. 1 Noviciado	(1.48)	1.4	0.6	1/ 600	0.42	2.0	0.3	
Lat. 2 Noviciado	(1.28)	1.0	0.8	1/1000	0.50	2.0	0.3	
Carmen	(20.50)	3.5	1.5	1/ 480	4.20	5.9	6.7	
"	(27.37)	5.5	1.2	1/ 380	4.95	7.3	8.6	Irrigation water is drawn from the Maipo river.
"	(34.30)	1.6	1.2	1/ 560	1.44	3.4	1.5	
"	(36.38)	2.5	1.0	1/ 450	1.75	3.9	2.1	
Cerrillos (Main)	(6.20)	1.0	1.0	1/ 600	0.70	2.4	0.6	
Lat. Cerrillos	(4.40)	1.4	0.6	1/ 390	0.42	2.0	0.3	
Cerrillos (Main)	(6.70)	2.3	1.0	1/ 460	1.61	3.7	1.9	
Batuco	(12.10)	2.0	1.4	1/ 890	2.20	4.2	2.1	
"	(18.18)	2.0	1.0	1/ 150	1.40	3.4	2.8	
Lat. Batuco	(5.70)	0.8	0.7	1/ 170	0.32	1.6	0.4	

Note : Roughness coefficient n:0.023 (0.016 for Punta 1.00km and 19.60km)

Table A-11-10 Dimension of Existing Reservoirs

Block	Name	Dimensions(m)	Capacity (max.) (m^3)
		W W H	
1	Esperanza Res. 1	150 × 100 × 2.5	21,000
	Esperanza Res. 2	170 × 120 × 2.7	27,000
	Esperanza Res. 3	160 × 120 × 3.0	35,000
	Esperanza Res. 4	100 × 60 × 2.0	5,000
2	Rinconada Res. 1	250 × 120 × 2.5	50,000
	Rinconada Res. 2	110 × 100 × 2.0	12,000
3	Noviciado Res. 1	300 × 200 × 2.5	90,000
	Noviciado Res. 2	140 × 100 × 1.5	9,000
	Noviciado Res. 3	100 × 60 × 1.5	2,500

Table A-11-11 Estimated Dam Construction Cost

Dam	Item	Unit Cost (Ch$)	Quantity	Amount (10^6Ch$)	Remarks
Mapocho Dam (1)	1 Dam body	1,500/m^3	4.73x10^{6}m^3	7,095	
	2 Spillway	-	LS	400	
	3 Discharge facilities	-	LS	150	
	4 Temporary tunnel	0.4x10^6/m	770m	308	
	5 Direct cost (1+2+3+4)			7,953	
	6 Indirect cost			1,988	25% of 5
	Total (5+6)			9,941 (4,971/m^3)	2.0m^3/s
Mapocho Dam (2)	1 Dam body	1,550/m^3	3.66x10^6	5,673	
	2 Spillway	-	LS	900	
	3 Discharge facilities	-	LS	200	
	4 Temporary tunnel	0.7 x 10^6/m	750m	525	
	5 Direct cost (1+2+3+4)			7,298	
	6 Indiret cost			1,825	25% of 5
	Total (5+6)			9,123 (2,765/m^3)	3.3 m^3/s
Maipo Dam	1 Dam body	1,800/m^3	2.02x10^6	3,636	
	2 Spillway	-	LS	3,000	
	3 Discharge facilities	-	LS	500	
	4 Temporary tunnel	1.5x10^6/m	700mx2	2,100	
	5 Erosion Control dam	120x10^6/site	2 sites	240	
	6 Total (1+2+3+4+5)			9,476	
	7 Indirect cost			2,369	25% of 6
	Total (6+7)			11,845 (1,394/m^3)	8.5 m^3/s

Note : LS : Lamp Sum

Table A-11-12 Construction Cost of A Conduct along the Mapocho River (Case A)

Item	Unit	Quantity	Unit Cost (ch$)	Amount (10^6x ch$)
1.Excavation	m^3	250,000	2,000	500
2.Backfill	m3	210,000	1,000	210
3.Hauling	m^3	40,000	1,500	60
4.Sand fill	m^3	40,000	3,000	120
5.Concrete pipe (ϕ 1,200)	m	10,000	25,000	250
6.Pavement	m^2	23,000	2,000	46
7.Reinforced concrete	m^3	10,000	12,400	124
8.Reinforcing bar	ton	300	210,000	63
9.Wooden form	m^2	10,000	1,200	12
10.Main hole	unit	20	500,000	10
Sub-total				1,395
11 Indirect cost	25%			349
Total				1,744

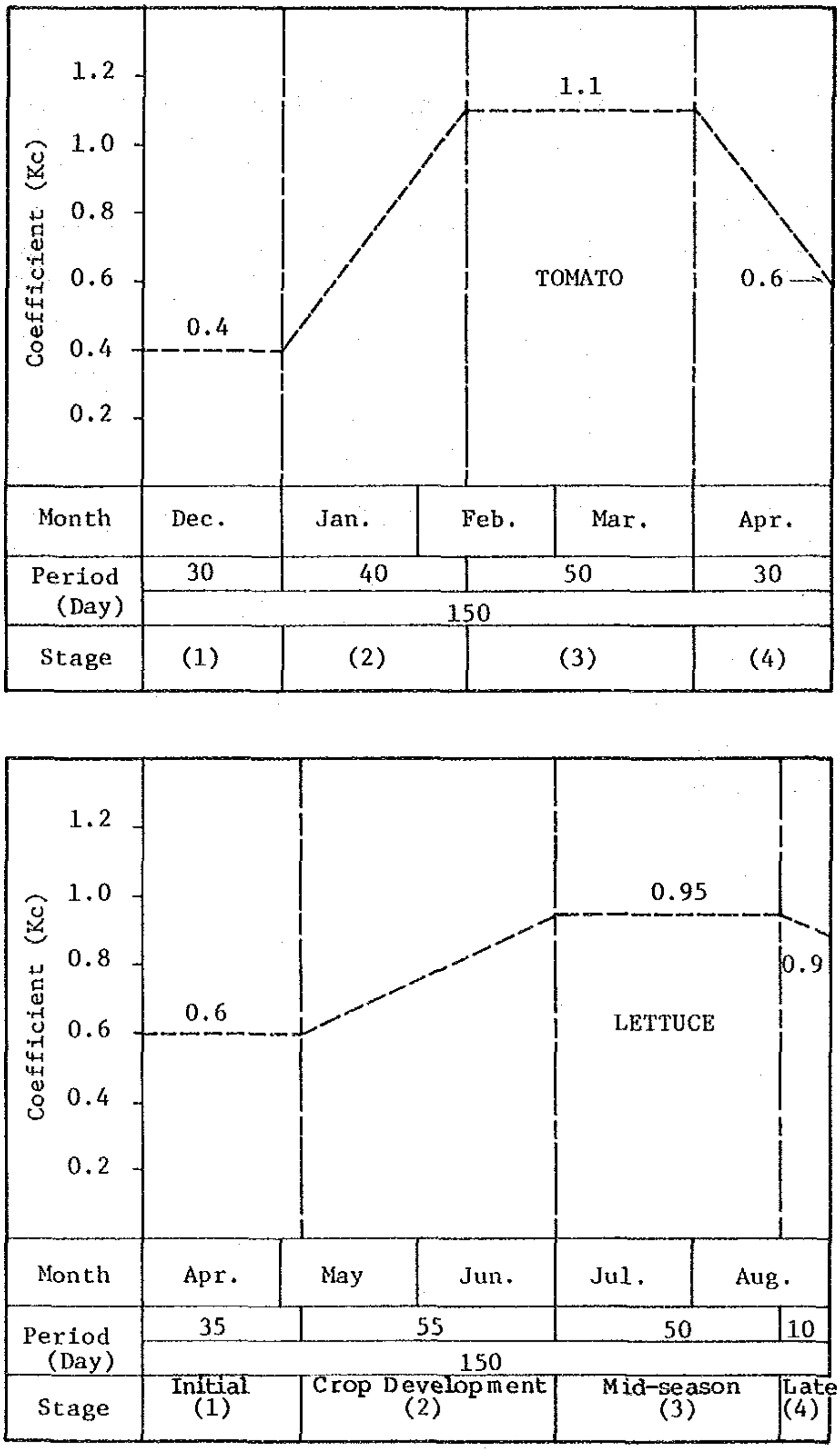


Fig A-11-1(1) Crop Coefficient Curve

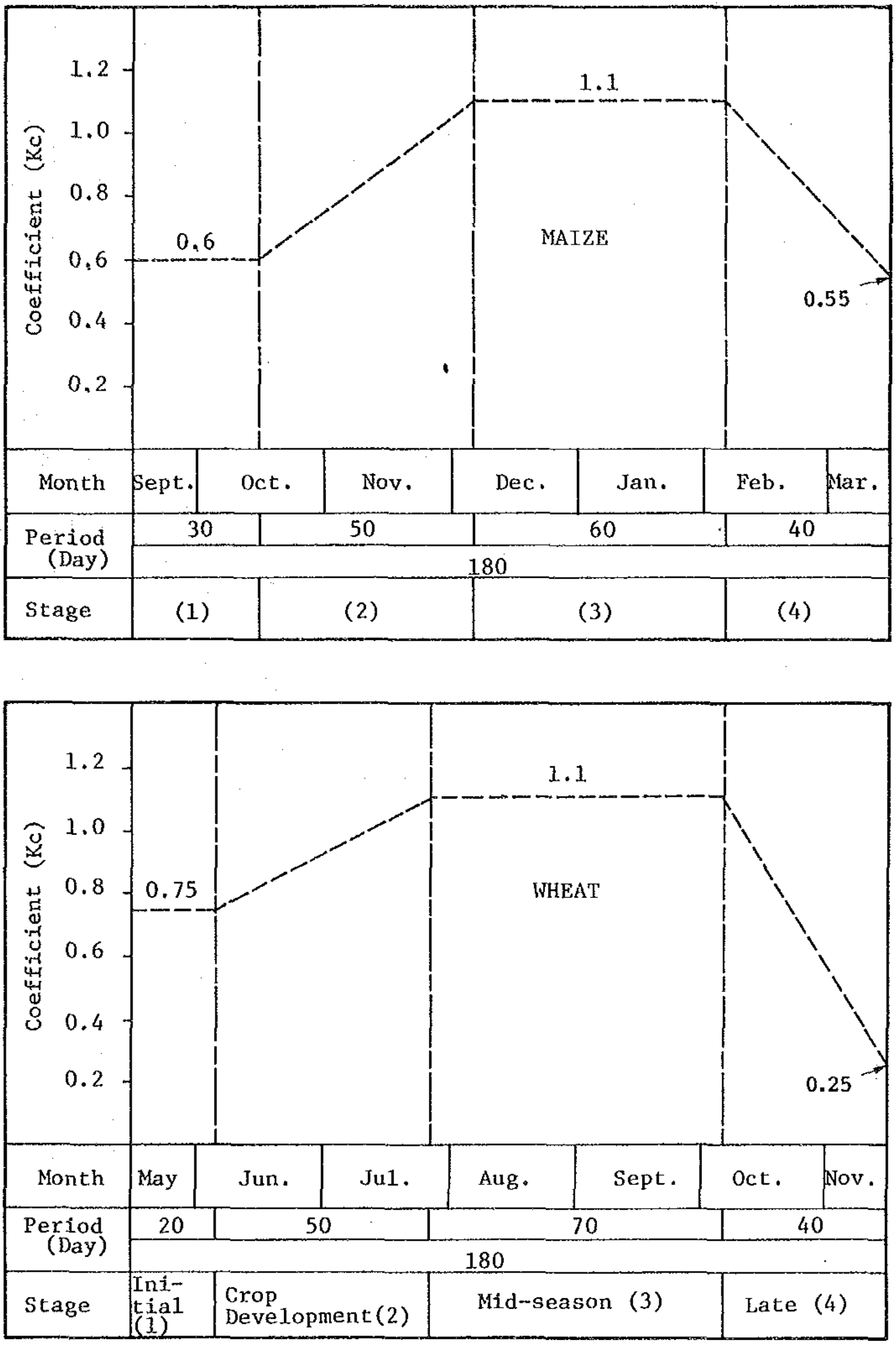


Fig A-11-1(2) Crop Coefficient Curve

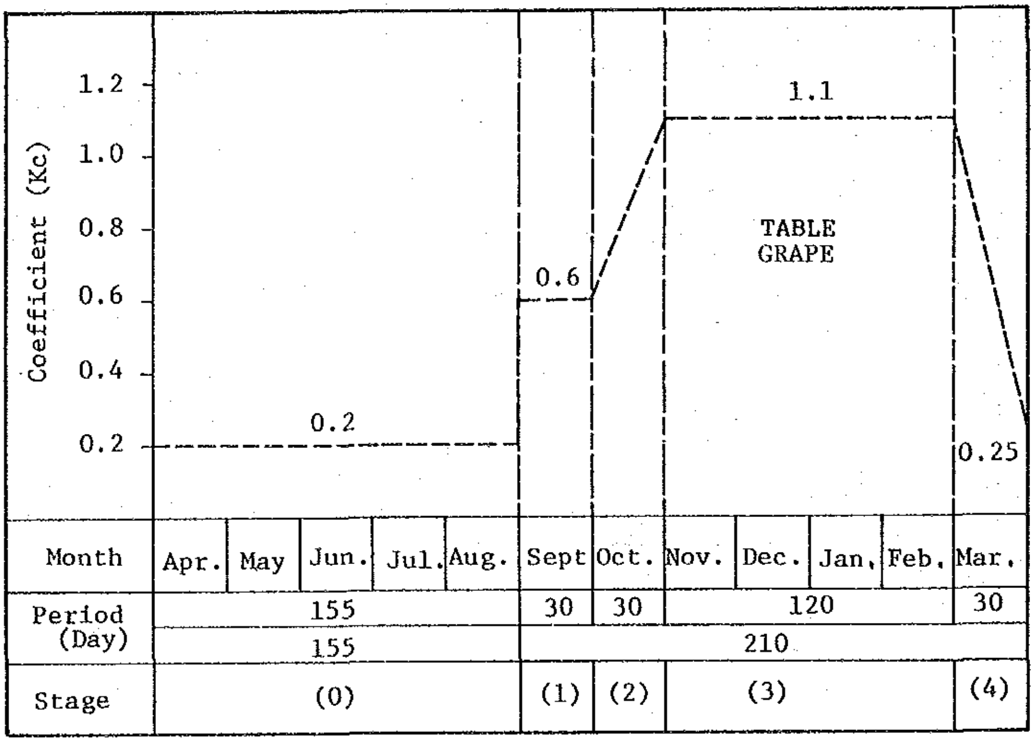
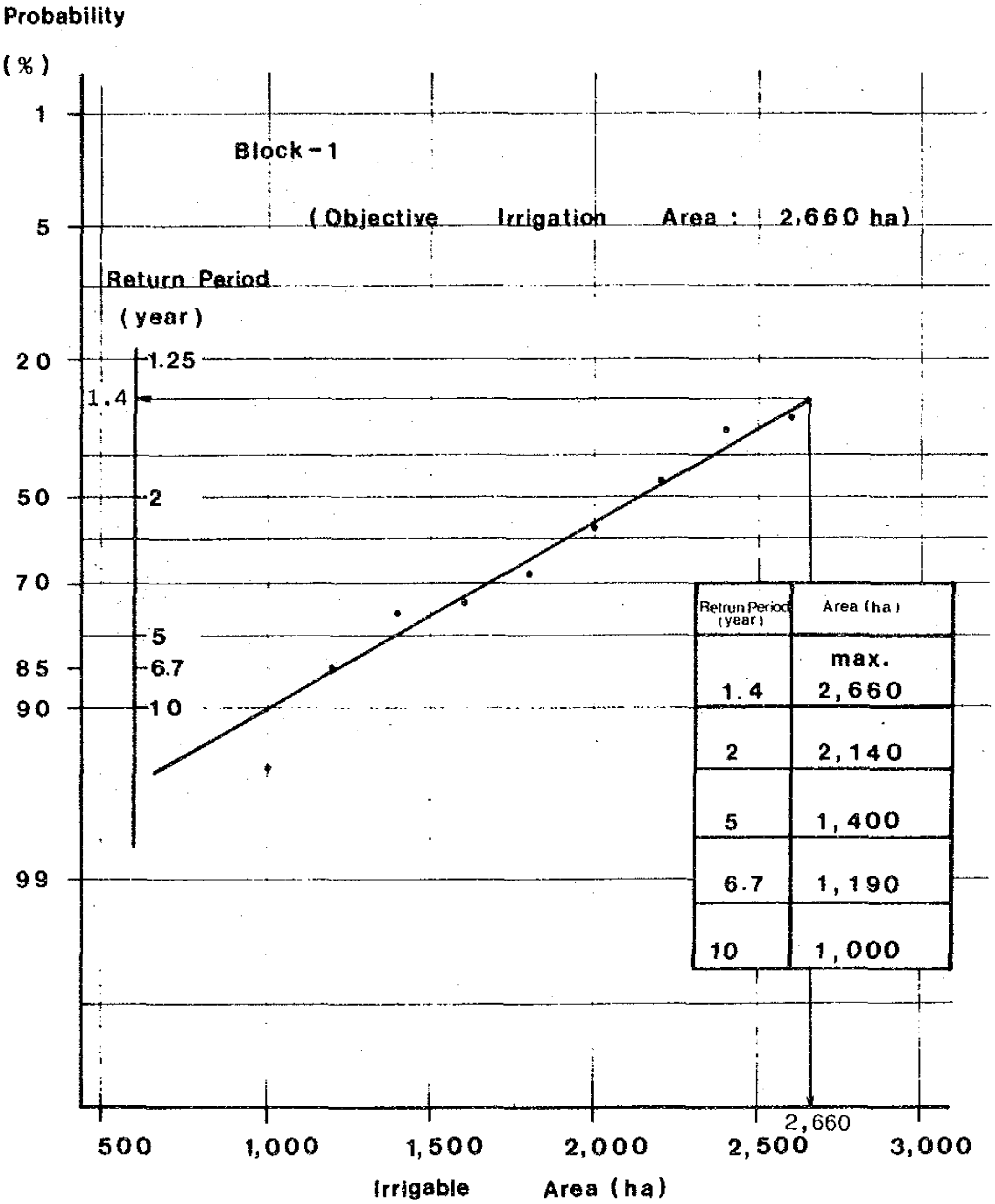


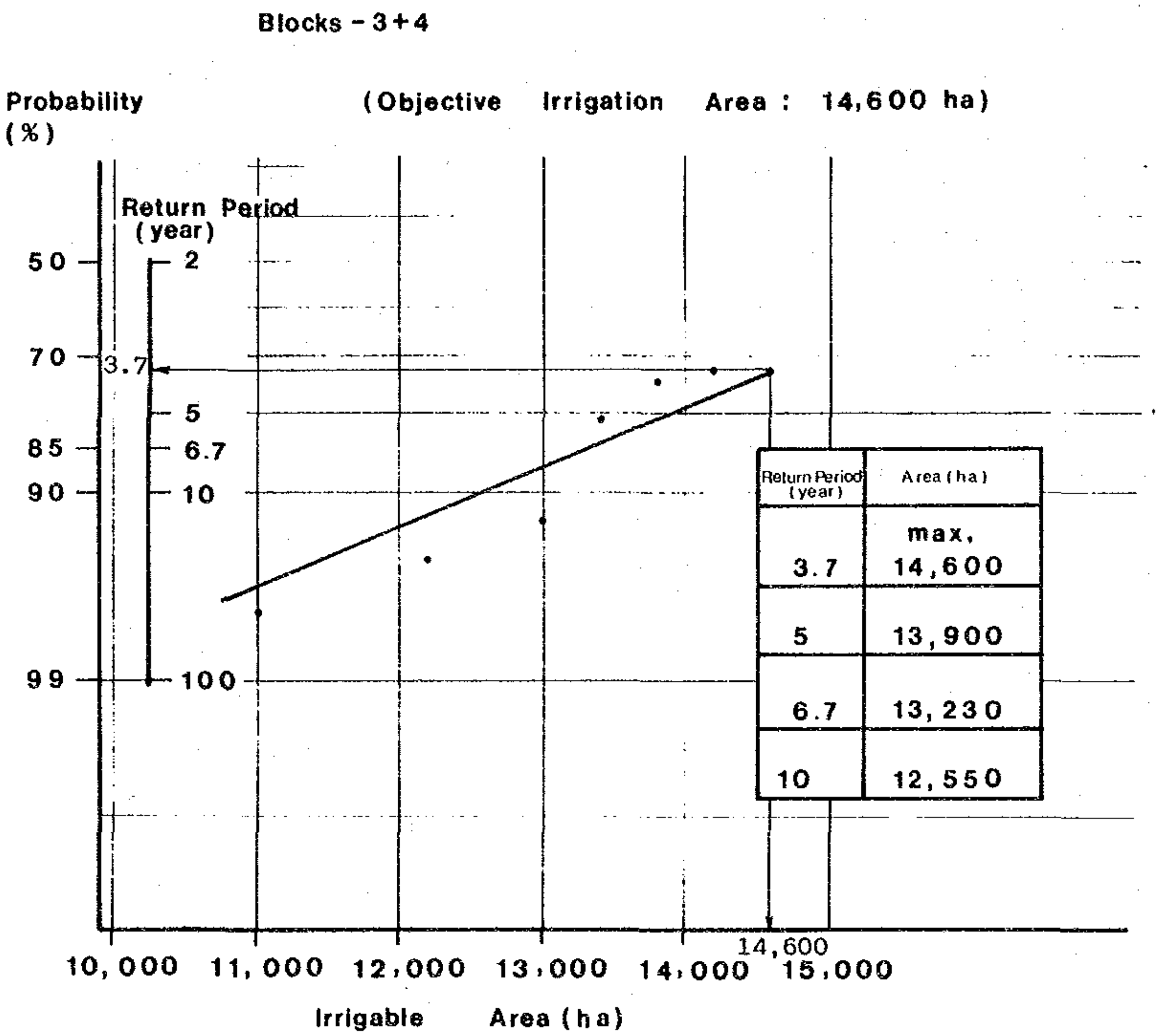
Fig A-11-1(3) Crop Coefficient Curve



Retrun Period (year)	Area (ha)
1.4	max. 2,660
2	2,140
5	1,400
6.7	1,190
10	1,000

Note : Irrigable areas on the proposed condition were obtained by probability through the computation of water balance for 40 years by changing the acreage of the irrigation area.

Fig A-11-2 (1) Irrigable Area by Probability (Block-1)



Return Period (year)	Area (ha)
3.7	max. 14,600
5	13,900
6.7	13,230
10	12,550

Fig A-11-2 (2) Irrigable Area by Probability (Block-3 & 4)

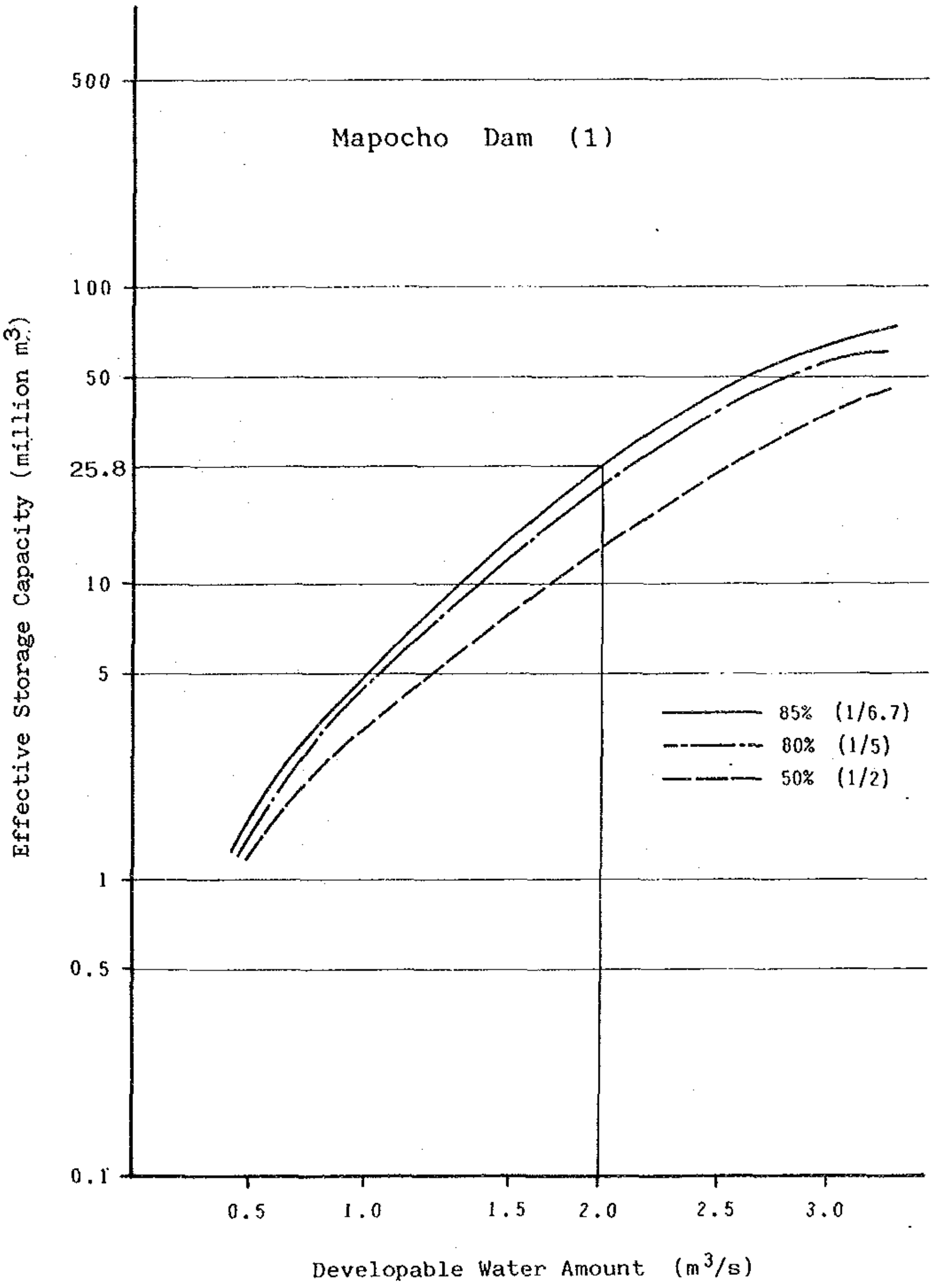


Fig A-11-3 (1) Developable Water Amount ÷ Storage Volume Curve, Mapocho Dam (1)

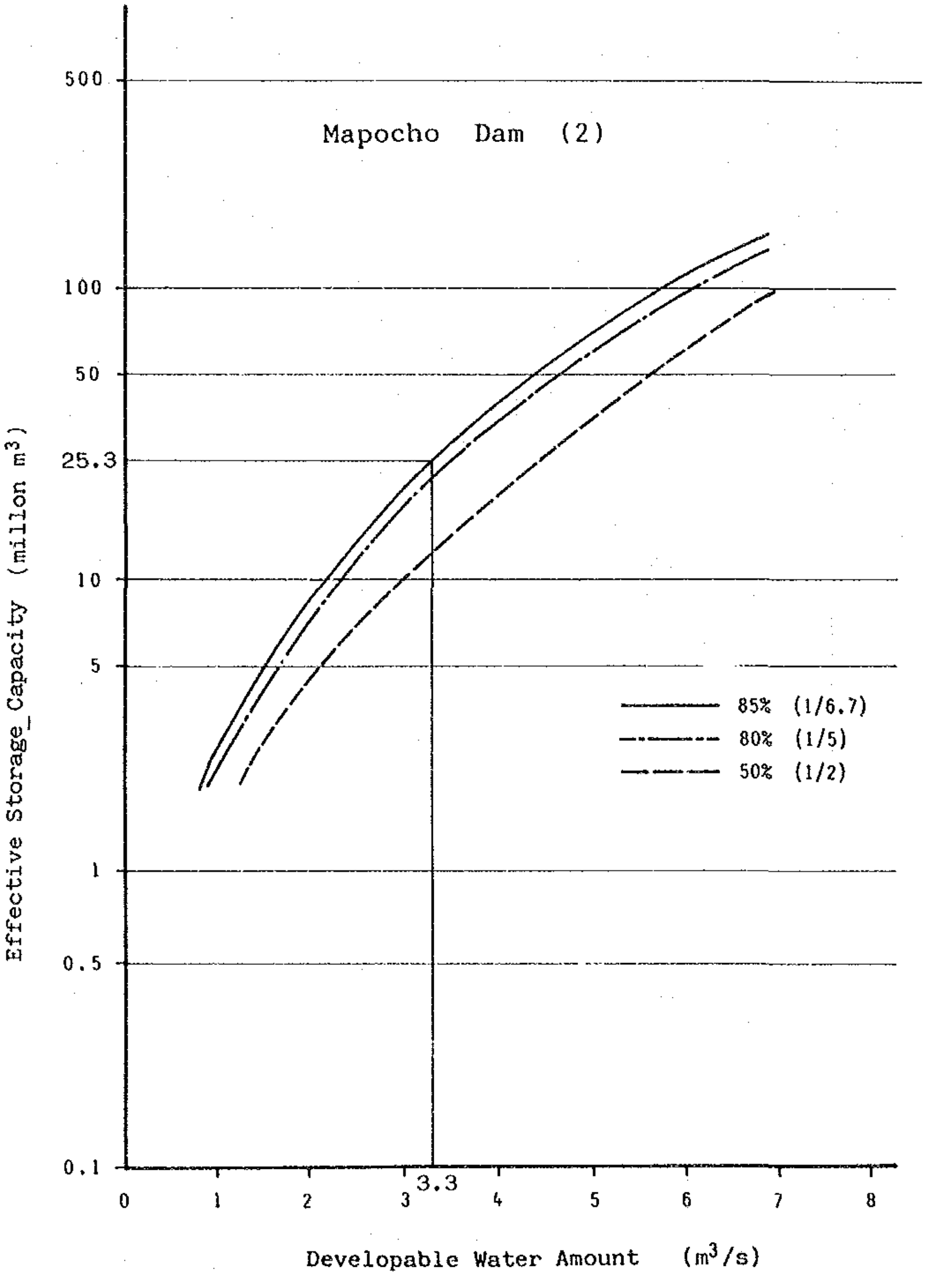
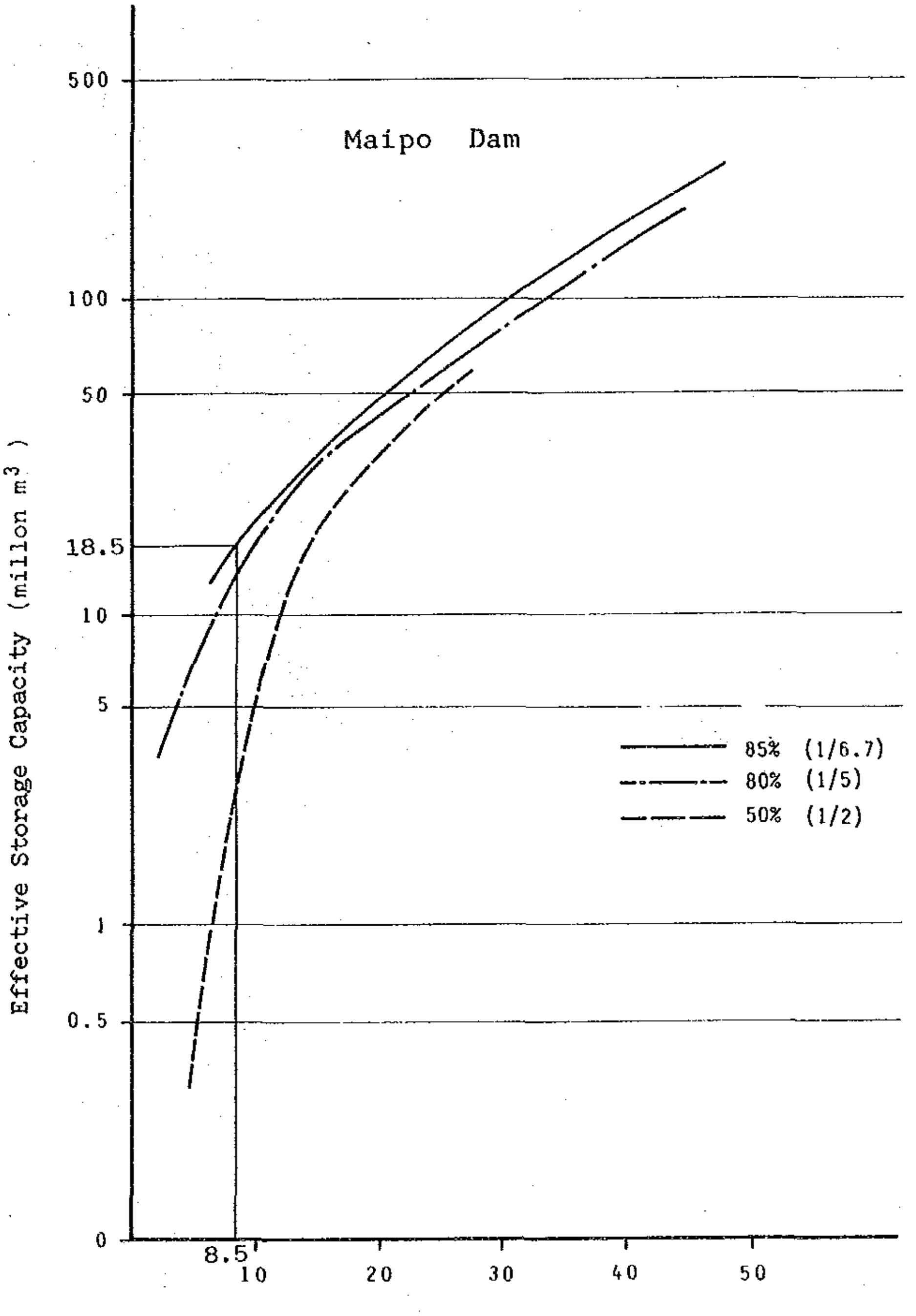


Fig A-11-3 (2) Developable Water Amount - Storage Volume Curve, Mapocho Dam (2)



Developable Water Amount - Storage Volume Curve

Fig A-11-3 (3) Developable Water Amount - Storage Volume Curve, Maipo Dam

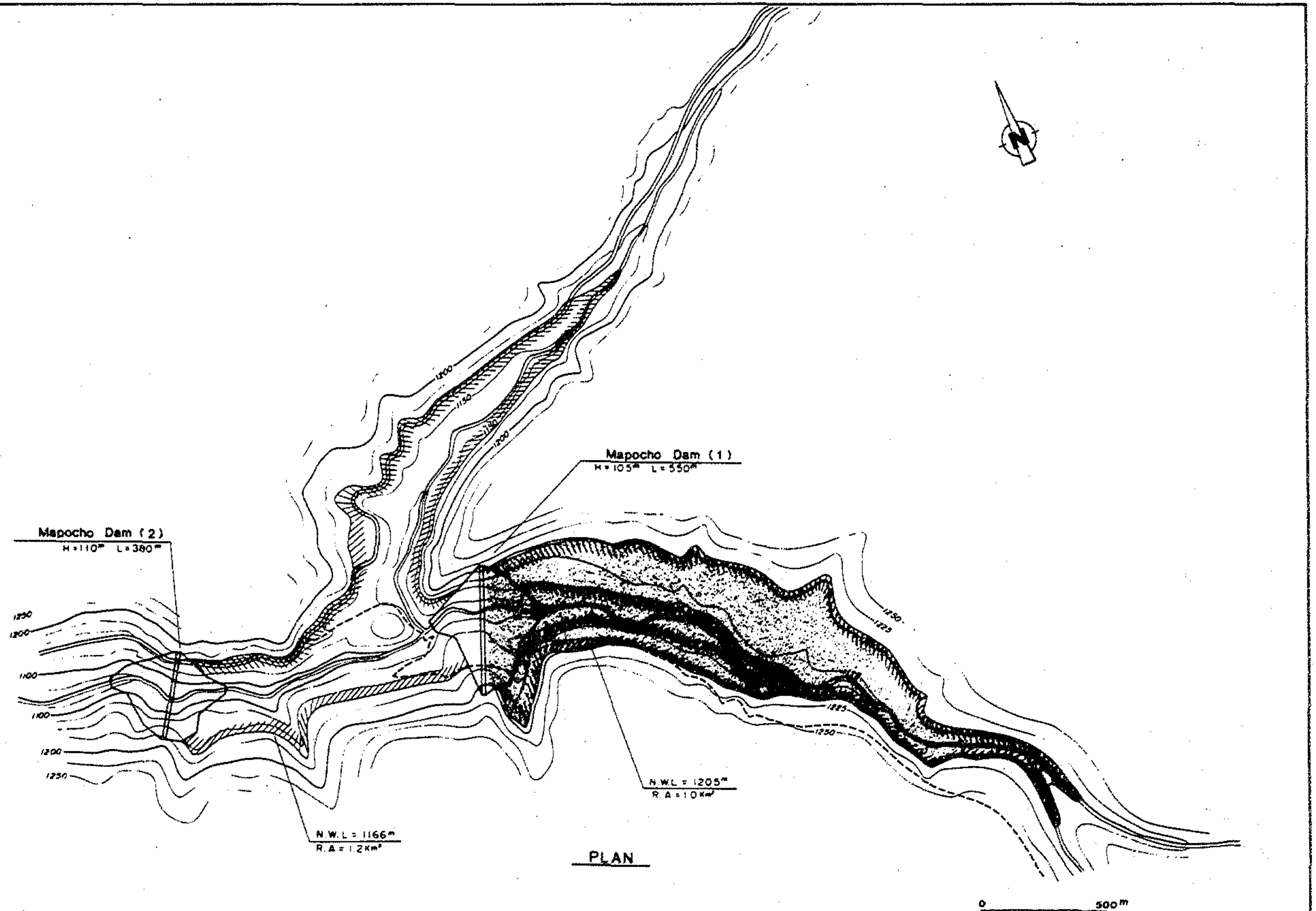
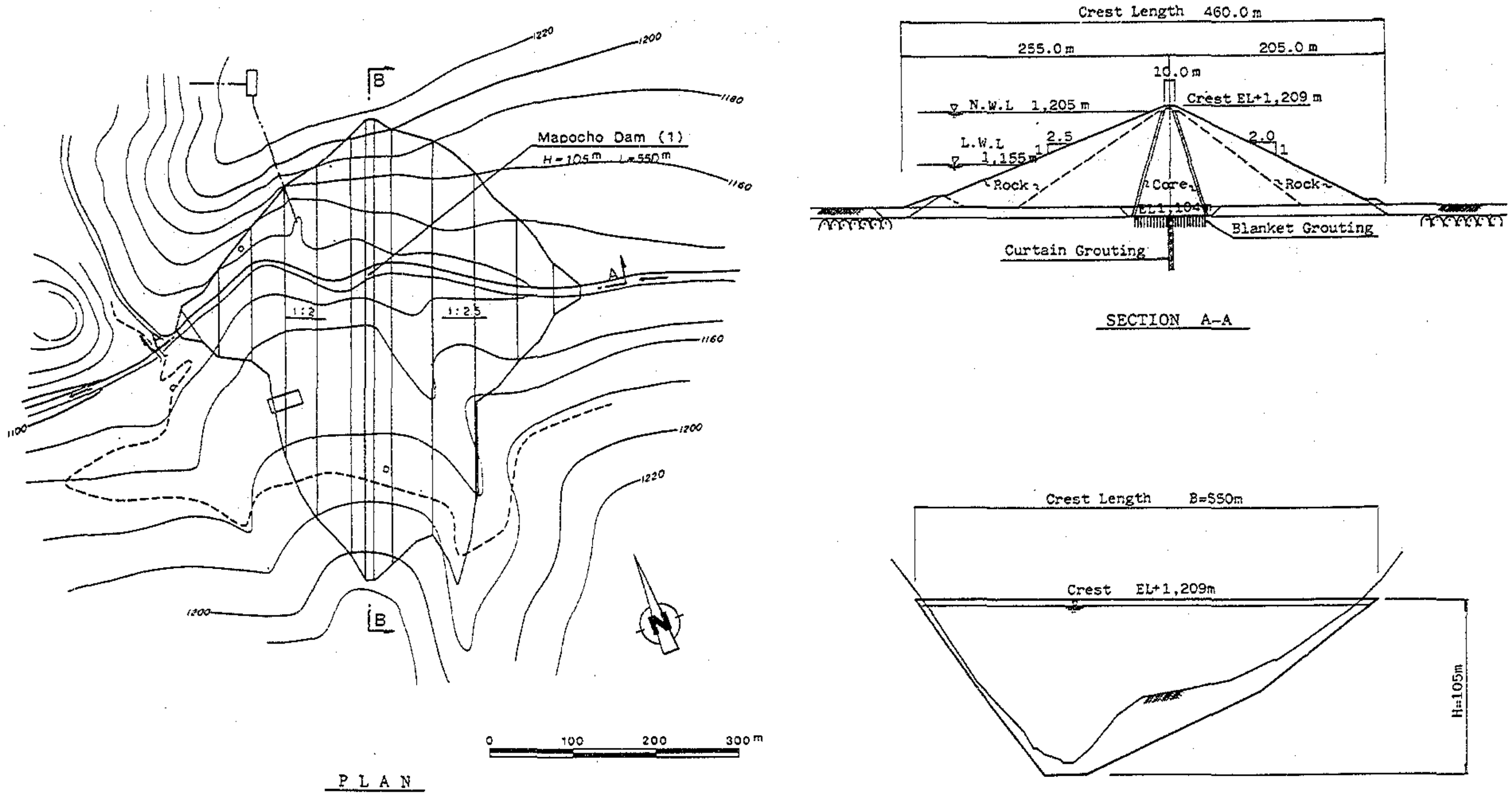


Fig A-11-4 General Plan of Mapocho Dam (1) and Dam (2)

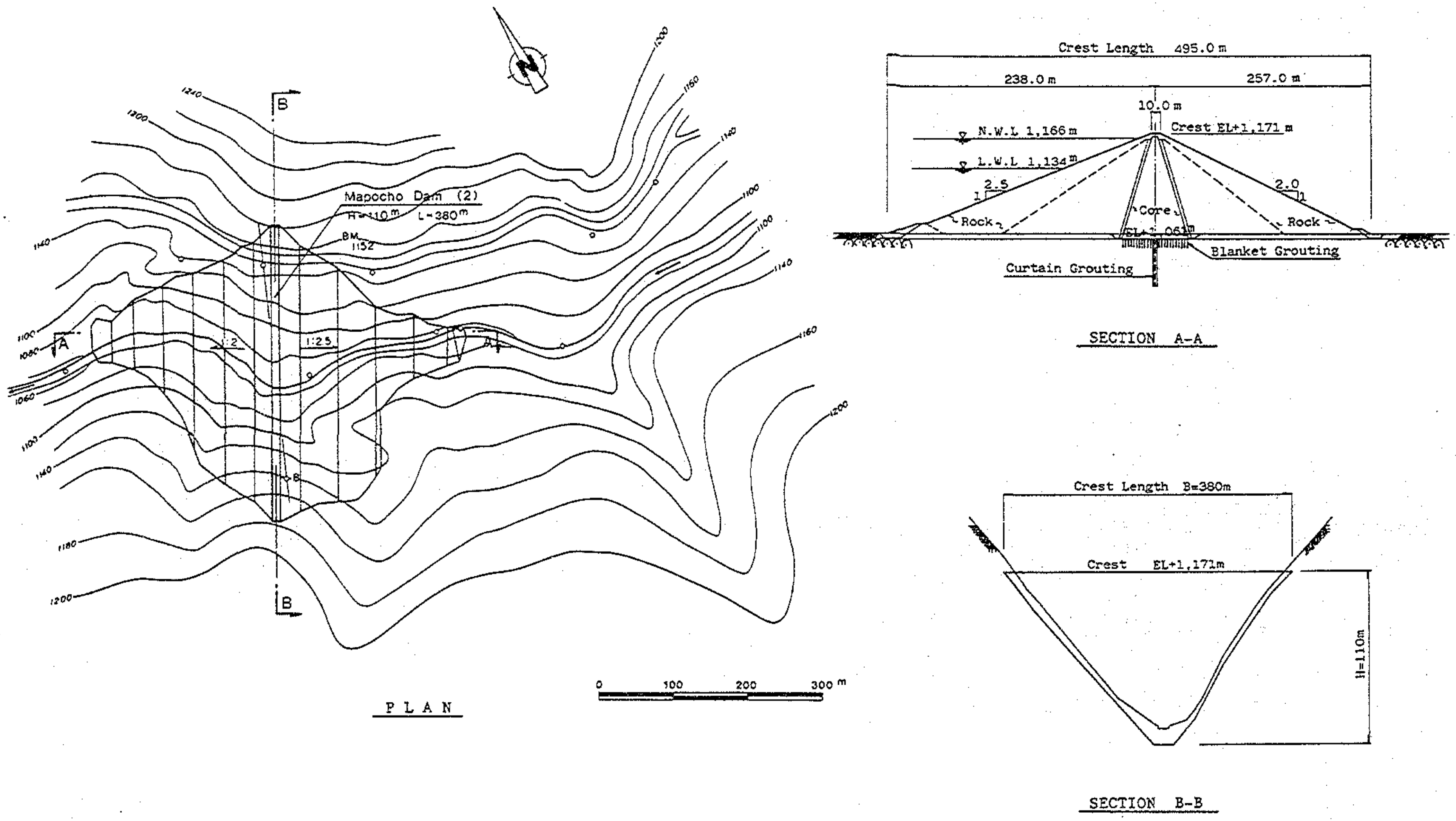


PLAN

SECTION A-A

SECTION B-B

Fig A-11-5 Profile of Mapocho Dam (1)



PLAN

SECTION A-A

SECTION B-B

Fig A-11-6 Profile of Mapocho Dam (2)

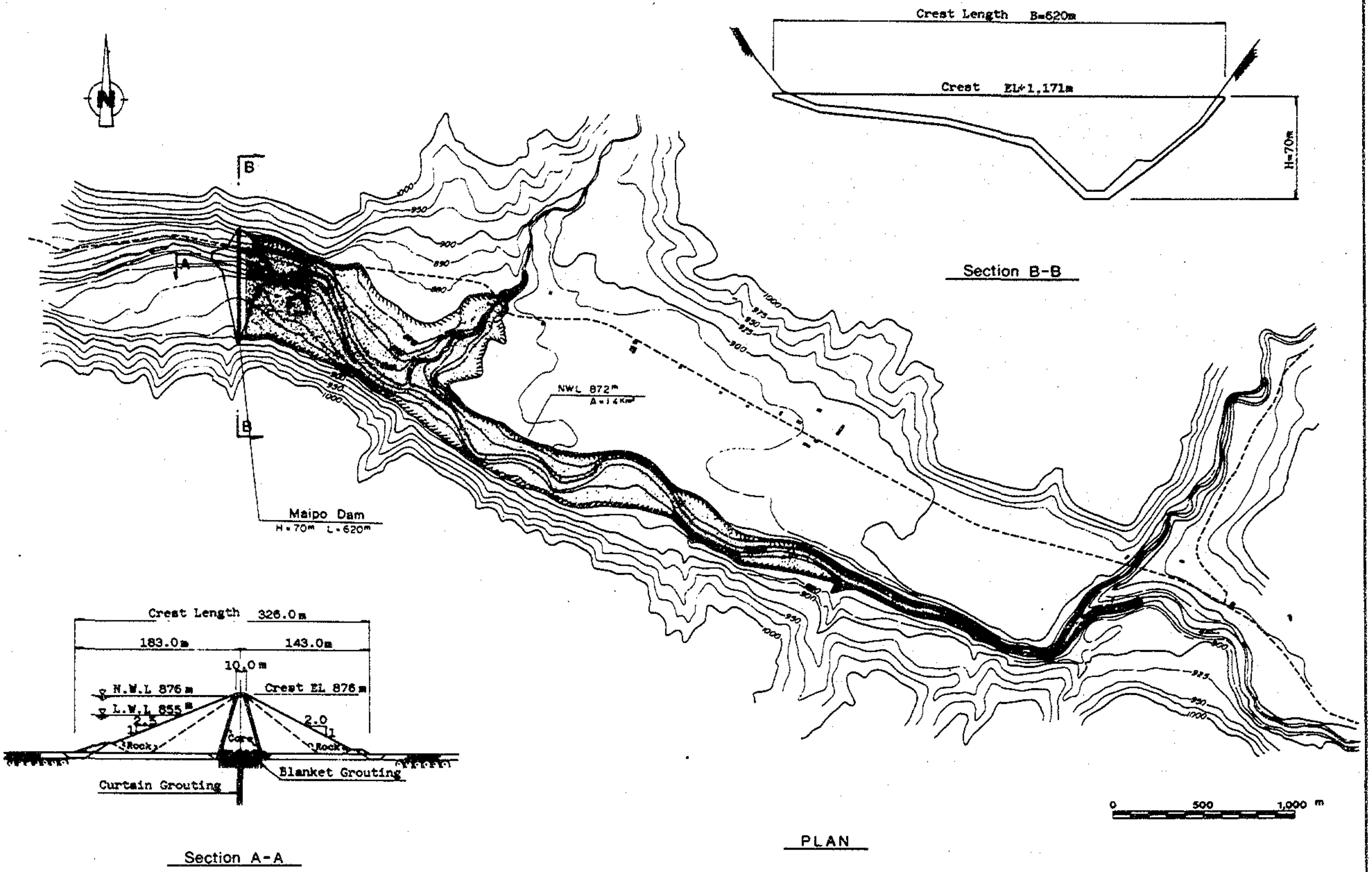


Fig A-11-7 General Plan and Profile of Maipo Dam

Area of Reseveroir

Mapocho(1) Reservoir					Mapocho(2) Reservoir				
River Bed E.L. (m)	H (m)	A (10^3m^2)	V	ΣV	River Bed E.L. (m)	H (m)	A (10^3m^2)	V	ΣV
			(10^6m^3)					(10^6m^3)	
1,115				0.0	1,070				0.0
1,140	25	85	0.71	0.7	1,100	20	207	2.17	2.2
1,160	20	229	3.02	3.7	1,120	20	207	4.14	6.3
1,180	20	471	6.86	10.6	1,140	20	498	6.84	13.2
1,200	20	888	13.37	24.0	1,160	20	1,039	15.04	28.2
1,205	-	(990)	-	(28.6)	1,166	-	(1,240)	-	(31.3)
1,220	20	1,285	21.61	45.6	1,180	20	1,712	27.23	55.4
1,240	20	1,660	29.37	74.9	1,200	20	2,483	41.71	97.1

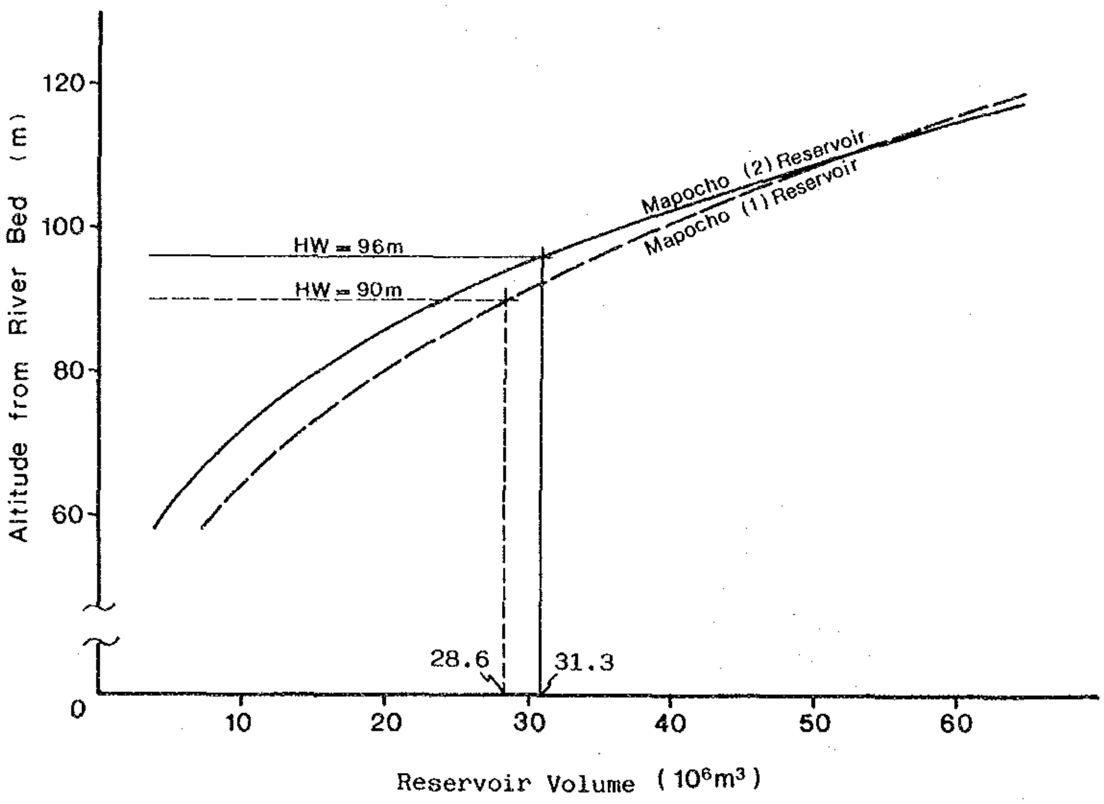


Fig A-11-8 H-V Curve of Mapocho Dam (1) and Dam (2)

Area of reservoir

River Bed E.L. (m)	H (m)	A (10^3m^2)	V	Σ V
			(10^6m^3)	
811				0.0
840	29	287	2.77	2.8
860	20	845	10.83	13.6
870	10	1,282	10.56	24.2
872	-	(1,450)	-	(27.0)
880	10	2,107	16.78	40.9
890	10	3,588	28.15	69.1

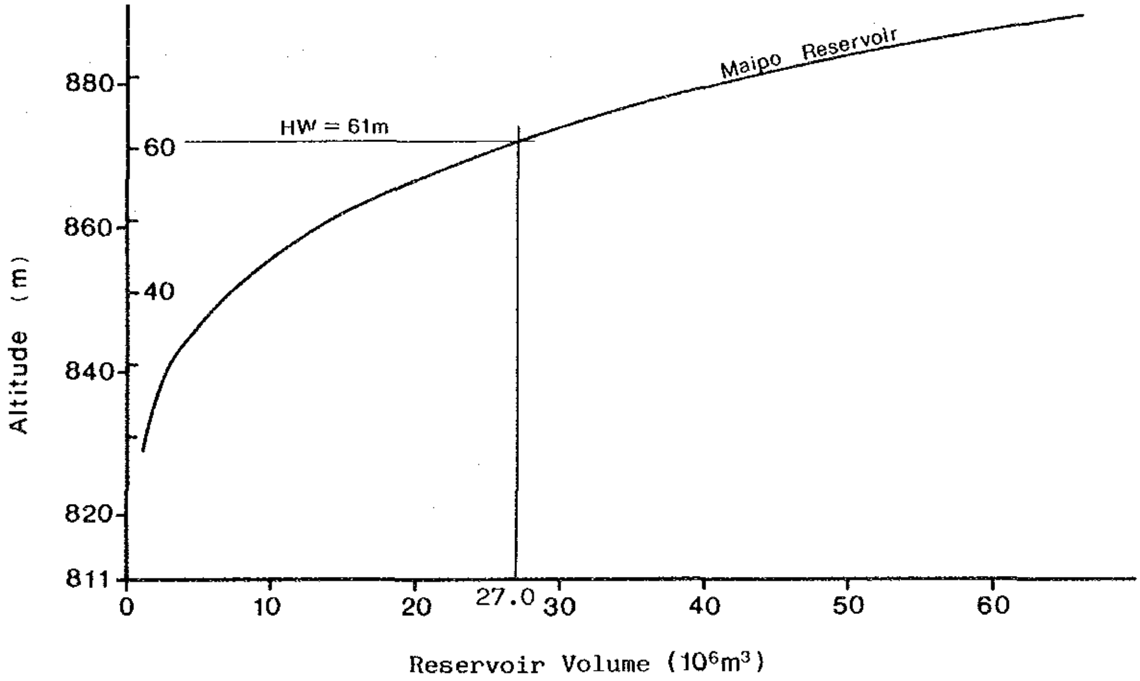
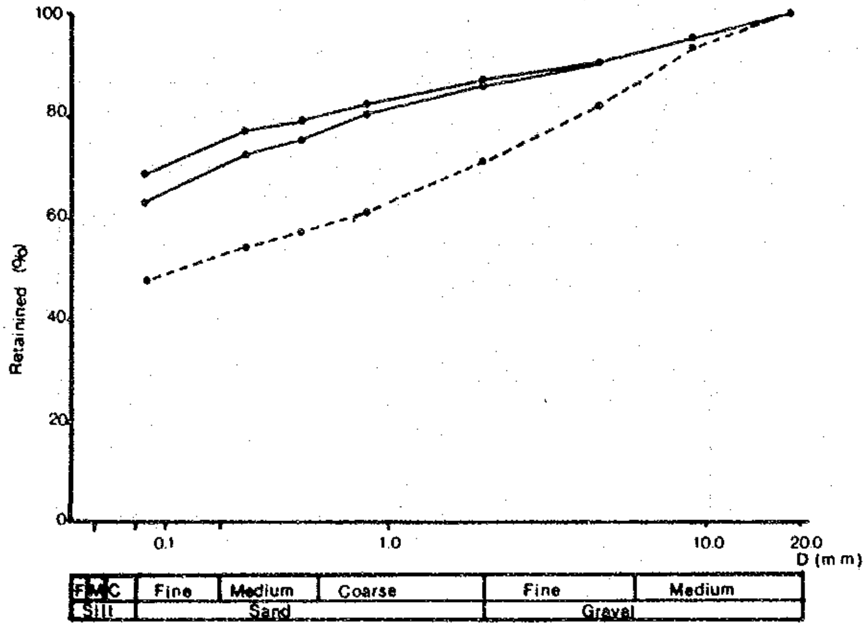
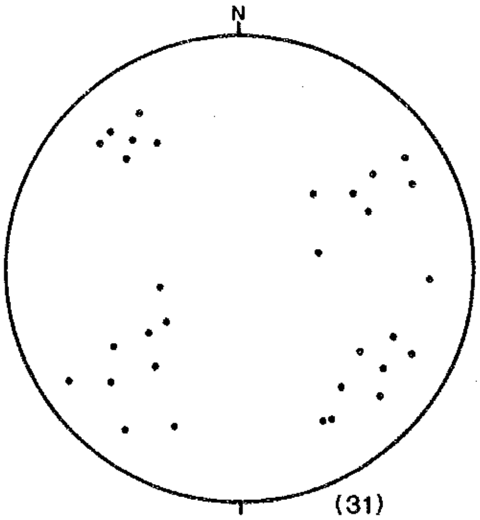


Fig A-11-9 H-V Curve of Maipo Dam



Grading Curves

Fig A-11-10 Grading Curve of Mapocho Dam(1)

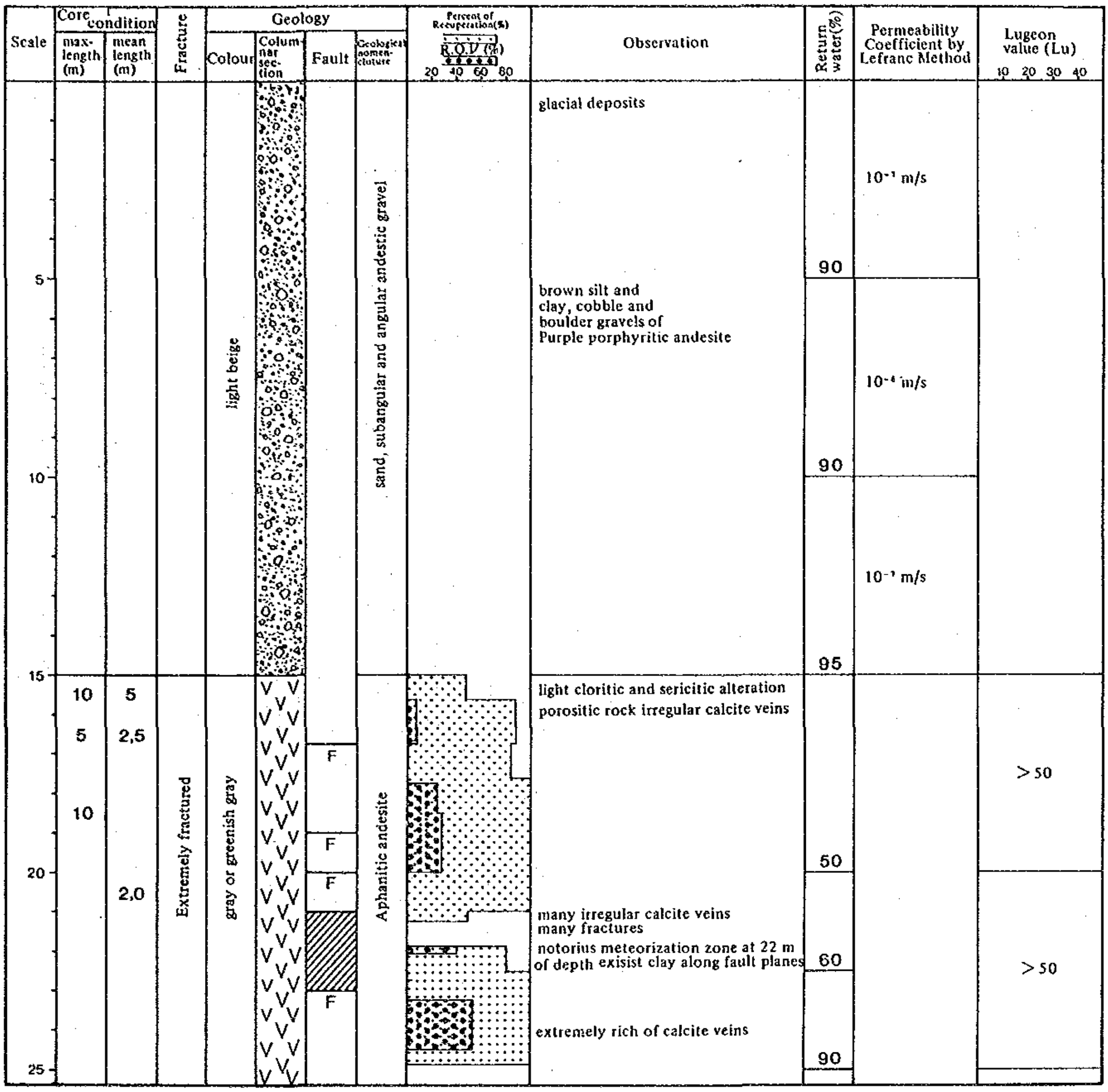


π-Diagram

Fig A-11-11 π-Diagram

Boring Core Log

Study Name : Boring for Mapocho dam (1) (S-2)
Boring Point : Molina river left Margen
Elevation : 1,167 m
Depth : 25 m
Angle : Vertical



glacial deposits

brown silt and
clay, cobble and
boulder gravels of
Purple porphyritic andesite

light cloritic and sericitic alteration
porositic rock irregular calcite veins

many irregular calcite veins
many fractures
notorius meteorization zone at 22 m
of depth exisist clay along fault planes

extremely rich of calcite veins

Fig. A-11-12 Boring Log at Mapocho Dam (1)

Study Name : Boring for Mapocho dam (2) (S-1)
Boring Point : Upper stream of Mapocho river
along the road to Disputado

Elevation : 1,152 m
Depth : 20 m
Angle : Vertical

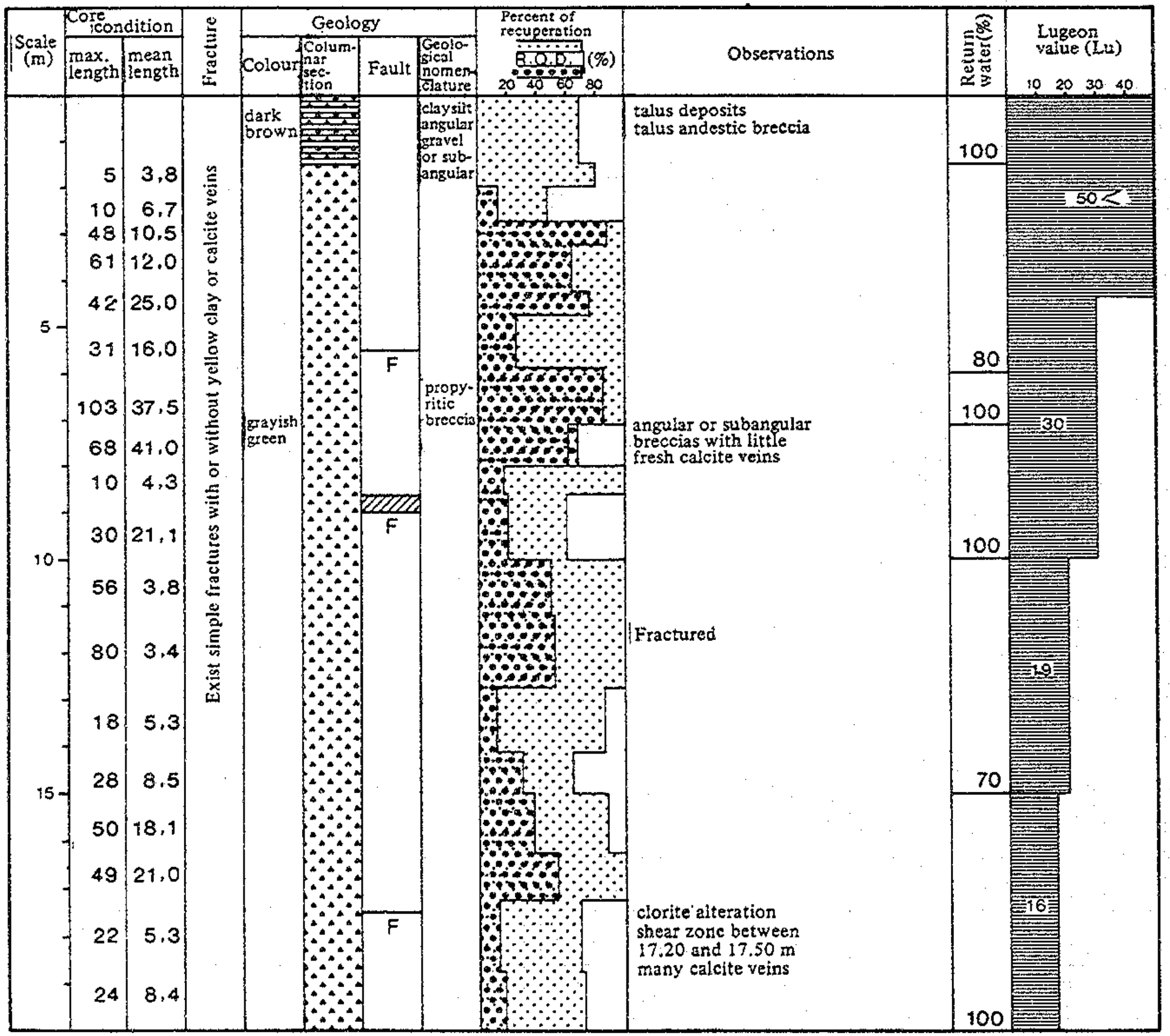


Fig. A-11-13 Boring Log at Mapocho Dam (2)

Pit Point Maipo River Left margen　　Elevation 850m

Excavation Method: Hand Dug　　Groundwater Level no appear

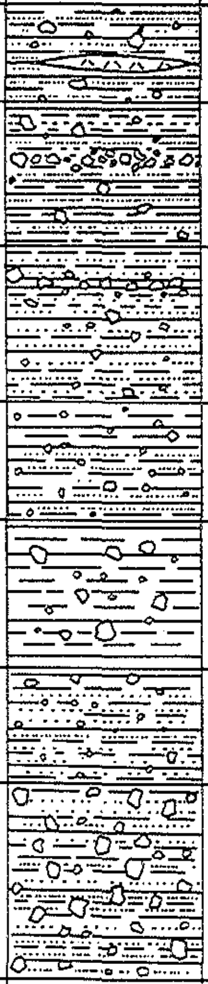
Scale (m)	Eleva-tion(m)	Depth (m)	Thick-ness(m)	Section	Colour	Geological nomenclature	Observation	Permeability coefficient (m/s) (Nasberg-Terles Method Lefranc Method)
		1.5	1.5		light yellow ochre	silt, clay, sand and gravel	subrounded cobble and boulder gravels, clay, silt, sand, pumiceous bed (20cm of thickness)	
		3.7	2.2		grayish yellow ochre	silty clay with sand and gravel	subrounded cobble and boulder gravel (1m of thickness), clay, silt and sand	
5	845	6.1	2.4		light yellow ochre	silty clay with sand and gravel	subrounded and angular cobble and boulder gravels, silt, sand and clay	1.3×10^{-6} 2.0×10^{-5}
		7.9	1.8		dark yellow ochre	clayish silt with sand & gravel	subrounded cobble gravel (max. ϕ20cm), silt, clay and sand	
10	840	10.2	2.3		light yellow ochre	clayish silt with sand & gravel	subrounded classified cobble and boulder gravels, silt, clay and sand	5.2×10^{-7} 2.0×10^{-6}
		12.0	1.8		light yellow ochre	clayish silt with sand and gravel	subrounded pebble gravel (max. ϕ10cm),silt, clay and sand	
15	835	15.0	3.0		grayish yellow ochre	sand and clay with gravel	subrounded boulder gravel sand, silt and clay (max. 60~70 cm)	1.3×10^{-5} 2.1×10^{-4}

Fig. A-11-14 Hand Dug Pit of Maipo Dam

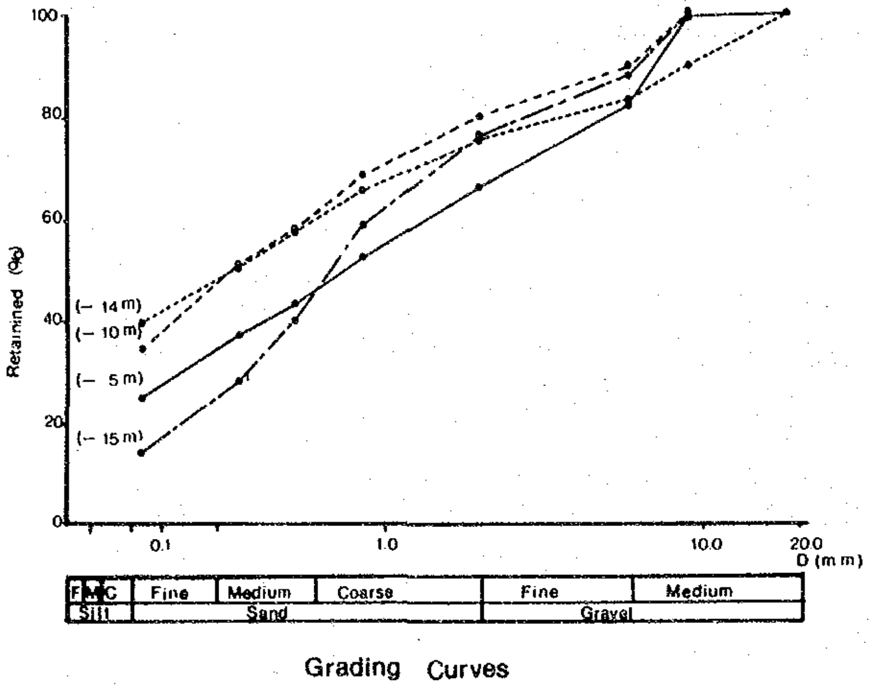
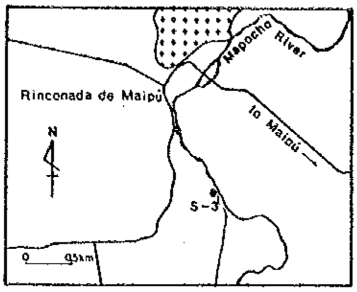
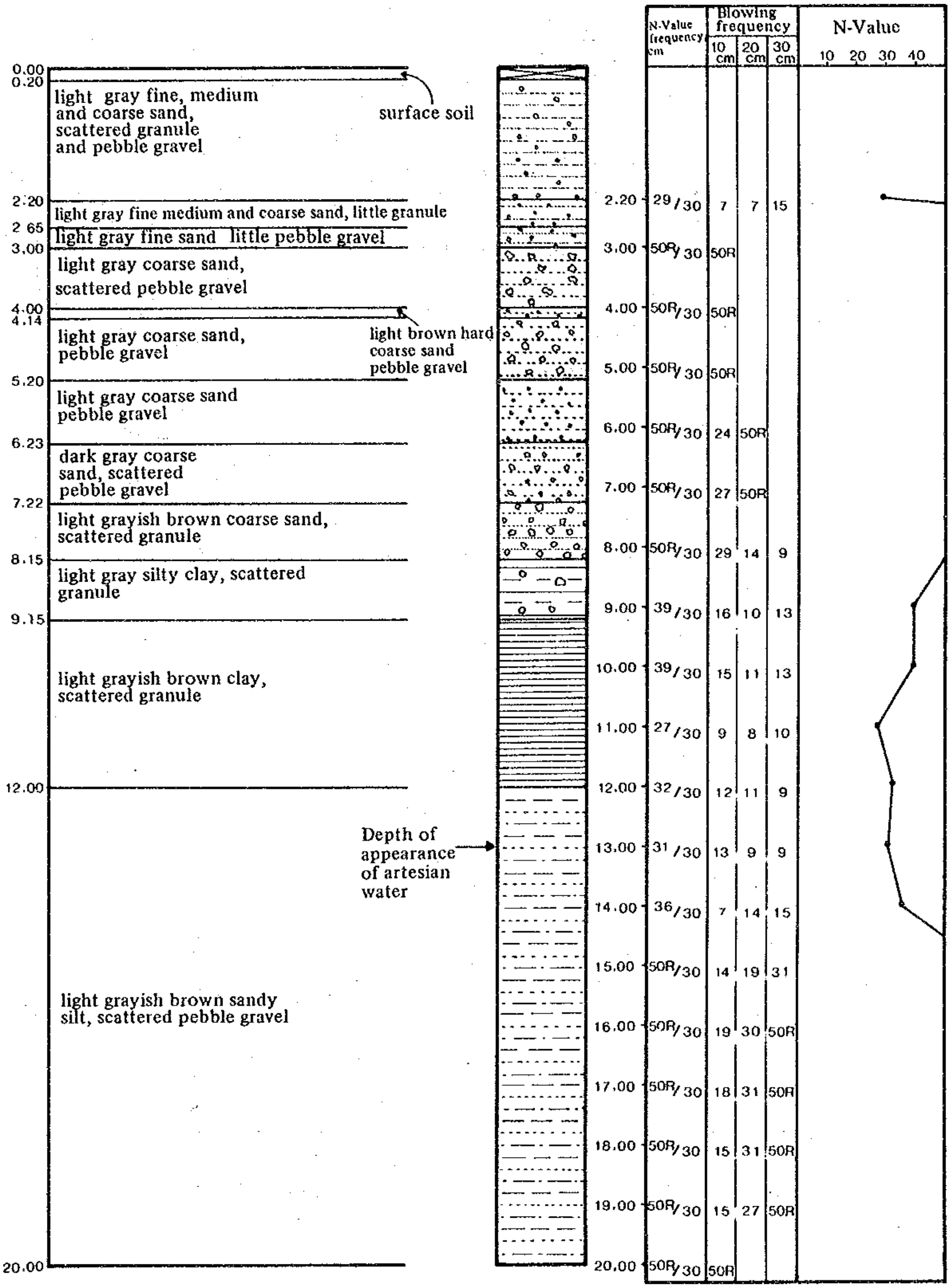


Fig A-11-15 Grading Curves of Hand Dug Pits along the Maipo River

Boring Core Log

Study Name : Boring for construction of head works (S-3)
Boring Point : Rinconada de Maipu





	N-Value frequency/cm	Blowing frequency 10 cm	20 cm	30 cm
2.20	29/30	7	7	15
3.00	50R/30	50R		
4.00	50R/30	50R		
5.00	50R/30	50R		
6.00	50R/30	24	50R	
7.00	50R/30	27	50R	
8.00	50R/30	29	14	9
9.00	39/30	16	10	13
10.00	39/30	15	11	13
11.00	27/30	9	8	10
12.00	32/30	12	11	9
13.00	31/30	13	9	9
14.00	36/30	7	14	15
15.00	50R/30	14	19	31
16.00	50R/30	19	30	50R
17.00	50R/30	18	31	50R
18.00	50R/30	15	31	50R
19.00	50R/30	15	27	50R
20.00	50R/30	50R		

Fig. A-11-16 Boring Log of Esperanza Headworks

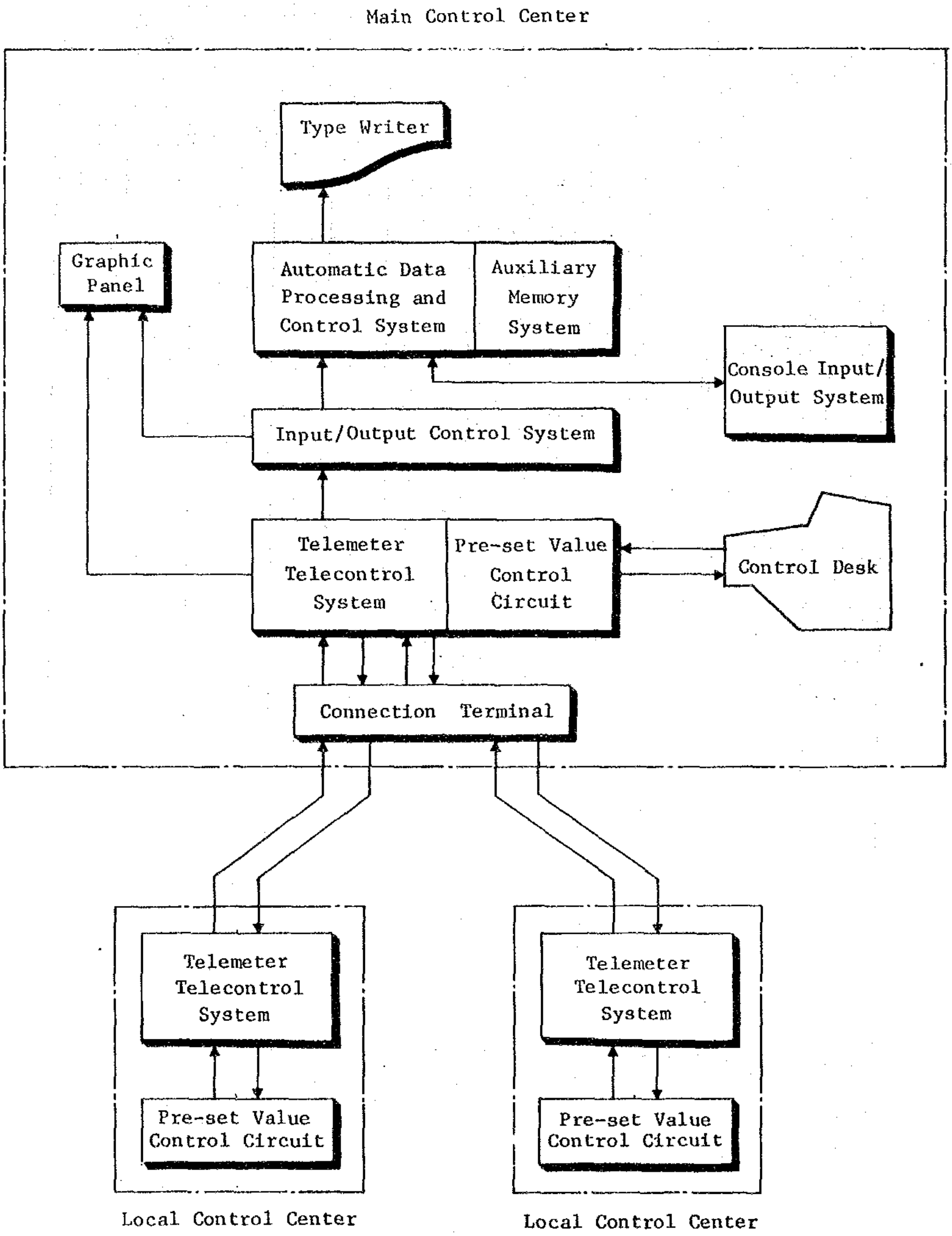


Fig A-11-17 Centralized Control System

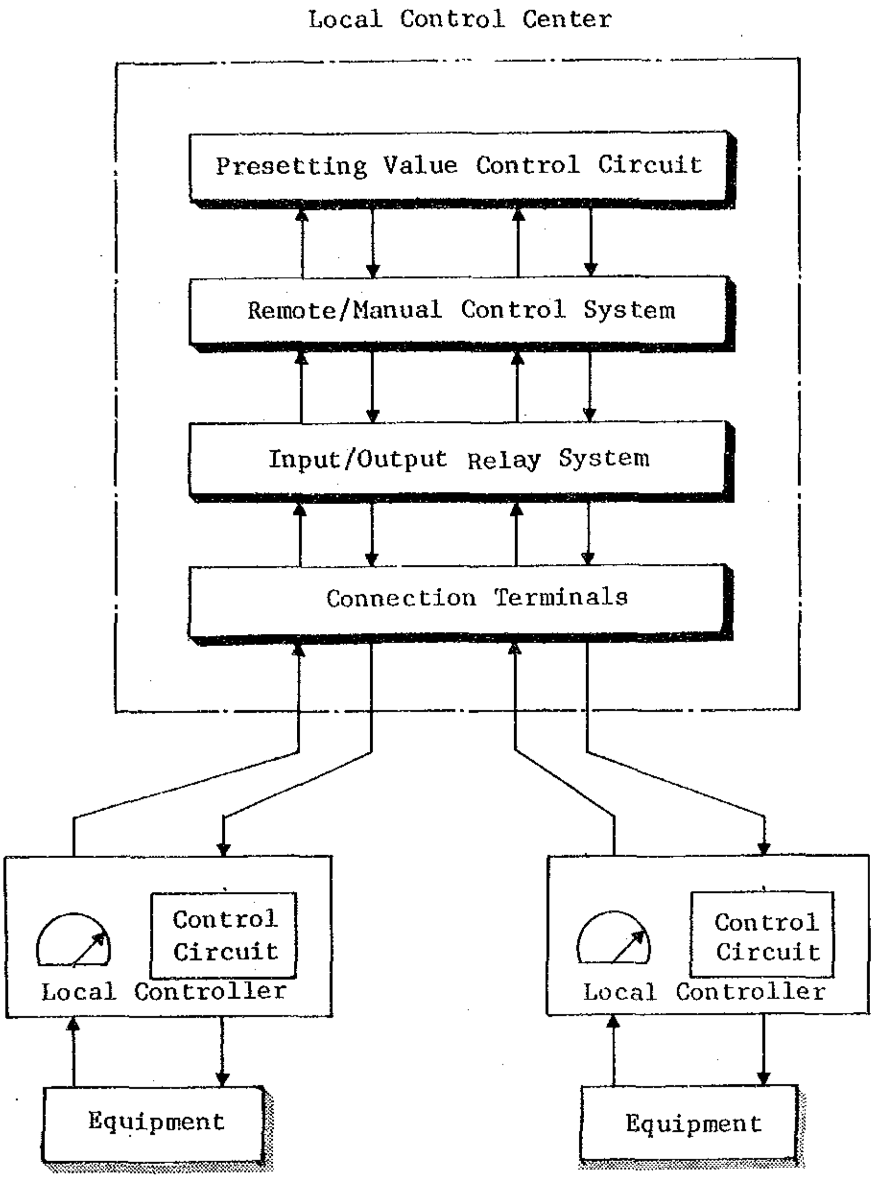


Fig A-11-18 Block Diagram of Local Control System

Appendix 12: Drainage

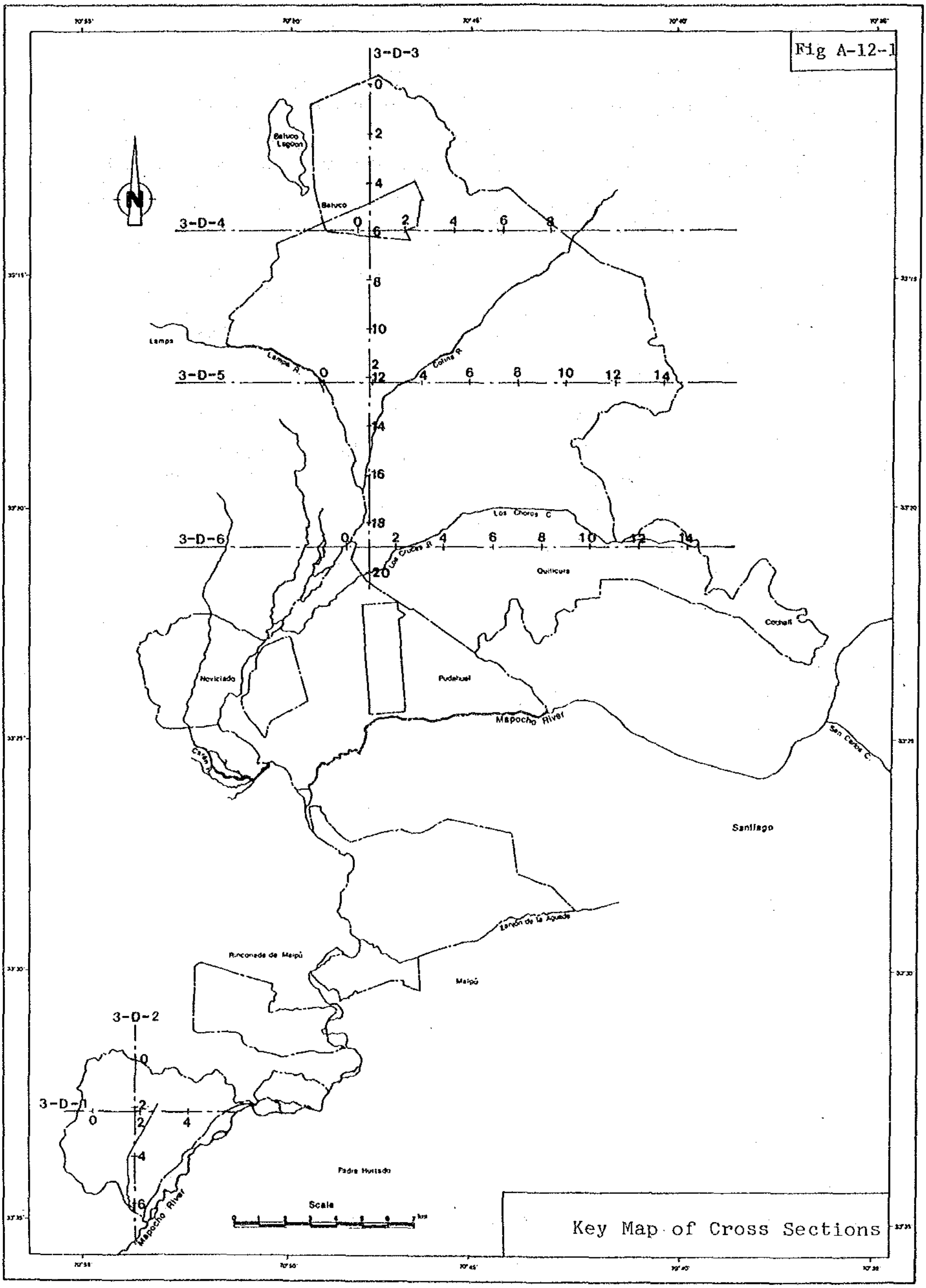
LIST OF TABLE

LIST OF FIGURES

Table A-12-1 Existing Main Drainage Canals /Streams

Block	Name	Capacity (m^3/s)	Observation Point
3	• Cruces river	30.0	
	• Carén river	5.0	
4	• Huechuraba canal	3.0	Rinconada El Salto
	• - do -	18.0	El Guanaco
	• Choros canal	20.0	Puente Verde
	• - do -	6.0-8.0	Quilicura

Fig A-12-1



Key Map of Cross Sections

(Block - 1)

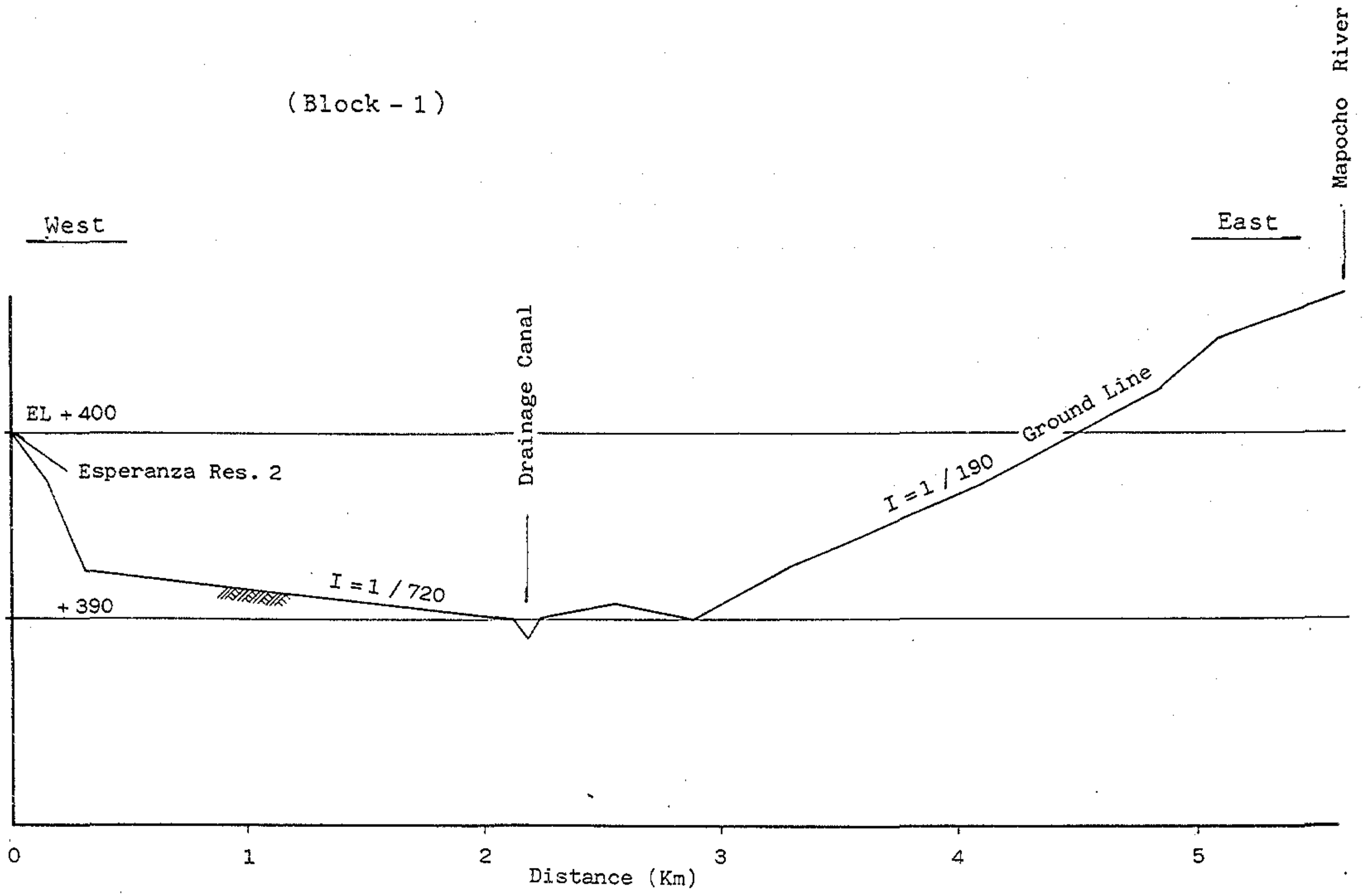


Fig A-12-2 Cross Section of 3-D-1

(Block - 1)

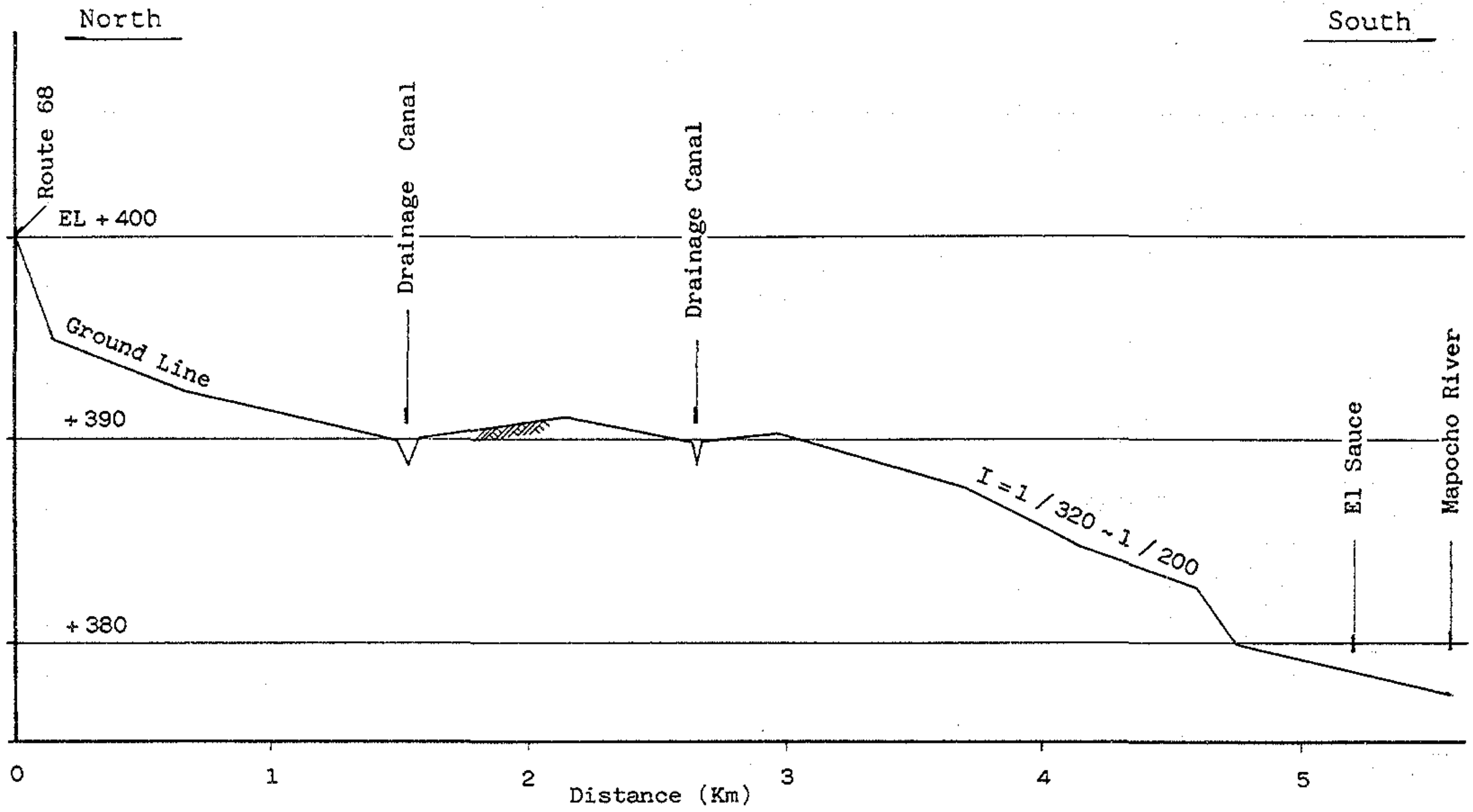


Fig A-12-3 Cross Section of 3-D-2

(Block - 4)

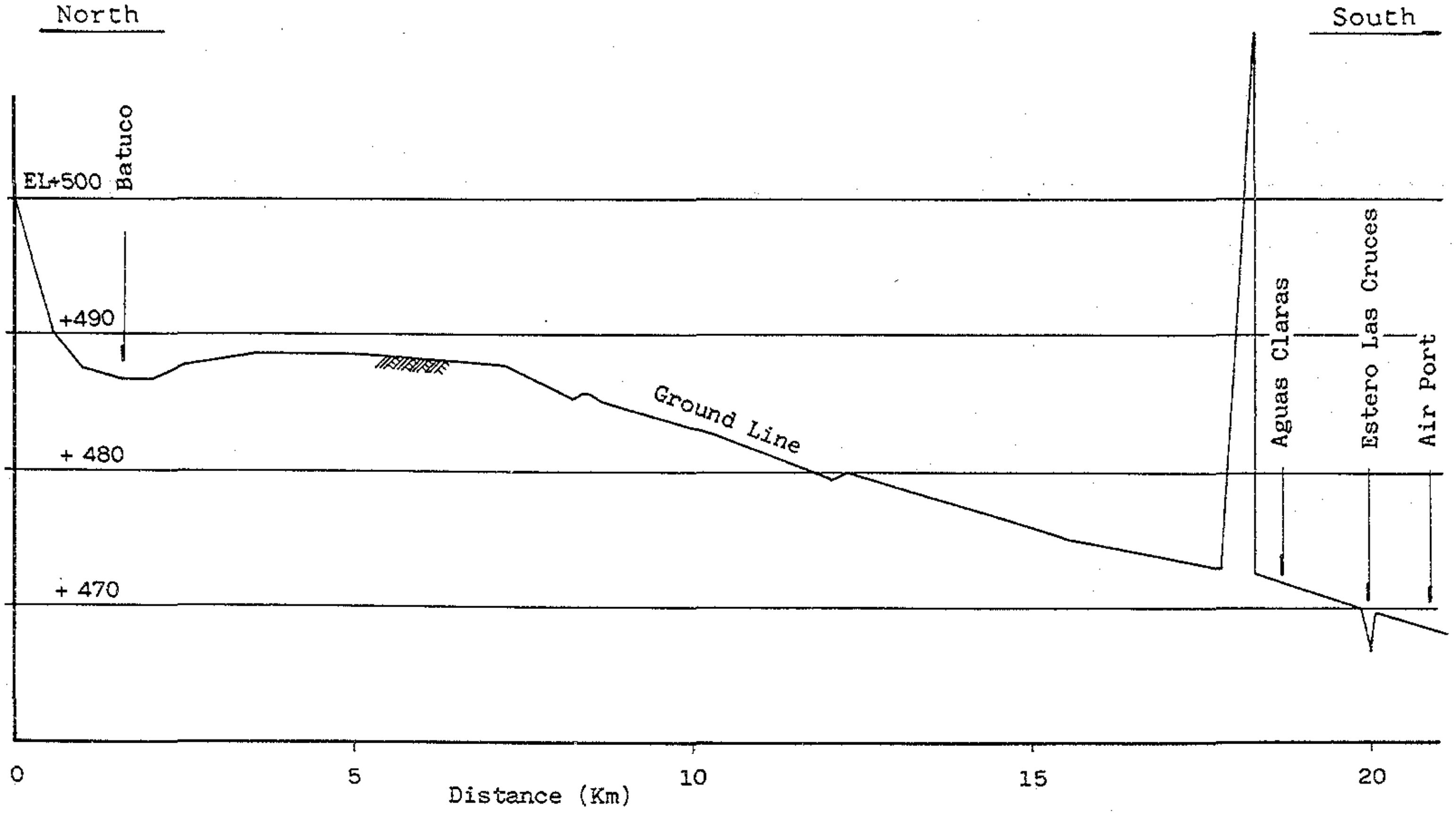


Fig A-12-4 Cross Section of 3-D-3

(Block - 4)

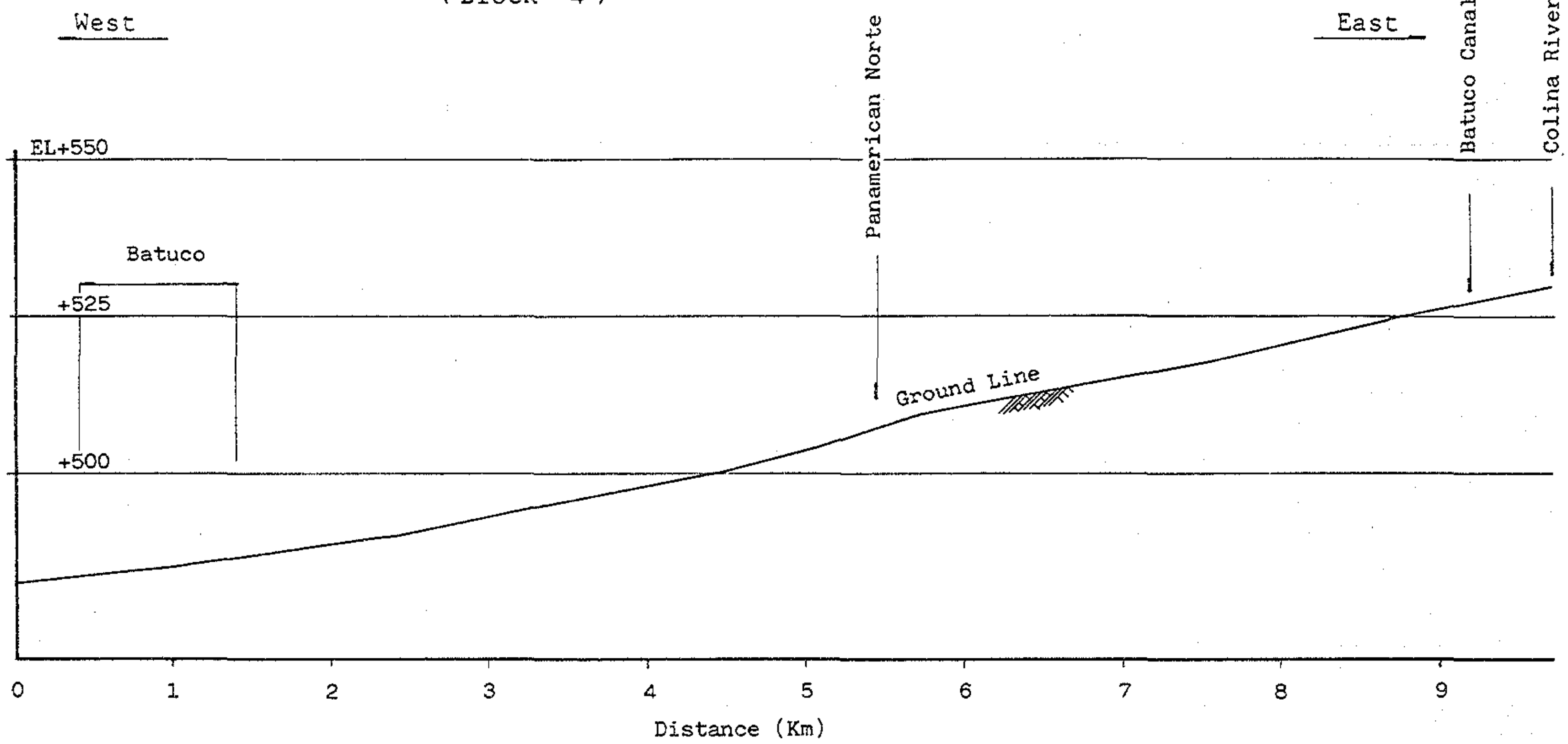


Fig A-12-5 Cross Section of 3-D-4

(Block - 4)

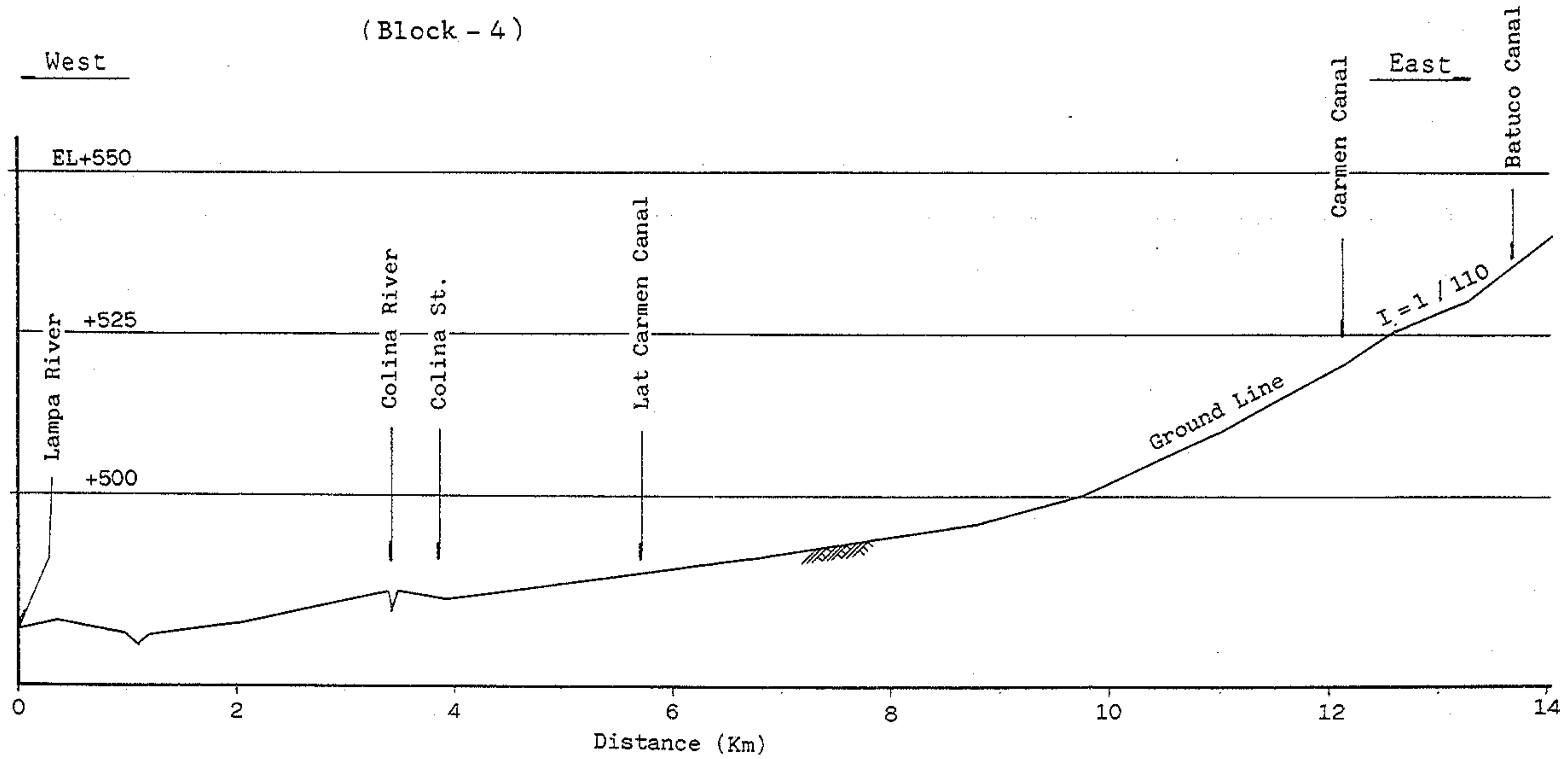


Fig A-12-6 Cross Section of 3-D-5

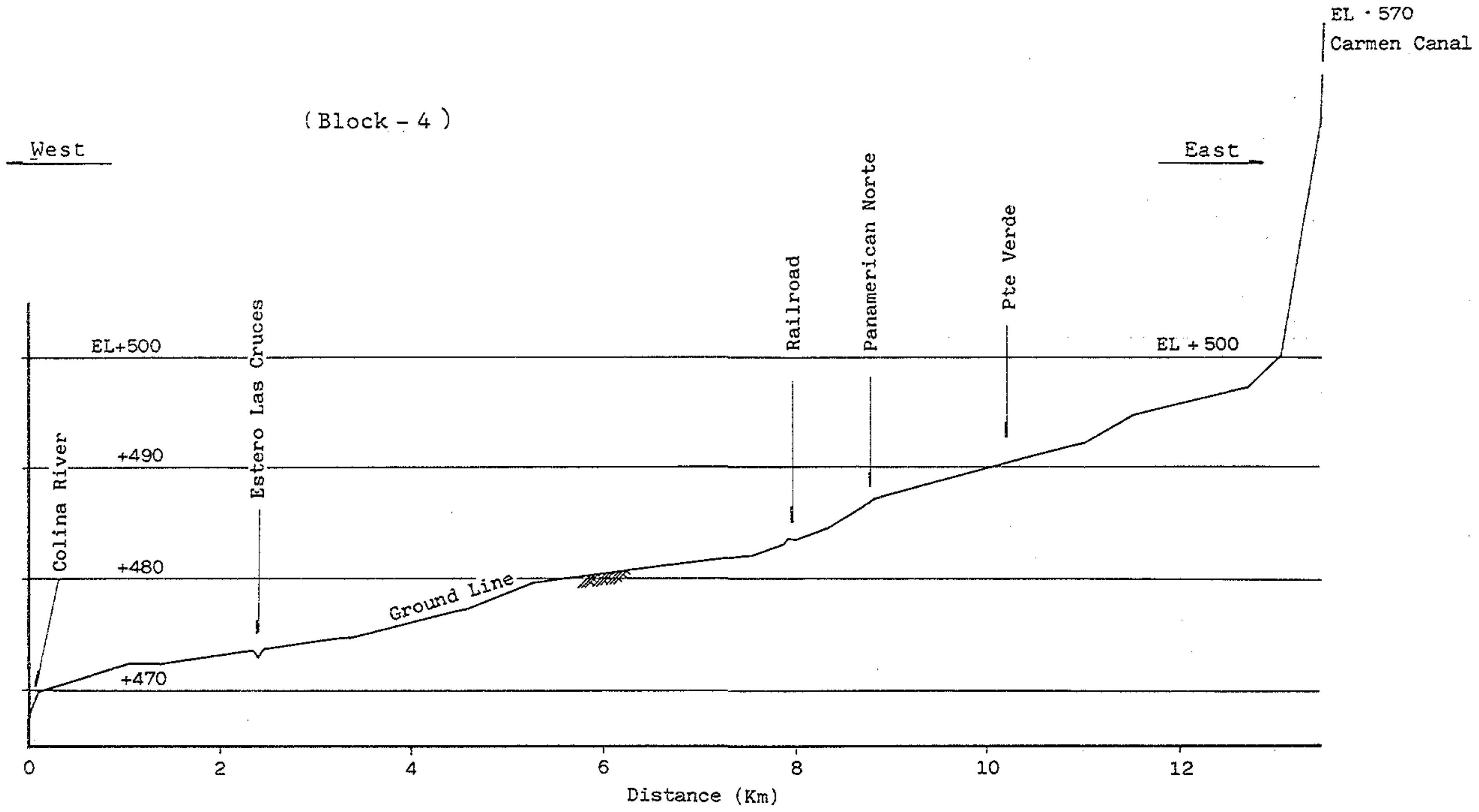


Fig A-12-7 Cross Section of 3-D-6

Appendix 13: Flood and Erosion

LIST OF TABLES

LIST OF FIGURES

13.1 Present Conditions of Flood and Erosion

(1) Present Conditions of Main Rivers

1) Mapocho River

The Mapocho river flows from the Andes Range (altitude of the headwaters is 5,200 m) in the east down towards southwest, reaching the northeast edge of Santiago city. On the way, it gathers several branch streams, such as the Covarrubias river from the left side and San Francisco and Arrayan rivers from the right side. Then the Mapocho river crosses the northern part of Santiago city and flows south after meeting the Lampa river at the western part of the Central Valley.

The stream gradient of the Mapocho river is as follows:

a. Mountainous section: 1/20 - 1/60
b. Santiago city section: 1/90
c. Confluence section with the Lampa river: 1/450
d. Confluence section with the Maipo river: 1/180

The upperstream of the Mapocho river has a U-type cross-section in the mountainous area due to little dissection of the river. It maintains an almost natural river section in the plain area. The river channel in the Santiago city section has been improved as follows:

a. Stone with concrete bank (built at the beginning of this century), approx. 4 km long along the Central part of the city.

b. Gabion bank (being constructed after the 1982 flood), approx. 5 km long

c. Riprap and groyne; some sections

2) Lampa River

The Lampa river flows down to the south along east edge of the Coastal Range along the west edge of the Central Valley into the Mapocho river. Its stream gradient is 1/150 in the mid-stream section (Til-Til) and 1/1,000 in the downstream section (confluence with the Mapocho river).

There are three main branch streams; the Chacabuco river, flowing into the Lampa river from the left side in the mid-stream section; the Colina river from the left side in the downstream section; the Carén river from the right side in the downstream section.

The Carén river flows south in paralllel with the Lampa river, collecting the rainwater from the Coastal Range and meets the Lampa river through Carén lake.

There are two irrigation dams; one is Rungue dam located in the upstream section of the Lampa river, and the other is Huechún dam in the mid-stream section of the Chacabuco river.

The Lampa river has a gentle stream gradient and the banks at both sides consist of soft rock, forming a wide U-shaped valley. the discharge water flows mostly underground in the mid-stream section due to a thick sediment layer on the river bed. Surface water in the river is not usually observed except in winter when there is a big discharge. The Lampa river for several kilometers has no clear river channel in the downstream section after Lampa town, because of its almost flat topography. It forms a network of streams down to the junction with the Colina river. In the downstream section after the confluence with the Colina river, the Lampa river forms a river channel again; 20 m wide and 3 m deep along the next 10 km and 36 m wide and 5 m deep between Noviciado village and the confluence with the Mapocho river. This narrow channel section of the Lampa river is the bottle neck against a smooth flow, and causes sedimentation in the upstream area, forming the large flat low-land.

3) Colina River

The Colina river with its waterheads in the mountains at the northeast flows down southwest with a steep gradient (1/10-1/20) to the well-developed alluvial fan near Peldehue, crossing it with a 1/500 gradient. The river section at the mountainous area is of U-shaped and the vegeation in the area is poor. The cross-section of the mid-stream is comparatively wide because of primary improvement works. However, the river section becomes narrow (15 m wide) in the downstream area. The river section in the area to the west of the Pan-American Highway is approx. 15 m wide and 3 m deep with a stream gradient of 1/400. This will not be enough to flow down the flood discharge.

The area at the confluence of the Colina and Lampa rivers is generally flat and is forming a large basin near the Batuco lake. The agricultural area spreading at the left side of the mid-stream of the Colina river has the same gradient as that of the Colina river and no sloping to the water-corcecource Therefore, no clear river channel is created in that area.

(2) Flood Damage

1) Mapocho River

The Mapocho river caused great damage to Santiago city and its surrounding areas in June 1982 due to flooding and inundation.

The specific features of the flood in June 1982 are as follows:

a. It is believed that the cause of the flood was the combination of rainfall and snowmelt dishcarges. The recorded flood discharge of 295 m^3/s at Los Almendros corresponds to a 30 to 40 year return period discharge.

b. The central part of Santiago city was inundated because of the concentration of the flood discharge from the upper part of the city, due to the steep curvature of the river at the Pio Nono bridge and the swell-head caused by the low bridge girders.

c. Inundation also occurred in the western part of Santiago city where there was no river bank and in downstream area near the confluence with the Maipo river.

d. Overflowing and erosion occurred in the small streams located in the eastern part of Santiago. There were also flood damags in the mountainous area of the city and in the areas along the Zanjón de la Aguada.

During the flood in July 1984, there was no great damage in the city except in the downstream areas.

2) Lampa River

Inundation in low areas is said to happen almost every year and floods in June 1982 and July 1984 were especially big.

Inundations caused by the discharge of the Lampa river occur mainly in the areas downstream of the confluence with the Colina river due to the following:

a. Peak discharge of the Colina and Carén rivers may occur during the flood discharge of the Lampa river.
b. The areas along the Lampa river are flat and low in altitude.
c. The river channel of the Lampa river has its bottle neck near Noviciado, causing the overflowing and preventing the immediate drainage of the inundated water.

According to what people say, the inundation of the low areas along the downstream section of the Lampa river occurs several times every year and lasts for 5-7 days each time (the inundation near the Airport lasted for 20 days during the floods in 1982 and 1984).

3) Colina River

The flooding and inundations for a few days in the wide low areas around the Colina river from Batuco to Quilicura occur due to the following:

a. Overflowing in the mid-stream area because of geographical features;

b. Overflowing in the downstream area because of a limited river section; and

c. Direct discharge from the mountainous areas.

Inundation in low areas is said to happen almost every year and floods in June 1982 and July 1984 were especially big.

4) Eastern Part of Santiago City

There are many small rivers on the steep western hillside of the Pre-Andes mountains located in the east of Santaigo city, all of which are flowing down towards the San Carlos canal. Among them, the main ones are the Apoquindo, San Ramon and Macul rives, from north to south.

Flood discharges including gravel and sand flow down through these rivers to the city with a high speed, due to the steep stream gradient and the short length of these streams. Inside of the city only, the banks of these rivers are improved with stones and concrete. However, these improved sections are usually narrow. Therefore, sometimes flood discharges overflow the river bank. Especially during the floods in 1982 and 1984, big damage occurred due to overflowing.

(3) Erosion Damage

1) Mapocho River

Available data/information are not enough for a detailed analysis of the erosion and sedimentation phenomena. However, it is assumed that no remarkable erosion and mudflow will occur in the Mapocho river, judging from the following:

a. The annual volume of rainfall is little and the frequency of heavy rain is low;

b. Progressing creeps and land slides reaching the river stream are few, even though the vegetation of the basin is poor and rocks are exposed in the slopes; and

c. Major scoring of the river bed and sedimentation seem to be little (Tables A-13-1 and 2).

2) Lampa River

The sediments of the Lampa river are small gravel-sand in the section of the town of Lampa and silt in the Noviciado section. There is no evidence of the movement of gravel by the discharge water. People say that after the flood, clay and silt settle with a thickness of several centimeters in the downstream area.

3) Colina River

There is no remarkable erosion damage.

4) Eastern Part of Santiago City

Sedimentation is observed in the San Ramon river in its park section and in the Macul river where it crosses the San Carlos canal. The sediment in these sections ranges from gravel to silt.

13.2 Flood Analysis and Basic Flood Discharge

(1) Simulation Model Formula

1) Simulation Model

The Lampa river has no distinct major stream. Hence a characteristic of the flood is that the discharge water flows down accompanying the inundated water adjacent to the river. Accordingly, a simulation model which is able to express the discharge reduction by overflooding and the flood water storage by inundation is necessary for the analysis of flood characteristics.

Considering the above conditions, the Storage Function Model was adopted for the simulation. The equation of the model is expressed as follows:

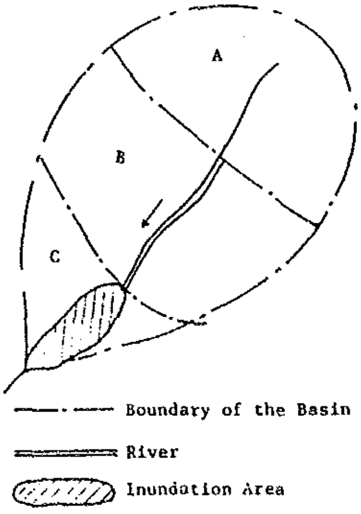
For Whole Basin

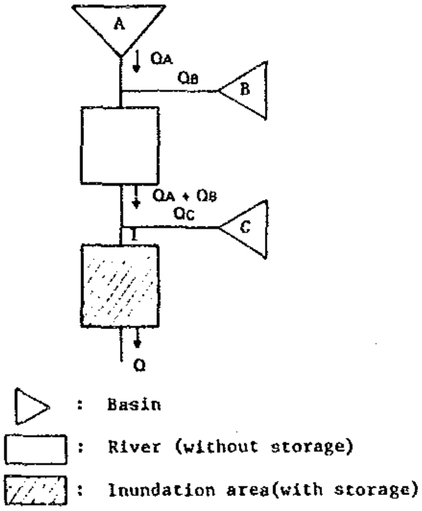
$$\begin{cases} S = K \times Q^{p} \text{ ....} \quad ① \\ \dfrac{ds}{dt} = \dfrac{1}{3.6} \times C \times R \times A - Q \text{ .} ② \end{cases}$$

For Innudation Area

$$\begin{cases} S = K \times Q^{p} \text{ ....} \quad ③ \\ \dfrac{ds}{dt} = I - Q \text{ ......} ④ \end{cases}$$

where:
S : Apparent storage volume (m^3)
Q : Outflow considering lag-time (m^3/s)
I : Inflow to the Inundation Area (m^3/s)
C : Inflow ratio
R : Average basin rainfall (mm/hr)
A : Catchment area (Km^2)
K : Parameter
P : - do -





The simulation model for discharge is shown in Fig A-13-6.

2) Determination of K and P

a. Basin

The values of K and P were determined with following formula:

$$K = 43.4 \times C \times I^{-1/3} \times L^{1/3}$$

$$P = 0.333 \text{ (constant)}$$

where:

C : Izzard Constant (0.12 for natural area, and 0.012 for urban area)
I : Mean Gradient of Basin
L : Length of River Course (Km)

Refer to Table A-13-5 for detail.

b. Inundation Area

The values of K and P were determined on the basis of the relationship between storage volume (S) in an inundated area and discharge (Q) from the area. The values of S and Q were estimated using uniform flow formula as follows:

$$S = A \times L$$

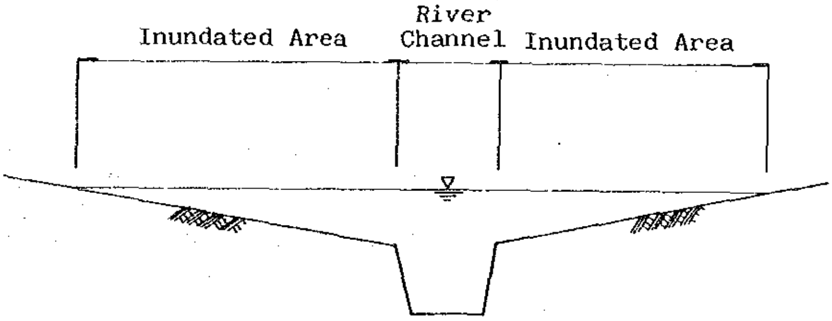
$$Q = A \times 1/n \times R^{\frac{2}{3}} \times I^{\frac{1}{2}}$$

where:

S : Storage volume (m^3)
A : Flow area during flood (m^2)
L : Length of inundated area (m)
Q : Discharge from the inundated area (m^3/s)
n : Roughness coefficient

0.20 for inundated area
0.04 for river channel portion

R : Hydraulic mean depth (m)
I : Hydraulic gradient



3) Estimation of Outflow from Basin

From the equation ② , the following approximate equation can be obtained:

$\left(N \times Rt + 1 - \frac{Qt + Qt+1}{2}\right) \times \; t = St+1 - St$ ..... ⑤

where : $N = C \times A/3.6$

Rt+1 : Rainfall during duration t (t+1 to t)
(t=1 hr in the analysis)

Qt and Qt+1 : Discharge at the time t and t+1

St and St+1 : Storage volume at the time t and t+1

The equation ⑤ can be re-arranged as follows:

$Qt+1 = 2 \times N \times Rt+1 - Qt - 2 \times (St+1 - St)/\Delta t$... ⑥

To combine equations ① and ⑥ , the following equation can be obtained:

$Qt+1 = 2 \times N \times Rt+1 - Qt - 2 \times K \times (Qt+1^{P} - Qt^{P})/\Delta t$ ...⑦

From the equation ⑦ , as the values of Rt+1, Qt, Δt, N, K and P are known ones, the value Qt+1 can be estimated.

In the analysis, the retarding time ($T\ell$) is added to the duration Δt. ($T\ell = 0.047 \times L^{-0.56}$)

Therefore, it is assumed that the basin discharge Qt+1 corresponds to the discharge period $\Delta t + T\ell$.

4) Estimation of Outflow from Inundation Area

The equation used in the estimation of outflow from the basin is applied.

In this case, the average inflow (It + It+1)/2 is used instead of N x Rt+1.

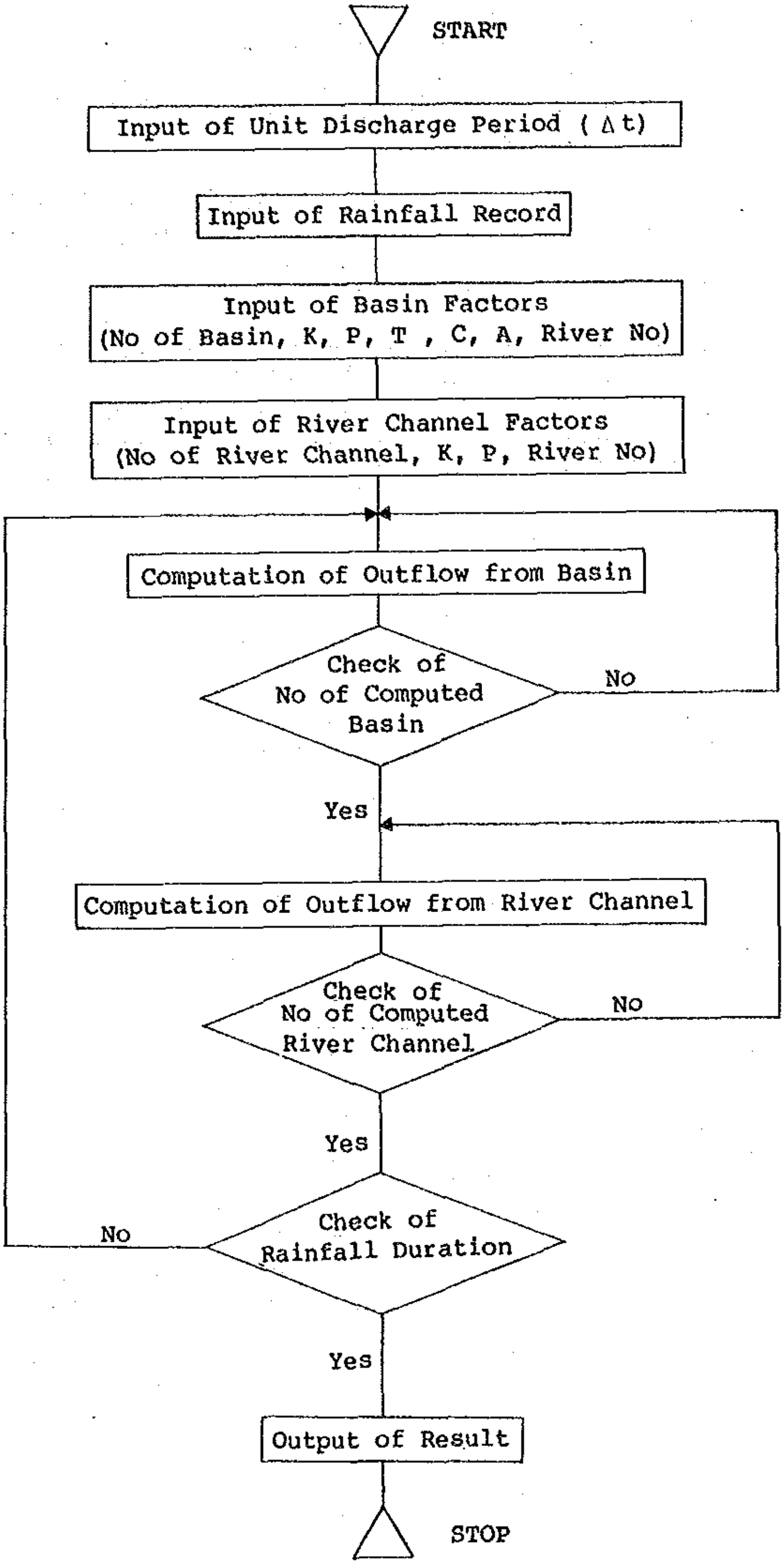
$\left(\frac{It + It+1}{2} - \frac{Qt + Qt+1}{2}\right) \times \; t = St+1 - St$............⑧

$\left(\frac{It + It+1}{2} - \frac{Qt + Qt+1}{2}\right) \times \; t = K\,(Qt+1^{P} - Qt^{P})$ .....⑨

From the equation ⑨ , the value Qt+1 can be obtained as the values of It, It+1, Qt, t, K and P are known ones.

The discharge from the inundation area Qt+1 corresponds to the discharge time Δt.

5) Flow Chart of Storage Function Model Analysis.



6) Inundation Analysis

a. Objective

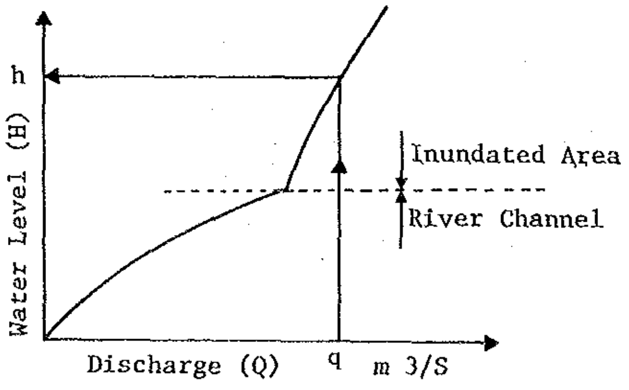
The objective of the inundation analysis is as follows:

- To clarify the dischange volume, water level, inundation area and inundation period

- Based on the above, to estimate the effect of the improvement of the Lampa river system

b. Estimation of Water Level

The values of Q from inundation area were estimated using the Storage Function Model. The water levels (h) corresponding to q were then obtained from the water level (H) - discharge (Q) curve which was obtained using uniform flow formula as follows:



c. Inundated Area

The inundated area was determined using the topographic map of 1:10,000 scale based on the above estimated water level.

d. Inundation Period

The inundation period was obtained simultaneously with the estimation of the water level of the inundated water.

(2) Flood Analysis in Present Conditions

1) Selection of Objective Flood

The floods in June 1982 and July 1984 were selected as the objective flood to be used in the analysis for the following reasons:

a. Meteorological and hydrological data during these floods necessary for the analysis are available.

Item		Hourly Rainfall			Hourly Discharge			Daily Temperature		
Station N°		4	16	24	2	5	8	4	16	24
Flood	June 1982	-	o	o	*	o	-	o	o	o
	July 1984	o	-	o	o	o	o	o	-	o

o : available
* : Daily Mean Discharge only
\- : not available

b. These floods were the major ones in recent years. So the basic flood discharge can be obtained with reasonable accuracy without any big modification.

c. There are more data for the verification of the analysed values for other floods.

The data available for the verification are as follows:

Mapocho River

- Hourly discharge records at Station Los Almendrose(No 5)
- Hourly discharge records at Station Rinconada de Maipú (No 8), for July 1984 flood only
- News film during June 1982 flood
- Information about the floodmarks obtained through interviews during the field survey

Lampa and Colina Rivers

- Discharge records at Station N° 2 (Estero Polpaico en Chicauma)
- Flooded area
- Inundation period
- Information about the floodmarks obtained through interviews during the field survey

2) Catchment Area Division

The basin was divided into sub-basins in order to know the discharges at the main points including the gauging stations. As shown in Fig A-13-6, the whole basin was divided into 19 sub-basins, 8 for the Mapocho river and 11 for the Lampa river. The limit of the downstream portion was determined at Rinconada de Maipù on the Mapocho river.

3). Rainfall Analysis

On the basis of a result of the simulation, the mean rainfall for each sub-basin was obtained with the following adjustment on the observed rainfall.

a. Rainfall Increase Ratio with Altitude

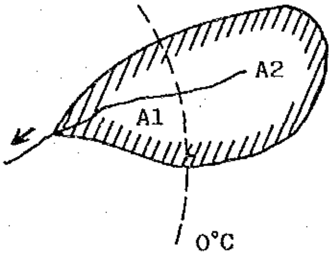
The following rainfall increase ratio with altitude was considered in accordance with the average altitudes of the respective sub-basins.

Average Sub-basin Altitude	Increase Ratio
below EL + 1,000 m	1.0
EL + 1,000 to 2,000m	1.2
above EL + 2,000m	1.4

b. Discharge Area Reduction by Temperature

It was assumed that outflow would not occur from the area where the temperature was less than 0°C.

$$f = \frac{A1}{A1 + A2}$$



where: f : Reduction ratio
A1 : Basin area with outflow
A2 : Basin area without outflow

The assumed discharge area was obtained by multiplying the basin areas to the reduction ratio (f) shown above. The temperature for each altitude was determined using a decreasing ratio of $-0.7^{o}C/100m$.

4) Effectiveness of Existing Dams

There are two dams, Huechún and Rungue in the Lampa river basin. It was assumed in the simulation that 50% of the storage capacity of these dams would be effective against flood discharge.

Item \ Dam	Huechún Dam (m^3)	Rungue Dam (m^3)
Storage Capacity	29×10^6	3×10^6
Flood Control Volume	15×10^6	1.5×10^6

5) Simulation Results

a. Flood Analysis

The results of simulation will be appropriate, judging from the similarity between estimated and observed peak discharges as shown below:

Period \ Station	Mapocho en Los Almendros (No 5)		Estero Polpaico en Chicauma (No 2)	
	(m^3/s) Observed	(m^3/s) Estimated	(m^3/s) Observed	(m^3/s) Estimated
June 1982	295.0	311	390.0	352
July 1984	25.5	22	364.0	444

Fig A-13-7 shows the simulated peak discharges in respective points. The following are the results obtained from the simulation analysis:

Mapocho River

i. The flood peak discharge of the Mapocho river in 1982 was ten times that of 1984, in spite of only a 30% difference in rainfall during both floods.

Station	Santiago (No 24)	Los Almendros (No 5)	Santiago (No 24)
Item / Period	Rainfall (mm)	Peak Discharge(m^3/s)	Temperature(^oC)
June 1982	100.4 (5.0)1/	295.0	11.5
July 1984	77.6 (9.0)	25.5	4.5

1/ Hourly maximum rainfall (mm/hr)

This fact shows that the discharge in 1982 was larger due to the higher temperature. Judging from the temperature (N^o24), the basin area below altitude EL + 2,500 m was the discharge area during the 1982 flood, and the basin area below EL + 1,500 m during 1984 flood.

The estimated discharge area during 1982 flood is four times that of 1984 flood, causing the bigger damages along the Mapocho river.

Item / Flood	Total basin area at N^o 5 (km^2)	Runoff Area at N^o 5 (km^2)
June 1982	620	248
July 1984	620	62

ii. The peak discharges of the Mapocho river during the 1982 flood in Santiago city would have been 900-1,000 m^3/s, exceeding the flow capacity of the Mapocho river. On the other hand, the peak discharge during 1984 flood would have been approximately 100 m^3/s only.

These phenomena were verified through interviews at the site.

Lampa River

iii. Almost all rainfall will discharge without turning into snow because of the low altitude of the Lampa river basin. The probable discharge of the Lampa river, therefore, is bigger than that of the Mapocho river.

iv. The effectiveness of the Huechún dam for regulating the flood discharge will be very big. The dam would have reduced the flood discharge by 150 m^3/s and 270 m^3/s during 1982 and 1984 floods, respectively.

b. Inundation Analysis

The results of the simulation analysis of inudations on the present condition and after improvement of rivers and canals are shown in Table A-13-6 and Figs A-13-9 and 10.

(3) Basic Flood Discharge

1) The distribution of the Probable Rainfall

The distribution of the probable rainfalls for respective return period was prepared by applying the observed rainfall patterns during 1982 flood at Stations Rungüe (No 4) and Santiago (No 24) to the estimated probable rainfalls.

The duration of the rainfall during 1984 flood was 3 days. The other past records at Stations N^{o}s 4 and 24, 1957-1983, also show that 3-day duration predominates among the rainfalls during floods. The relationship between the probable 3-day rainfall and observed one is shown below:

Station N^{o}	Observed Rainfall (mm) (July 1984)	Probable 3-day Rainfall (mm)						
		Return Period (year)						
		2	3	6.7	30	50	100	200
Rungüe (No 4)	236.0	92	123	175	274	306	348	390
Santiago (No 24)	77.6	60	75	100	145	160	180	200

For the sub-basins of the mountainous area of the Lampa river (T1, T2, C1, C2, P1, L1 and Co1), the probable rainfall estimated on the basis of Station N^{o} 4 rainfall was applied.

For other sub-basins, the probable rainfall based on N^{o} 24 rainfall was applied, considering the altitudinal increase factor. The same reduction ratio by temperature was applied for 1982 flood analysis.

2) Basic Flood Discharge

The analysis of basic flood discharge was conducted with the condition that there is no overflowing from any rivers and canals and the existing two dams function. The results of the simulation analysis are shown in Fig A-13-8.

Only for Station N° 5 of the Mapocho river, the probable discharges were estimated with the Gumbel Method by CNR.

The results of the simulation analysis resemble the values estimated by CNR as shown below.

Return Period (year)		2	5	6.7	10	30	50	100	200
Probable Discharge (m^3/s)	This Study	60	-	150	-	270	320	380	450
	CNR	55	145	160	206	297	339	396	452

Note: Estimation at Los Almendros (N° 5)

These basic flood discharges were used as the basis for the flood control and drainage planning.

13.3 Flood Control Scheme

(1) Specific Discharge

The specific discharges for respective watersheds were determined on the basis of the design discharges obtained with the Storage Function Model as shown in Table A-13-7.

(2) Lampa and Colina Rivers Improvement Plan

The objective section for the improvement of the rivers shall be of the river within the Project Area;

- Lampa river: from the confluence with the Mapocho river to confluence with Lalo river (L=24.0 Km)
- Colina river: from the confluence with the Lampa river to the cross section with railway bridge (L=5.9 Km)

The section of the Lampa river was divided into 3 subsections due to the present river characteristics.

- Lampa (1) section: from the confluence with the Mapocho river to the Membrillo bridge (L=9.7 Km)

  This section is narrow and creates one of the causes of the overflowing at the upstream section. The backwater of the Mapocho river may affect this section. However, the overflowing is scarce.

- Lampa (2) section: from the Membrillo bridge to the confluence with the Colina river (L=8.3 Km)

  The downstream limit of the inundation is the Membrillo bridge because of the existence of the embanked Noviciado canal at the right bank side and the high-land at the left bank side. The area along this section is usually inundated.

- Lampa (3) section: from the confluence with the Colina river to the confluence with the Lalo river (L=6.0 Km)

  There is no distinct major stream in this section. Therefore, a flood flow may change the route from time to time.

(3) Retarding Basin Plan

1) Location

The location near the confluence of the Colina river with the Lampa river was selected in consideration of the hydrological advantage, present landuse and soil conditions.

2) Design Flood Discharge

The design storage discharge (Qd) to a retarding basin was obtained as 420 m^3/s in the following:

- The flood discharge of 6.7 year return period at the selected site (Qlu) is 530 m^3/s.
- The flood discharge of the Lampa river before joining with the Mapocho river (Qld) is 650 m^3/s.
- The flood discharge of the Mapocho river before joining with the Lampa river (Qm) is 430 m^3/s.
- The allowable discharge of the Mapocho river after joining with the Lampa river (Qma) is 660 m^3/s.
- The discharge from the downstream area of the Lampa river between the retarding basin and the confluence with the Mapocho river (Qlm) is 120 m^3/s (Qlm = Qld-Qlu = 650-530 = 120).
- The allowable discharge of the Lampa river to the Mapocho river (Qla) is 230 m^3/s (Qla = Qma-Qm = 660-430 = 230).
- The allowable discharge from the retarding basin to the Lampa river (Qba) is 110 m^3/s (Aba = Qla-Qlm = 230-120 = 110).
- The design storage discharge to the basin (Qd) is 420 m^3/s (Qd = Qlu-Qba = 530-110 = 420).

3) Capacity of Retarding Basin

The required capacity of a retarding basin will be 40 x 10^6 m^3 due to the big discharge control (420 m^3/s). In this case, the required area for a basin is 1,000 ha with a water depth of 4 m.

Even in the present conditions, as the discharge capacity of the Lampa river in the downstream section is 240 m^3/s, the required capacity of a basin will be 19 x 10^6 m^3 due to the discharge control of 290 m^3/s (530 m^3/s - 240 m^3/s). In this case, required area for a basin is 480 ha with a water depth of 4 m.

4) Result

Considering the required large area and huge investiment (Ch$9.2 x 10^9), the plan of a retarding basin will not be feasible.

Even the area around the Batuco lagoon is selected as the site for a retarding basin, the result of the analysis will be the same.

Estimated Construction Cost

Item	Quantity	Amount (10^6Ch$)	Remarks
Excavation	500,000 m^3	2,000	Ch$400/$m^3$
Embankment	500,000 m^3	4,750	Ch$950/$m^3$
Inlet and Outlet	LS	250	Inlet = 1, Outlet = 2
Sub-total		7,000	
Indirect cost		1,750	25 %
Land Acquisition	1,300 ha	494	Ch$38/$m^2$
Total		9,244	

(4) Dam Plan

1) Dam Site

The following two sites were selected in consideration of the hydrological, geological and topographic conditions.

- Lampa dam site: Upstream section of Lampa village
- Colina dam site: Narrow section in the mountainous area

2) Specific Features

Lampa Dam

- Catchment area : 1,290 Km^2
- Height x Length : 27 m x 1,350 m
- Storage volume : 62 x 10^6 m^3
- Volume of dam : 2.3 x 10^6 m^3 (Fill type)

- It is possible to store the total 6.7 year discharge of 360 m^3/s.

- However, the discharge in the downstream section exceeds the allowable discharge of 230 m^3/s; i.e. 650-360 = 290 $m^3/s > 230$ m^3/s.

Colina Dam

- Catchment area : 230 Km^2
- Height x Length : 78 m x 330 m
- Storage volume : 12 x 10^6 m^3
- Volume of dam : 0.26 x 10^6 m^3 (Concrete Gravity type)

- It is possible to store the total 6.7 year discharge of 110 m^3/s.

- However, the effect for the flood control is scarce compared with the big discharge of the Lampa river.

3) Result

The plan to construct a flood control dam in the Lampa or Colina river will not be feasible judging from the huge investmant as shown below:

Estimated Construction Cost

Name of Dam	Item	Quantity	Amount (10^6Ch$)	Remarks
Lampa Dam	Dam body	2,330,000 m^3	3,495	Ch$1,500/$m^3$
	Spillway	LS	2,000	
	Facilities	"	150	
	Foundation	"	2,000	
	Temporary tunnel	1,400 m	1,680	Ch$1.2 x 10^6/m
	Sub-total		9,325	
	Indirect cost		2,331	25%
	Total		11,656	
Colina Dam	Dam body	260,000	4,160	Ch$16,000/$m^3$
	Facilities	LS	1,000	
	Temporary tunnel	1,000 m	1,200	Ch$1.2 x 10^6/m
	Sub-total		6,360	
	Indirect cost		1,590	25%
	Total		7,950	

(5) Sabo Dam Plan

1) Sabo Dam Site

a. Construction Site

The upstream section in the immediate area of the old Nilhue Bridge was selected as the construction site of the proposed Sabo dam on the basis of the topographic and geological conditions along the Mapocho river.

b. Topography and Geology

The topography of the site consists of a deep gorge with scarce vegetation. The bed soil is very poor (20-50cm thick). Rock facies are mainly dark gray pyroxene andesites and propylites with moderate development of joints and fractures. In general, weathering is not deep. Some basic dykes (principally basaltic rocks) of max. width 1 m and calcite and chlorite stringers intrude along weak lineaments in the rocks. Large tectonic features are not found.

Topographic and geological observations thus suggest that this site is suitable for the proposed Sabo dam.

2) Dam Type

The concrete gravity type was selected for the proposed Sabo dam for the following reasons:

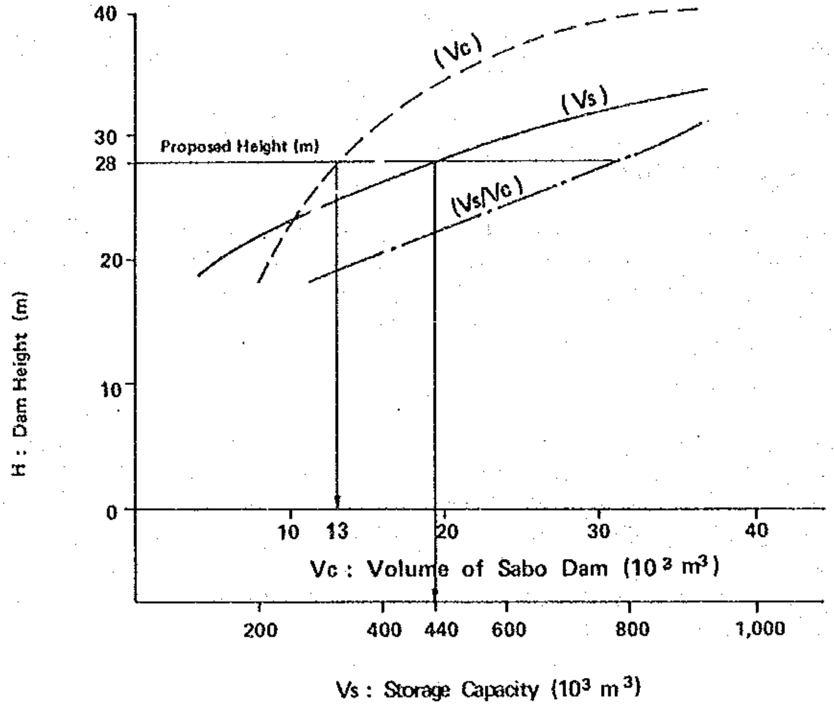
a. Judging from the size of the dam, concrete frame type and steel type will not be practicable.

b. Concrete arch type dam will not be economical, considering the difficulty of construction works caused by the geological and topography of the site.

3) Size of Dam

Wash-load discharge of the Mapocho river sediments has been mentioned by CNR and UCh. However, no data are available for riverbed load discharge. Due to the large watershed area of the Sabo dam site (610 km^2), a bigger dam will be more economical, as shown in the figure below.

Height of the proposed dam was determined to be 28 m, considering the topographic and geological conditions at the site.



4) Main Dam

The main dam was designed to let the bed-load materials settle in the pocket of the dam for a period of 10 years. 1/

The features of the main dam are as follows:

Type	:	Concrete gravity
Dam Height	:	28 m (Max. height due to topographic and geological conditions)
Dam Length	:	48 m
Slope	:	Downstream side: 1: 0.2
		Upstream side : 1: 0.95
Spillway	:	Width : 20 m
Dam Volume	:	13 x 10^3 m^3
Design Storage Capacity	:	440 x 10^3 m^3
Related Structures	:	Sub-dam and Apron

1/ - Storage capacity: 440 x 10^3 m^3.
(with the condition that settling gradient is one-half of the river gradient)

- Assumed bed-load discharge: 50 - 100 m^3/year/km^2
- Watershed : 620 Km^2
- T = 440 x 10^3/(50 - 100) x 620 = 7-14 years

5) Spillway

The flood discharge(Q) and depth of over-flow(h) through the spillway section with each return period are as follows:

Return(T) Period	Flood Discharge(Q)	Depth of Overflow (h)	Remarks
2	60 m^3/s	1.40 m	- Maximum observed
30	270	3.70	discharge at Los
50	320	4.12	Almendros station in
100	380	4.59	June, 1982 : 295 m^3/s
			- Depth of overflow: 3.91m

$$Q = (1.771\ w + 0.708\ h) \times h^{3/2}$$

where : w : Width of water surface

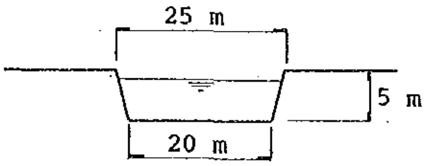
The design flood discharge was estimated as 320 m^3/s for a 50 year return period, based on the observed maximum discharge at Los Almendros station.

$$320 = (1.771\ w + 0.708 \times 4.12) \times 4.12^{3/2}$$

$$w = 19.96\ m$$

The dimensions of the spillway are as follows:

- Height: 5 m
- Width at the bottom: 20 m
- Width at the top: 25 m



However, 4.6 m depth of overflow for flood discharge Q of 380 m^3/s with a 100 year return period was adopted in calculating the stability of the main dam.

6) Apron and Sub-dam

The apron and sub-dam are provided to prevent the ground immediately downstream of the main dam from scouring by falling water and gravels.

Dimensions of the Sub-dam are as follows:

- Location: 45 m downstream of the main dam 1/

1/ $L = 1.5 \times (H+h)$
$= 1.5 \times (25+4.1)$
$= 44$ m

where:
L: Distance between the main dam and the sub-dam
H: Height from riverbed to the bottom of spillway (25 m)
h: Water height of overflow (4.1 m)

- Height: 9 m from the bedrock

$Hs = 1/3 \times H$
$= 1/3 \times 25$
$= 8.3$ m

where: Hs: Height of the sub-dam

- Dam slope: Upstream side 1 : 0.7
Downstream side 1 : 0.2

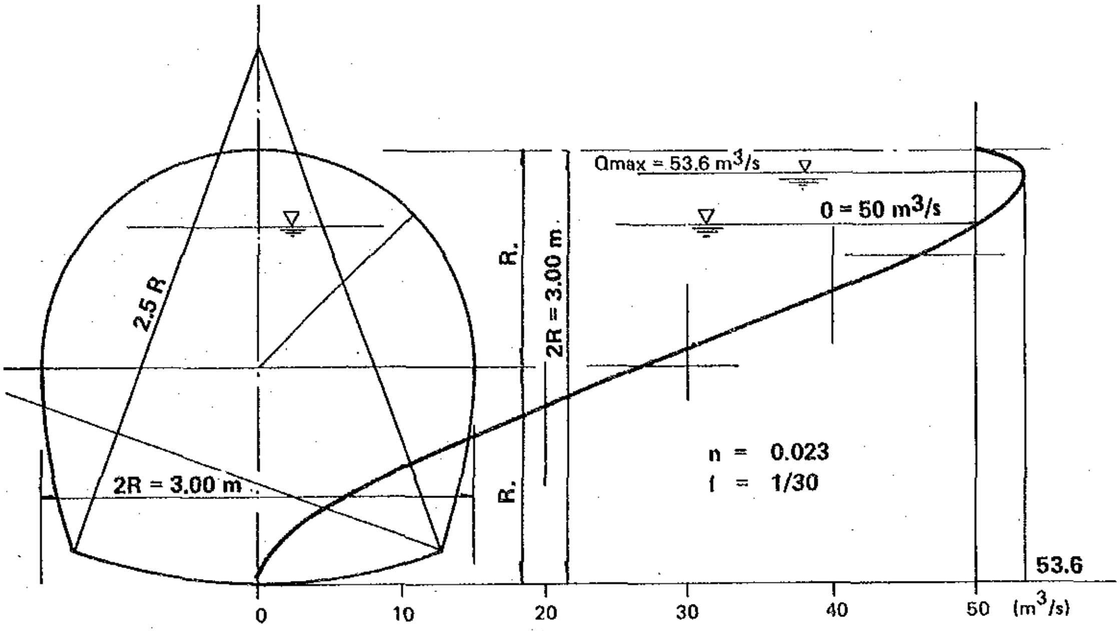
7) Temporary Drain

Due to the narrow topography of the construction site, especially at the Sub-dam site (15 m), it will be impossible to construct a dam with the half cofferdam method. It is proposed that a temporary drain tunnel be built at the right side, to ensure safe construction of the Sabo dam. The estimated construction period of the Sabo dam is 10 months.

The design criteria of the drain tunnel are as follows:

- Objective discharge : 50 m^3/s
(10 year return period discharge during dry season)
- Cross section : Standard horseshoe type
(2R = 3.0 m)
- Slope : I = 1/30
- Total length : L = 220 m

Cross section of the tunnel is of horseshoe type and the radian of the circle (1.50m) was determined by the hydraulic characteristic curve as illustrated below:



8) Stability Analysis

a. Combination of Load

Ordinary Case	Pw, Ps, U, KM Pd
Flood Case	Pw, Ps, U
Empty Case	KM

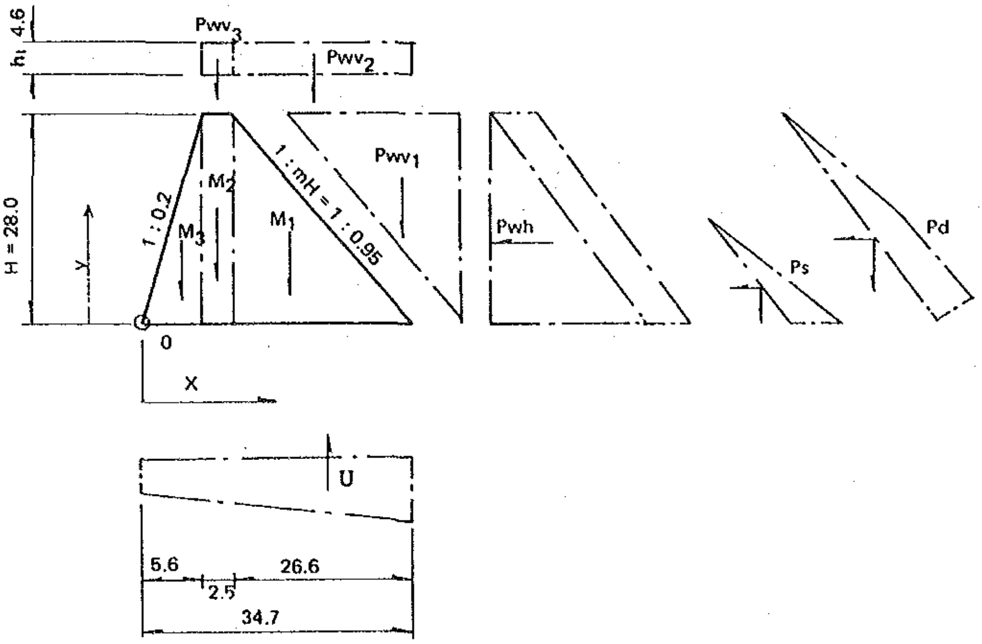
Where ; Pw : Hydrostatic pressure
Ps : Sediment load
U : Uplift
KM : Seismic inertia force
Pd : Hydrostatic pressure during earthquake

b. Design Parameter

Height of Dam	$H = 28.0$ m
Depth of Overflow	$h_1 = 4.6$ m

Unit weight of Concrete	$Wc = 2.35\ t/m^3$
Unit weight of flow water	$Wo = 1.0\ \ t/m^3$
Apparent unit weight of sediment	$\Upsilon = 1.8\ t/m^3$
Voids percentage of sediment	$v = 0.3$
Depth of sediment	$hs = 6.0$ m (= 0.2 H)
Earth pressure coefficient	$c = 0.33$
Compressive stress of concrete	$\sigma_c = 40\ kg/cm^2$
Shearing stress of concrete	$\sigma_\iota = 5\ kg/m^2$
Load resistance of foundation rock	$q = 200\ t/m^2$
Friction coefficient of " "	$f = 0.7$
Seismic intensity	$k = 0.15$
Uplift coefficient	$\mu = 1/3$
Depth of downstream water (Ordinary case)	$h_2 = 5.5$ m
" " (Flood case)	$h_2 = 10.0$

c. Load and Point of Application



(i) Body Weight (Ordinary case, Flood case and Empty case)

$M_1 = \frac{1}{2} \times 28.0^2 \times 0.95 \times 2.35 = 875.1$: $X = 16.97$

$M_2 = 28.0 \times 2.5 \times 2.35 = 164.5$: $X = 6.85$

$M_3 = \frac{1}{2} \times 28.0 \times 5.6 \times 2.35 = 184.2$: $X = 3.73$

(ii) Hydrostatic Pressure (Ordinary case)

$Pwv_1 = \frac{1}{2} \times 28.0^2 x 0.95 x\ 1.0 = 372.4$: $X = 25.83$

$Pwvh = \frac{1}{2} \times 28.0^2 \times 1.0 = 392.0$: $y = 9.33$

(iii) Hydrostatic Pressure (Flood case)

$Pwv_1 = \frac{1}{2} \times 28.0^2 x 0.95 \times 1.0 = 372.4$: $X = 25.83$

$Pwv_2 = 4.6 \times 26.6 \times 1.0 = 122.4$: $X = 21.40$

$Pwv_3 = 4.6 \times 2.5 \times 1.0 = 11.5$: $X = 6.85$

$Pwh = \frac{1}{2}(4.6+32.6) x 28.0 x 1.0 = 520.8$: $y = 10.49$

(iv) Sediment Load (Ordinary case and Flood case)

$Psv = \frac{1}{2}$ Ws H B $= \frac{1}{2} x 1.1 x 6.0 x 5.7 = 18.8$, $X = 32.80$

$Psh = \frac{1}{2}$ c Ws H B $= \frac{1}{2} x 0.33 x 1.1 x 6.0 x 5.7 = 6.2$,

$y = 2.00$

Ws = $-(1-\mu)$Wo = 1.1

(v) Uplift (Ordinary case)

Upstream tip: $h_2 + x\ (h_1 - h_2) = 5.5 + 1/3(28.0-5.5) = 13.00$

Downstream tip: $h_2 = 5.50$

$U = \frac{1}{2}\ (13.0+5.5) x 34.7 = 321.0$, $X = 19.69$

(vi) Uplift (Flood case)

Upstream tip: $h_2 + \mu x (h_1 - h_2) = 10.0 + 1/3 x (32.6 - 10.0)$

$= 17.53$

Downstream tip: $h_2 = 10.0$

$U = \frac{1}{2}\ (17.53 + 10.0) \times 34.7 = 477.6$, $X = 18.93$

(vii) Seismic Inertia Force (Ordinary case and Empty Case)

$KM_1 = 0.15 \times 875.1 = 131.3$: $y = 9.33$

$KM_2 = 0.15 \times 164.5 = 24.7$: $y = 14.00$

$KM_3 = 0.15 \times 184.2 = 27.6$: $y\ \ 9.33$

(viii) Hydrostatic Pressure during Earthquake (Ordinary case)

$$Pdv = \frac{1}{2} Cm \times \eta \times Wo\ KH^2B$$

$$= \frac{1}{2} x0.474x1.452x1.0x0.15x28.0^2x0.95 = 38.4$$

$$X = B_O - \lambda B = 34.7- \ 0.402x26.6 = 24.01$$

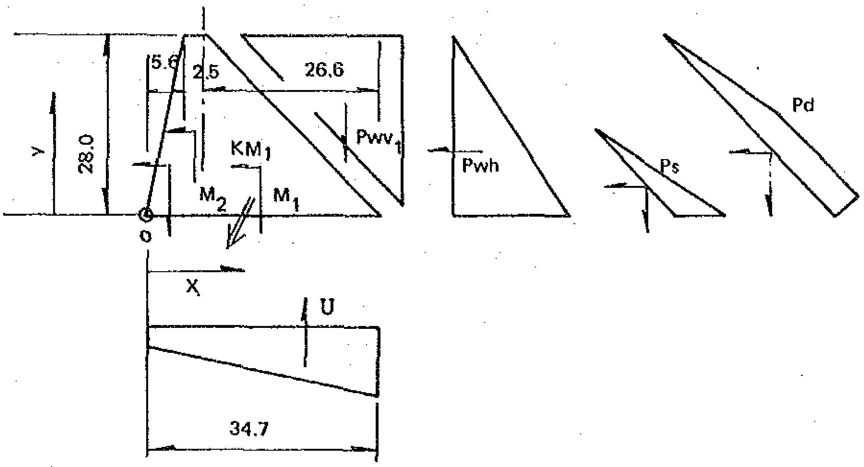
$$Pdh = \frac{1}{2}. Cm \times \eta \times Wo \times KH^2$$

$$= \frac{1}{2} x0.474x1.452x1.0x0.15x28.0^2 = 40.5$$

$$y = \lambda H = 0.402 \times 28.0 = 11.26$$

d. Stability Analysis

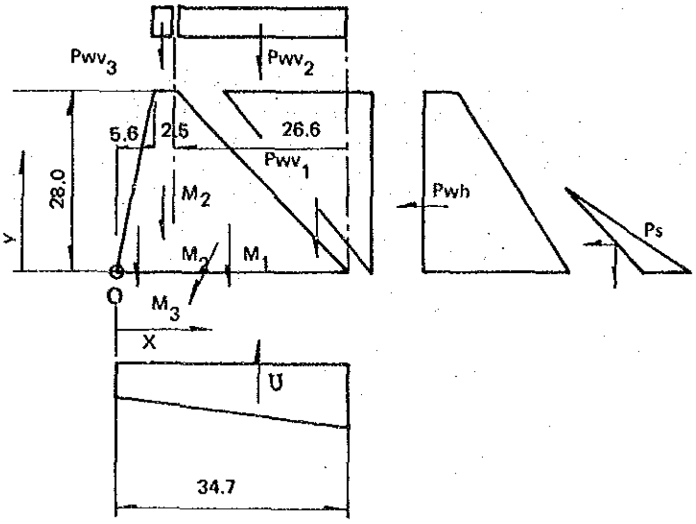
(i) Ordinary Case



Item	Symbol	Vertical force (w)	Horizontal force (p)	Distance (x)	Distance (y)	Moment at Point 0
Body Weight	M_1	875.1		16.97		14,850.4
	M_2	164.5		6.85		1,126.8
	M_3	184.2		3.73		687.1
Hydrostatic Pressure	Pwv_1	372.4		25.83		9,619.1
	Pwh		392.0		9.33	Δ 3,657.4
Sediment Load	Psv	18.8		32.80		616.6
	Psh		6.2		2.00	Δ 12.4
Uplift	U	Δ 321.0		16.69		Δ 6,320.5
Seismic Inertia Force	KM_1		131.3		9.33	Δ 1,225.0
	KM_2		24.7		14.00	Δ 345.8
	KM_3		27.6		9.33	Δ 257.5
Hydrostatic Pressure during Earthquake	Pdv	38.4		24.01		922.0
	Pdh		40.5		11.26	Δ 456.0
Total		1,332.4	622.3			15,547.4

$x = \frac{\Sigma M}{\Sigma W} = 11.67$ $\quad e = 5.68 < 5.78 \ (= \frac{34.7}{6})$

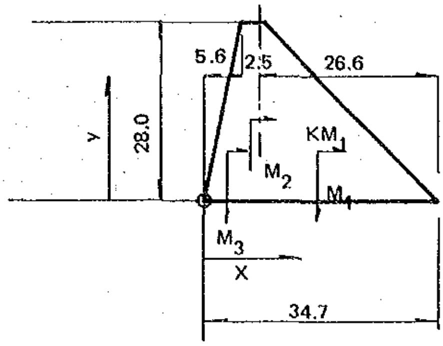
(ii) Flood Case



Item	Symbol	Vertical force (w)	Horizontal force (p)	Distance (x)	Distance (y)	Moment at Point 0
Body Weight	M_1	875.1		16.97		14,850.4
	M_2	164.5		6.85		1,126.8
	M_3	184.2		3.73		687.1
Hydrostatic Pressure	Pwv_1	372.4		25.83		9,619.1
	Pwv_2	122.4		21.40		2,619.4
	Pwv_3	11.5		6.85		78.8
	Pwh		520.8		10.49	Δ 5,463.2
Sediment Load	Psv	18.8		32.80		616.6
	Psh		6.2		2.00	Δ 12.4
Uplift	U	Δ 477.6		18.93		Δ 9,041.0
Total		1,271.3	527.0			15,081.6

$x = \frac{\Sigma M}{\Sigma W} = 11.86$ $\quad e = 5.49 < 5.78 \quad (= \frac{34.7}{6})$

(iii) Emply Case (Seismic movement toward upstream)



Item	Symbol	Vertical force (w)	Horizontal force (p)	Distance (x)	Distance (y)	Moment at Point 0
Body Weight	M_1	875.1		16.97		14,850.4
	M_2	164.5		6.85		1,126.8
	M_3	184.2		3.73		687.1
Seismic Inertia Force	KM_1		131.3		9.33	1,225.0
	KM_2		24.7		14.00	345.8
	KM_3		27.6		9.33	257.5
Total		1,223.8	183.6			18,492.6

$\frac{\Sigma M}{\Sigma W} = 15.11$ $e = 2.24 < 5.78$ $(= \frac{34.7}{6})$

(iv) Reaction of Foundation

$$\sigma = \frac{\Sigma W}{B} \times (1 \pm \frac{6e}{B})$$

Where ; ΣW: total vertical force
B: length of foundation
e: essentric distance between dam foundation center and application point

Condition	ΣW (t/m)	e (m)	$1 \pm \frac{6e}{B}$	σ (t/m^2)	
				Downstream	Upperstream
Ordinary Case	1,332.4	5.68	1,982 , 0.018	76.1	0.7
Flood Case	1,271.3	5.49	1,949 , 0.051	71.4	1.9
Empty Case	1,223.8	5.23	1,904 , 0.096	67.2	3.4

(v) Safety of Sliding

$$n = \frac{fw + \tau_o l}{\Sigma H} \geqq 4$$

where ; ΣH : total horizontal force
f : friction coefficient = 0.7
τ_o : resisting length = 34.7 m

Condition	ΣH (t/m)	ΣW (t/m)	$fW + \tau_o l$ (t/m) t/m	n
Ordinary Case	622.3	1,332.4	932.7 + 1,735.0 = 2,667.7	4.3
Flood Case	527.0	1,271.3	889.9 + " = 2,629.9	5.0
Empty Case	183.6	1,223.8	856.7 + " = 2,591.7	14.1

Table A-13-1 Sedimentation at Los Almendros

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	year
Discharge (Qm)	m^3/s 8.5	6.1	3.1	2.7	2.9	3.6	5.0	6.3	6.4	10.6	12.3	12.3	$m^3/s.d$ 2,430
Sediment (Gsa)	t/year 160	178	26	14	145	178	199	238	132	605	575	419	ton 87,506

A = 620 Km^2

Gsa = 87,506 t/year

Vsa = 43,753 m^3/year (= Gsa/2)

fs = 140 ton/year/Km^2 (= Gsa/A)

= 70 m^3/year/Km^2 (= Vsa/A)

Source: Paper of Prof. Lopez, University of Chile

Table A-13-2 Sediment Volume of the Mapocho River

A. Sediment volume at the Inlet of Ermita Power Station
(estimated on the basis of information collected through interview)

Rainy Season : 80 m^3/day
Dry Season : 40 m^3/day
Yearly sediment:
(80+40)/2 x 365 = 22,000 m^3/year
= 90 m^3/year/km^2

B. Sediment volume of the Mapocho River
(estimated on the basis of the sedimentation condition after the 1982 flood)

Sediment: V = 2,400 m^3/27 km^3/2 years
= 45 m^3/year/km^2

Note: It was assumed in the estimation that half of the sediments are flowed down.

Table A-13-3(1) Flow Capacity of Present River Channels

(1) Mapocho River

Station No. 1/	Distance L(Km)	Slope I	Depth h (m)	Area of Flow $A(m^2)$	Velocity $V(m^3/s)$	Flow Capacity $Q(m^3/s)$	Roughness Coef. n
No.-5 -3.0	-28.0	1/200	3.30	899.5	3.8	3,439	0.04
No.-4 -4.5	-24.5	1/200	2.70	446.1	3.0	1,338	0.04
NO.-3 -3.0	-18.0	1/450	4.20	484.8	2.4	1,138	0.04
No.-1 -3.0	- 8.0	1/450	4.40	435.5	1.9	1,138	0.04
No.0 -2.6	- 2.6	1/450	5.4	309.0	2.5	660	0.04
No.0	0.0	1/450	5.40	309.0	2.5	660	0.04
No.1 + 1.5	6.5	1/330	6.70	262.9	3.3	865	0.04
No.2 + 3.5	13.5	1/160	2.20	210.5	1.6	326	0.04
No.3 + 1.4	16.4	1/ 90	2.20	210.5	2.1	434	0.04
No.3 + 3.0	18.0	1/ 90	2.70	170.9	4.8	822	0.04
No.3 + 4.1	19.1	1/ 90	3.90	171.3	7.8	1,330	0.03
No.4 + 2.9	22.9	1/ 90	2.50	147.5	4.6	683	0.04
No.5 + 2.1	27.1	1/ 60	2.50	147.5	5.7	836	0.04
No.6 + 2.9	32.9	1/ 50	2.40	150.1	5.5	832	0.04
No.7 + 1.5	36.5	1/ 50	2.40	150.1	5.5	832	0.04

1/ Refer to Fig.A-13-1

(2) Lampa River

Station No.	Distance L(Km)	Slope I	Depth h (m)	Area of Flow $A(m^2)$	Velocity $V(m^3/s)$	Flow Capacity $Q(m^3/s)$	Roughness Coef. n
No.0	0.00	1/3000	5.90	402.7	0.9	361	0.04
No.0 + 0.9	0.90	1/3000	7.00	301.4	1.0	314	0.04
No.0 + 2.4	2.40	1/3000	5.70	445.0	0.7	307	0.04
No.0 + 4.1	4.10	1/1500	8.60	269.4	1.8	490	0.04
No.1 + 0.7	5.70	1/ 650	7.40	187.0	2.4	446	0.04
No.1 + 2.0	7.00	1/ 650	6.70	162.6	2.2	355	0.04
No.1 + 3.2	8.20	1/ 650	7.50	196.3	2.3	458	0.04
No.1 + 4.7	9.70	1/ 650	5.70	229.0	1.9	427	0.04
No.2 + 1.4	11.40	1/ 650	8.90	138.8	2.5	343	0.04
No.2 + 3.3	13.30	1/ 650	4.80	106.9	1.9	199	0.04
No.3 + 0.4	15.40	1/ 650	2.30	98.4	1.2	122	0.04
No.3 + 3.0	18.00	1/ 650	2.90	18.6	1.1	20	0.04

Table A-13-3 (2)　Flow Capacity of Present River Channels

(3) Colina River

Station No.	Distance L (Km)	Slope I	Depth h (m)	Area of Flow A (m^2)	Velocity V (m^3/s)	Flow Capacity Q (m^3/s)	Roughness Coef. n
No.0	0.00	1/600	2.90	18.6	1.1	21	0.04
No.0 + 3.4	3.40	1/600	1.82	20.8	0.9	18	0.04
No.1 + 0.5	5.50	1/300	1.88	15.8	1.5	24	0.04
No.1 + 4.0	9.00	1/300	2.15	22.9	1.8	42	0.04

Table A-13-4 Flow Capacity of Mapocho River at Bridge Sections

Name of Bridge	Station No. 1/	Distance from Station No.0 (km)	Flow Capacity of Bridge Section (m^3/s)	Flow Capacity of River Section (m^3/s)
Ruta 68	No.0 + 0.7	0.7	334	660
Pudahuel	No.1 + 1.5	6.5	989	660
Resbalon	No.2 + 0.1	10.1	1,080	865
Pasarela Lo Espinoza	No.2 + 4.0	14.0	2,109	326
Dorsal	No.2 + 4.4	14.4	3,485	326
Pasarela Las Javas	No.2 + 4.9	14.9	998	326
La Maquina	No.3 + 1.5	16.5	1,316	434
Bulnes	No.3 + 3.0	18.0	847	822
Manuel Rodriguez Poniente	No.3 + 4.1	19.1	1,431	1,331
Independencia	No.3 + 4.8	19.8	503	1,331
Los Carros	No.4	20.0	1,031	1,331
Recoleta	No.4 + 0.2	20.2	590	1,331
Patronato	No.4 + 0.6	20.6	417	1,331
Loreto	No.4 + 0.8	20.8	803	1,331
Purisima	No.4 + 1.2	21.2	2,052	1,331
Pio Nono Oriente	No.4 + 1.4	21.4	1,704	1,331
Pio Nono Poniente	No.4 + 1.5	21.5	930	1,331
Embudo Entrada a Canalizacion	No.4 + 2.6	22.6	2,065	1,331
Pedro de Valdivia	No.4 + 4.2	24.2	714	683
Padre Letelier	No.4 + 4.6	24.6	975	683
El Cerro	No.4 + 4.9	24.9	1,156	683
Lo Saldes	No.5 + 0.9	25.9	1,156	683
A. Vespucio	No.5 + 3.2	28.2	246	836
Lo Curro	No.6 + 3.3	33.3	2,091	832
La Dehesa	No.7 + 1.4	36.4	4,056	832
Pasarela San Antonio	No.7 + 2.8	37.8	1,580	832
San Enrique	No.7 + 4.1	39.1	1,039	832

1/ Refer to Fig. A-13-1

Table A-13-5 Estimation of K and Tl Values

Item / Catchment Area	Catchment Area (Km^2)	Calculated Area (Km^2)	Max. Altitude (m.ASL)	Min. Altitude (m.ASL)	Difference of Altitude (m)	Length of River Cource L (km)	Mean Gradient of Catchment Area I	C Value (Izzard Constant) C	K	P	Retarding Time Tl (hr)
T1	188	188.00	1,581	780	801	22.0	1/ 27	0.12	43.8	0.333	0.474
T2	247	247.00	2,222	511	1,711	36.0	1/ 21	0.12	47.4	"	1.132
C1	414	414.00	2,643	574	2,069	30.0	1/ 14	0.12	39.0	"	0.850
C2	86	86.00	1,043	511	532	18.5	1/ 35	0.12	45.1	"	0.310
P1	163	163.00	1,657	516	1.141	29.0	1/ 25	0.12	46.8	"	0.803
L1	128	128.00	2,140	489	1,651	18.0	1/ 11	0.12	30.4	"	0.286
L2	216	216.00	1.012	465	574	33.0	1/ 60	0.12	65.4	"	0.991
Co1	293	175.80	3,709	664	3,044	33.0	1/ 11	0.12	37.2	"	0.991
Co2	169	169.00	1,070	465	605	30.0	1/ 50	0.12	59.6	"	0.850
Cr1	263	263.00	1,820	465	1,355	31.0	1/ 23	0.12	46.5	"	0.897
L3	227	227.00	1,993	465	1,528	30.0	1/ 20	0.12	43.9	"	0.850
M1	280	112.00	5,318	1,184	4,134	35,0	1/ 8	0.12	34.1	"	1.085
M2	340	136.00	4,025	950	3,075	39.0	1/ 13	0.12	41.5	"	1.273
M3	237	118.50	3,636	850	2,786	38.0	1/ 14	0.12	42.2	"	1.226
M4	177	159.30	2,898	680	2,218	30.0	1/ 14	0.12	39.0	"	0.850
S1	232	208.80	2,653	606	2,047	24.0	1/ 12	0.11	31.5	"	0.568
M5	104	104.00	734	465	269	26.0	1/ 97	0.08	47.3	"	0.662
M6	34	34.00	500	460	40	10.0	1/250	0.12	70.7	"	0.000
Z1	270	270.00	632	460	172	25.0	1/145	0.07	46.7	"	0.615

$K = 43.4 \times C \times I^{-1/3} \times L^{1/3}$

$Tl = 0.047 \times L^{-0.56}$

Table A-13-6 Simulated Inundation Area of Lampa River Basin

(Unit : ha)

Blocks - 3+4					
Condition	Category of Land	July, 1984	return period		
			3 year	6.7 year	30 year
Non-improved	Agricultural Land	3,090	1,660	2,700	3,710
	Other Area	2,750	1,750	2,940	3,210
	Out of Project Area	1,940	890	2,000	3,260
	Total	7,780	4,300	7,640	10,180
3 year return period	Agricultural Land	1,650	0	2,100	2,870
	Other Area	460	0	1,490	2,380
	Out of Project Area	990	0	1,370	2,350
	Total	3,100	0	4,960	7,600
6.7 year return period	Agricultural Land	90	0	0	2,570
	Other Area	0	0	0	2,160
	Out of Project Area	90	0	0	1,650
	Total	180	0	0	6,380
Block - 3					
Non-improved	Agricultural Land	1,330	600	1,360	1,540
	Other Area	300	200	290	300
	Total	1,630	800	1,650	1,840
6.7 year return period	Agricultural Land	40	0	0	1,050
	Other Area	0	0	0	230
	Total	40	0	0	1,280
Block - 4					
Non-improved	Agricultural Land	1,760	1,060	1,340	2,170
	Other Area	2,450	1,550	2,650	2,910
	Total	4,210	2,610	3,990	5,080
6.7 year return period	Agricultural Land	50	0	0	1,520
	Other Area	0	0	0	1,930
	Total	50	0	0	3,450

Table A-13-7 Design Discharge and Specific Discharge

Name	Site	Catchment Area ① (km^2)	Design Discharge ② (m^3/s)	Specific Discharge ② / ① (l / s / ha)
Lampa R. (1)	A	2,394	650	2.7
Lampa R. (1)	B	2,167	580	2.7
Lampa R. (2)	C	1,904	300	2.8
Lampa R. (3)	D	1,442	270	2.8
Colina River	E	130	80	2.8
Choros Canal	F	263	70	2.7
Caren River	G	227	90	4.0
San Carlos Canal	H	232	120	5.2

Location Map

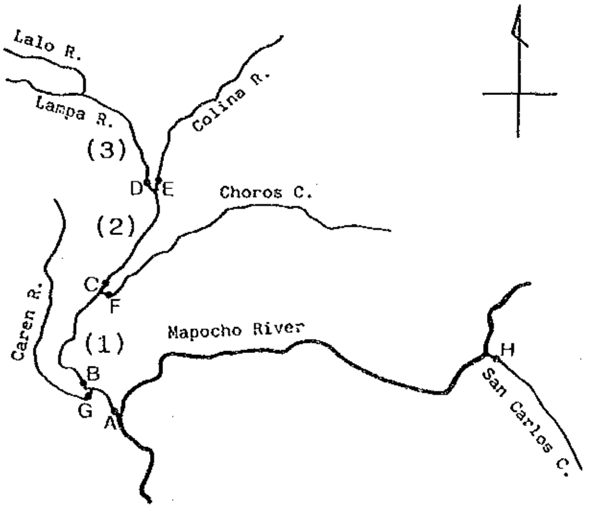


Table A-13-8 Estimated Construction Cost of Ground Sill

(Unit : Ch$)

Item	Quantity	Unit Price	Amount (x10^3)
(1) Ground Sill (30 Units) 2.5 m high , 50 m long			
a. Excavation , gravel	15,000 m^3	300	4,500
b. Reinforced concrete	20,000 m^3	9,900	198,000
c. Reinforcing bar	600 ton	210,000	126,000
d Miscellaneous works	20 %		65,700
Sub-total			394,200
(2) River Bank (9,000 m x 2 lines)			
a. Embankment	360,000 m^3	2,100	756,000
b. Gabion	43,000 m^3	3,000	129,000
c. Miscellaneous works	30 %		265,500
Sub-total			1,150,500
(3) Total of direct cost			1,544,700
(4) Indirect cost	25 %		386,200
Total			1,930,900

Table A-13-9 Rainfall Record (July 1984)

Rungüe (No 4)

(Unit : mm/hour)

Day Time (hr)	3rd	4th	5th
1	0	7.1	3.5
2	0	7.2	3.6
3	0	11.1	1.6
4	0	11.2	1.6
5	0	10.9	2.8
6	0	11.0	2.8
7	0	9.7	0.2
8	0	9.8	0.2
9	0	5.8	0.2
10	0.1	5.8	0.2
11	0	6.5	0.6
12	0.1	6.5	0.7
13	0.2	7.8	0.6
14	0.3	7.8	0.6
15	3.0	5.4	1.2
16	3.1	5.5	1.2
17	3.7	4.2	1.0
18	3.7	4.3	1.0
19	3.4	6.5	0
20	3.5	6.5	0.1
21	3.9	6.4	0
22	4.0	6.5	0.1
23	4.8	4.9	0
24	4.9	5.0	0.1
Total	38.7	173.4	23.9
Accu. Total	38.7	212.1	236.0

Santiago (No 24)

(Unit : mm/hour)

Day Time (hr)	3rd	4th	5th
1	–	–	1.0
2	–	–	2.5
3	–	–	0.2
4	–	–	5.0
5	–	1.5	4.5
6	–	0.4	0.8
7	–	1.2	–
8	–	–	–
9	–	1.6	–
10	–	0.8	–
11	–	1.8	–
12	–	2.7	–
13	–	3.0	–
14	–	5.0	–
15	0.4	8.5	–
16	1.0	3.5	–
17	1.5	9.0	–
18	2.0	4.0	–
19	0.6	4.5	–
20	–	1.5	–
21	0.3	1.8	–
22	0.1	2.0	–
23	0.4	1.5	–
24	–	3.0	–
Total	6.3	57.3	14.0
Accu. Total	6.3	63.6	78.4

Table A-13-10 (1) Simulated Rainfall (1/4)

(Rungüe No 4)

Return Period (3 year)

(Unit : mm/hour)

Day / Time (hr)	1st	2nd	3rd
1		3.7	1.8
2		3.8	1.9
3		5.8	0.8
4		5.8	0.8
5		5.7	1.5
6		5.7	1.5
7		5.1	0.1
8		5.1	0.1
9		3.0	0.1
10	0.1	3.0	0.1
11	0	3.5	0.3
12	0.1	3.5	0.4
13	0.1	5.1	0.3
14	0.2	5.1	0.3
15	1.6	2.8	0.6
16	1.6	2.9	0.6
17	1.9	2.2	0.5
18	1.9	2.2	0.5
19	1.9	3.4	0
20	1.8	3.4	0.1
21	2.0	3.3	0
22	2.1	3.4	0.1
23	2.5	2.6	0
24	2.6	2.6	0.1
Total	20.4	92.7	12.5
Accu. Total	20.4	113.1	125.6

Return Period (6.7 year)

(Unit : mm/hour)

Day / Time (hr)	1st	2nd	3rd
1		5.3	2.7
2		5.3	2.7
3		8.2	1.3
4		8.2	1.3
5		8.2	2.2
6		8.2	2.2
7		7.2	0.2
8		7.2	0.2
9		4.3	0.2
10	0.1	4.3	0.2
11	0	4.8	0.4
12	0.1	4.8	0.4
13	0.1	5.8	0.4
14	0.2	5.8	0.4
15	2.2	4.0	0.9
16	2.3	4.0	0.9
17	2.7	3.1	0.7
18	2.7	3.1	0.7
19	2.5	4.8	0
20	2.5	4.8	0.1
21	3.0	4.8	0
22	3.0	4.8	0.1
23	3.6	3.6	0
24	3.6	3.6	0.1
Total	28.6	128.2	18.3
Accu. Total	28.6	156.8	175.1

Return Period (30 year)

(Unit : mm/hour)

Day / Time (hr)	1st	2nd	3rd
1		8.3	1.2
2		8.3	1.2
3		13.0	1.9
4		13.0	1.9
5		12.9	3.3
6		12.9	3.3
7		11.4	0.2
8		11.4	0.2
9		6.7	0.2
10	0.2	6.7	0.2
11	0	7.5	0.7
12	0.3	7.5	0.7
13	0.4	9.1	0.7
14	3.6	9.1	0.7
15	3.7	6.3	1.4
16	3.7	6.3	1.4
17	4.4	5.1	1.2
18	4.4	5.1	1.2
19	4.0	7.6	0
20	4.0	7.6	0.1
21	4.6	7.6	0
22	4.6	7.6	0.1
23	5.7	5.9	0
24	5.7	5.9	0.1
Total	49.3	202.8	21.9
Accu. Total	49.3	252.1	274.0

Table A-13-10 (2) Simulated Rainfall (2/4)

(Rungüe No 24)

Return Period (50 year)

(Unit : mm/hour)

Day Time (hr)	1st	2nd	3rd
1		9.4	4.5
2		9.4	4.5
3		14.5	2.1
4		14.5	2.1
5		14.3	3.6
6		14.3	3.6
7		12.6	0.3
8		12.6	0.3
9		7.5	0.3
10	0.1	7.5	0.3
11	0	8.4	0.8
12	0.1	8.4	0.8
13	0.3	10.1	0.8
14	0.4	10.1	0.8
15	4.0	7.1	1.6
16	4.0	7.1	1.6
17	4.8	5.4	1.3
18	4.8	5.4	1.3
19	4.4	8.4	0
20	4.4	8.4	0.1
21	5.1	8.3	0
22	5.1	8.3	0.1
23	6.4	6.4	0
24	6.4.	6.4	0.1
Total	50.3	224.8	39.9
Accu. Total	50.3	275.1	306.0

Return Period (100 year)

(Unit : mm/hour)

Day Time (hr)	1st	2nd	3rd
1		10.6	5.2
2		10.6	5.2
3		16.5	2.3
4		16.5	2.3
5		16.2	4.1
6		16.2	4.1
7		14.5	0.3
8		14.5	0.3
9		8.6	0.3
10	0.1	8.6	0.3
11	0	9.6	0.9
12	0.1	9.6	0.9
13	0.3	11.5	0.9
14	0.4	11.5	0.9
15	4.4	8.0	1.8
16	4.4	8.0	1.8
17	5.5	6.2	1.5
18	5.5	6.2	1.5
19	5.1	9.6	0
20	5.1	9.6	0.1
21	5.9	9.6	0
22	5.9	9.6	0.1
23	7.1	7.2	0
24	7.1	7.2	0.1
Total	56.9	256.2	34.9
Accu. Total	56.9	313.1	348.0

Return Period (200 rear)

(Unit : mm/hour)

Day Time (hr)	1st	2nd	3rd
1		11.8	5.8
2		11.8	5.8
3		18.6	2.6
4		18.6	2.6
5		18.1	4.6
6		18.1	4.6
7		16.1	0.3
8		16.1	0.3
9		9.4	0.3
10	0.2	9.4	0.3
11	0	10.8	1.0
12	0.2	10.8	1.0
13	0.3	13.0	1.0
14	0.5	13.0	1.0
15	5.0	9.0	2.0
16	5.0	9.0	2.0
17	6.1	7.1	1.7
18	6.1	7.1	1.7
19	5.6	10.7	0
20	5.6	10.7	0.2
21	6.4	10.6	0
22	6.4	10.6	0.2
23	7.9	8.3	0
24	7.9	8.3	0.2
Total	63.2	28.7	39.2
Accu. Total	63.2	91.9	131.1

Table A-13-10 (3) Simulated Rainfall (3/4)

(Santiago No 24)

Return Period (3 year)

(Unit : mm/hour)

Day Time (hr)	1st	2nd	3rd
1		0	1.0
2		0	2.4
3		0	0.2
4		0	4.0
5		1.4	4.3
6		0.4	0.6
7		1.1	
8		0	
9		1.5	
10		0.6	
11		1.7	
12		2.6	
13		2.9	
14		4.8	
15	0.4	8.2	
16	1.0	3.4	
17	1.4	8.7	
18	1.9	3.9	
19	0.6	4.3	
20	0	1.4	
21	0.3	1.7	
22	0.1	1.9	
23	0.4	1.4	
24	0	2.9	
Total	6.1	54.8	12.5
Accu. Total	6.1	60.9	73.4

Return Period (6.7 year)

(Unit : mm/hour)

Day Time (hr)	1st	2nd	3rd
1		0	1.3
2		0	3.2
3		0	0.3
4		0	6.4
5		1.9	5.8
6		0.5	1.0
7		1.5	
8		0	
9		2.1	
10		1.0	
11		2.3	
12		3.5	
13		3.9	
14		6.4	
15	0.5	11.0	
16	1.3	4.5	
17	1.9	11.6	
18	2.6	5.2	
19	0.8	5.8	
20	0	1.9	
21	0.5	2.3	
22	0.1	2.6	
23	0.5	1.9	
24	0	3.9	
Total	8.2	73.8	18.0
Accu. Total	8.2	82.0	100.0

Return Period (30 year)

(Unit : mm/hour)

Day Time (hr)	1st	2nd	3rd
1		0	1.9
2		0	4.7
3		0	0.4
4		0	9.3
5		2.8	8.4
6		0.7	1.5
7		2.2	
8		0	
9		3.0	
10		1.5	
11		3.4	
12		5.0	
13		5.6	
14		9.3	
15	0.8	15.9	
16	2.0	6.5	
17	2.8	16.8	
18	3.7	7.5	
19	1.1	8.4	
20	0	2.8	
21	0.6	3.4	
22	0.2	3.7	
23	0.7	2.8	
24	0	5.6	
Time	11.9	106.9	26.2
Accu. Total	11.9	118.8	145.0

Table A-13-10 (4) Simulated Rainfall (4/4)

(Santiago No 24)

Return Period (50 year)

(Unit : mm/hour)

Day Time (hr)	1st	2nd	3rd
1		0	2.1
2		0	5.2
3		0	0.4
4		0	10.3
5		3.1	9.3
6		0.8	1.7
7		2.5	
8		0	
9		3.3	
10		1.6	
11		3.7	
12		5.6	
13		6.2	
14		10.3	
15	0.0	17.5	
16	2.1	7.2	
17	3.1	18.6	
18	4.1	8.2	
19	1.2	9.3	
20	0	3.1	
21	0.6	3.7	
22	0.2	4.1	
23	0.8	3.1	
24	0	6.2	
Time	12.1	118.1	29.0
Accu. Total	12.1	130.2	159.2

Return Period (100 year)

(Unit : mm/hour)

Day Time (hr)	1st	2nd	3rd
1		0	2.3
2		0	5.8
3		0	0.5
4		0	11.6
5		3.5	10.8
6		0.9	1.8
7		2.8	
8		0	
9		3.7	
10		1.9	
11		4.2	
12		6.3	
13		7.0	
14		11.6	
15	0.9	19.7	
16	2.3	8.2	
17	3.5	20.9	
18	4.6	9.3	
19	1.4	10.4	
20	0	3.5	
21	0.7	4.2	
22	0.2	4.6	
23	0.9	3.5	
24	0	7.0	
Time	14.5	133.2	32.8
Accu. Total	14.5	147.7	180.5

Return Period (200 year)

(Unit : mm/hour)

Day Time (hr)	1st	2nd	3rd
1		0	2.6
2		0	6.4
3		0	0.5
4		0	12.9
5		3.9	11.6
6		1.0	2.0
7		3.1	
8		0	
9		4.1	
10		2.1	
11		4.6	
12		7.0	
13		7.7	
14		12.9	
15	1.0	21.9	
16	2.6	9.0	
17	3.9	23.2	
18	5.2	10.3	
19	1.5	11.6	
20	0	3.9	
21	0.8	4.6	
22	0.3	5.2	
23	1.0	3.9	
24	0	7.7	
Total	16.3	147.7	36.0
Accu. Total	16.3	164.0	200.0

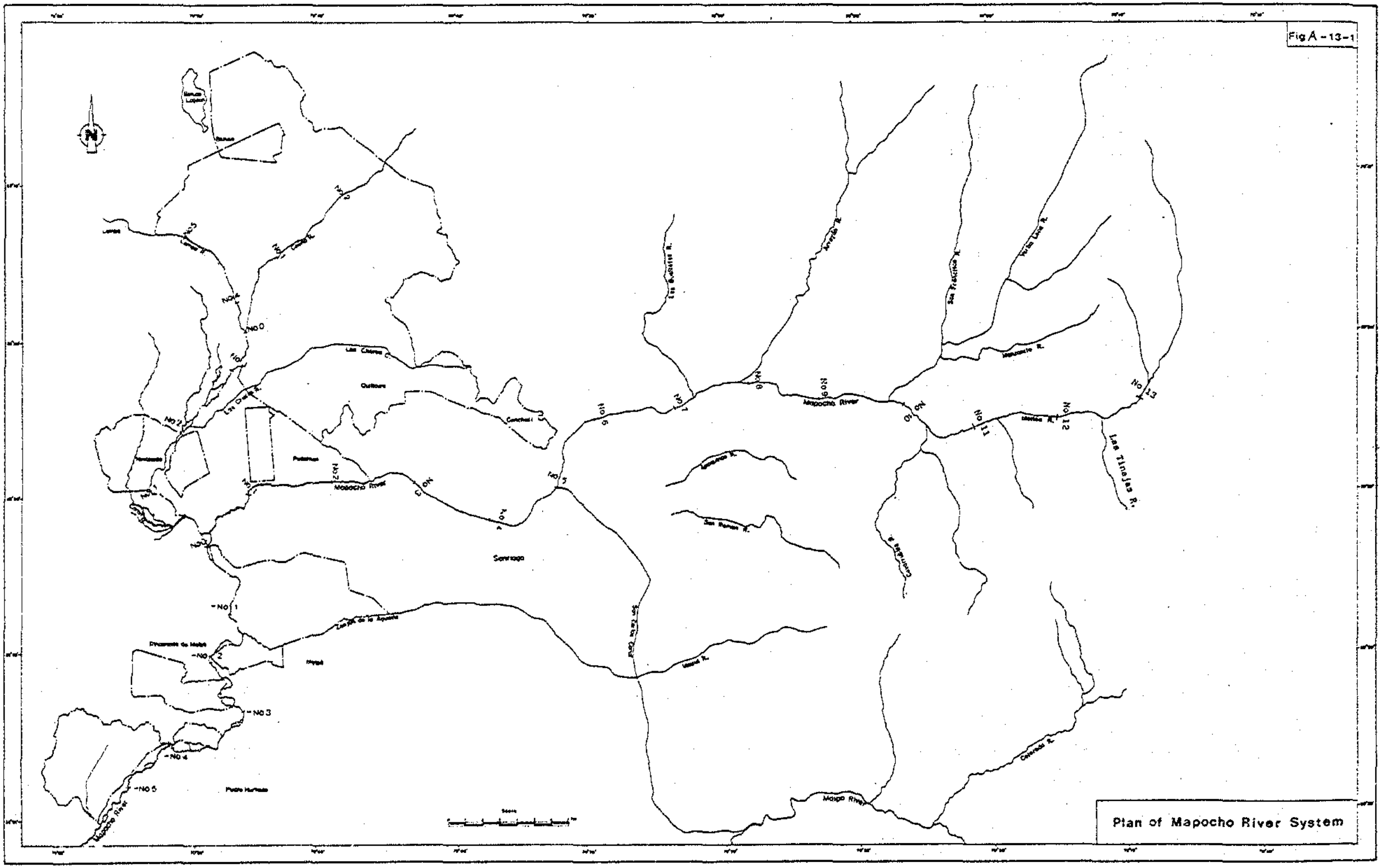


Fig A - 13-1

Plan of Mapocho River System

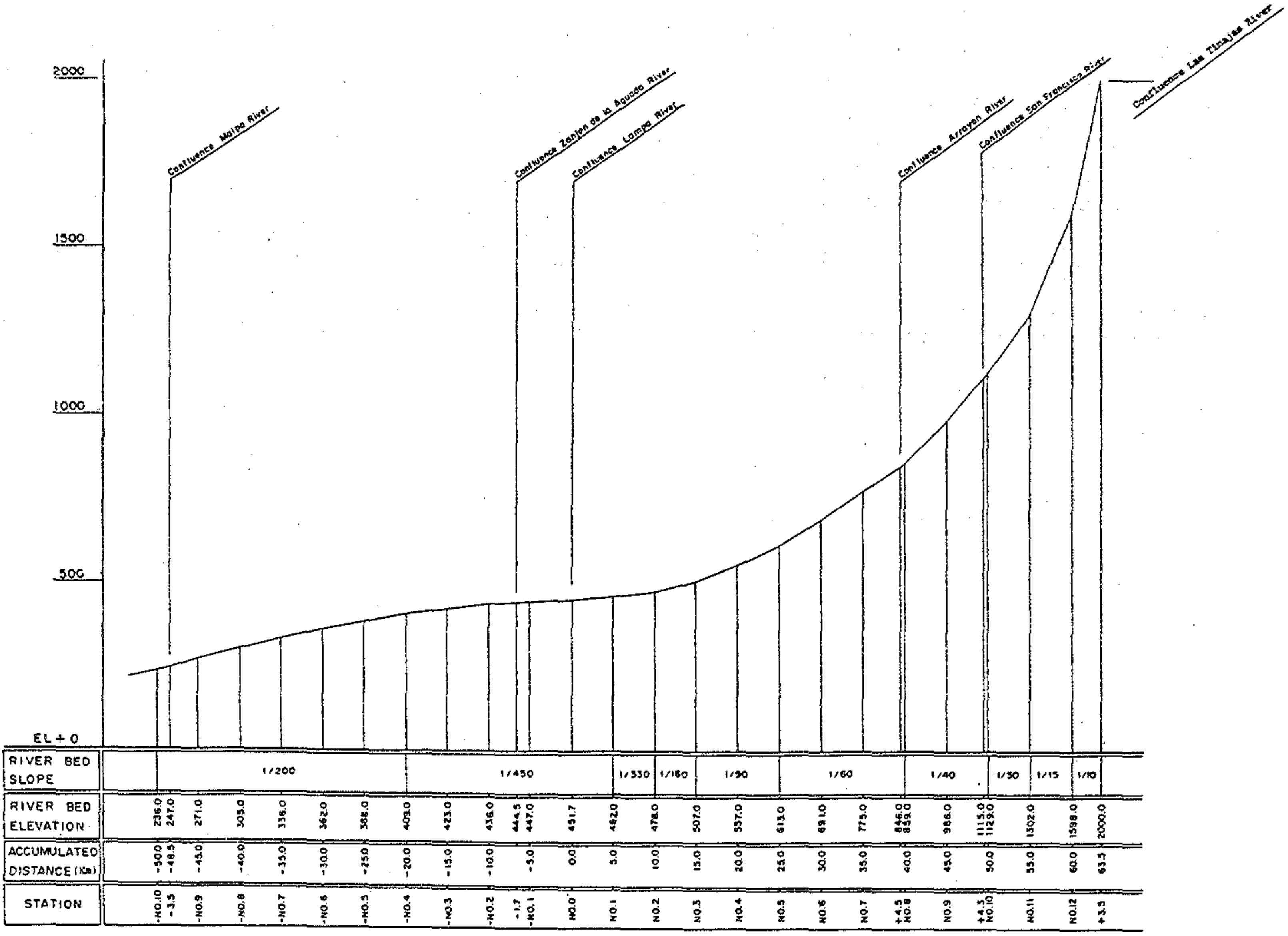


Fig A - 13 - 2 Longitudinal Profile of Mapocho River

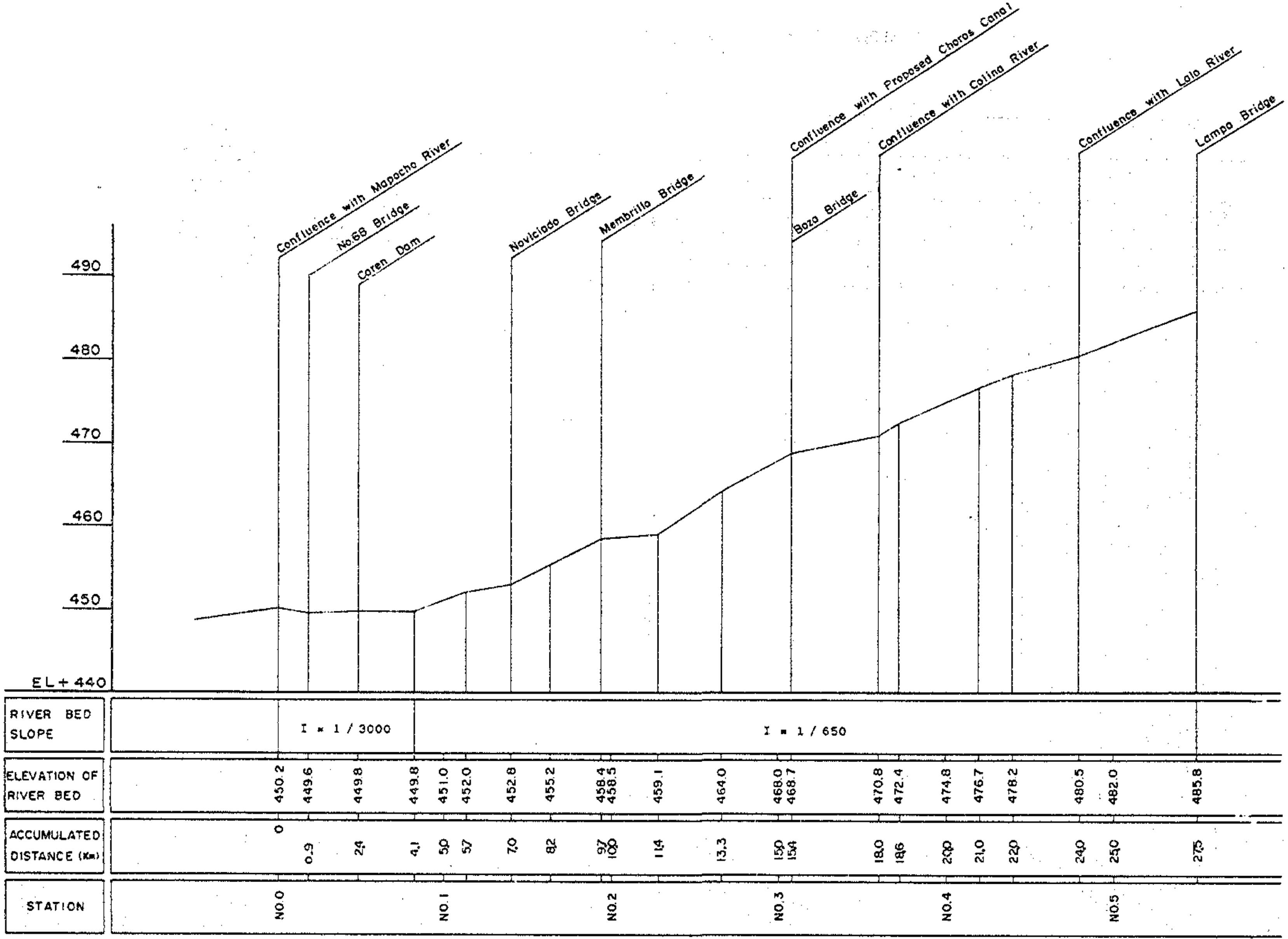


Fig A - 13 - 3 Longitudinal Profile of Lampa River

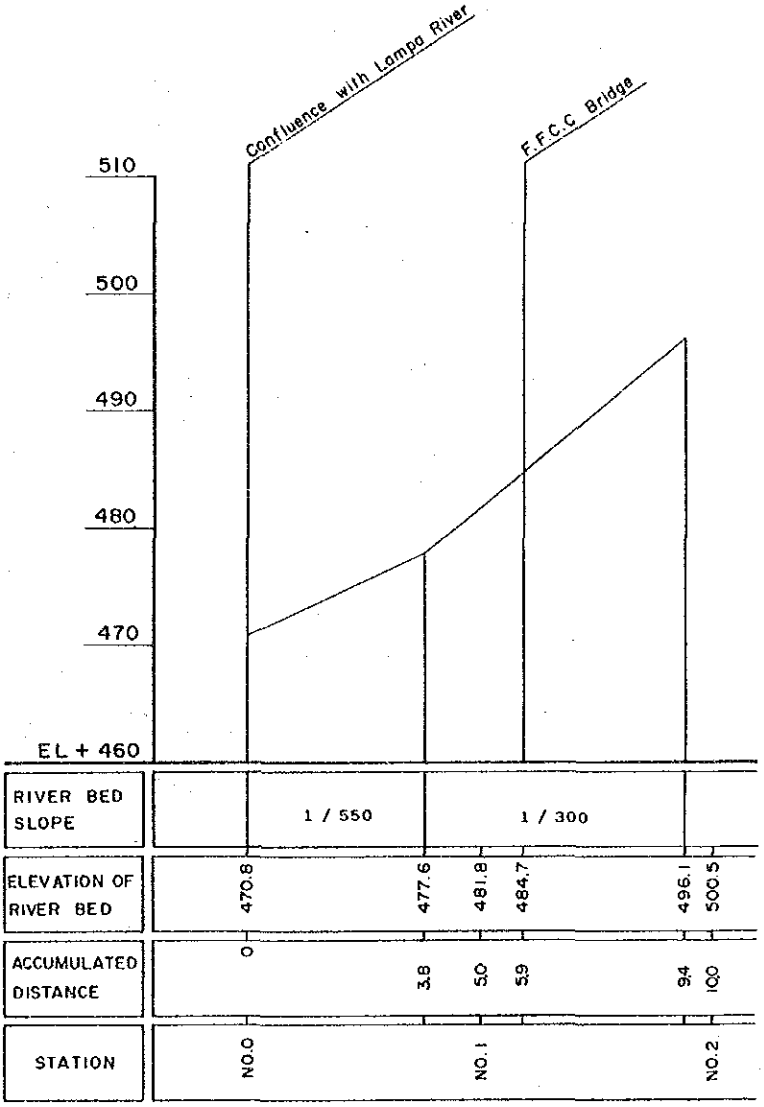
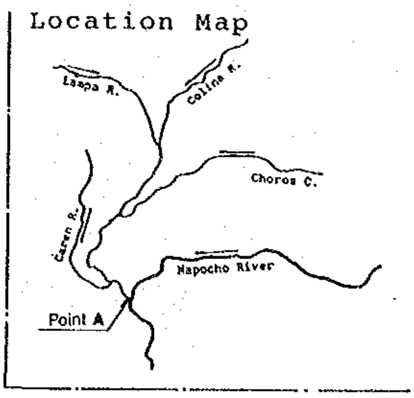
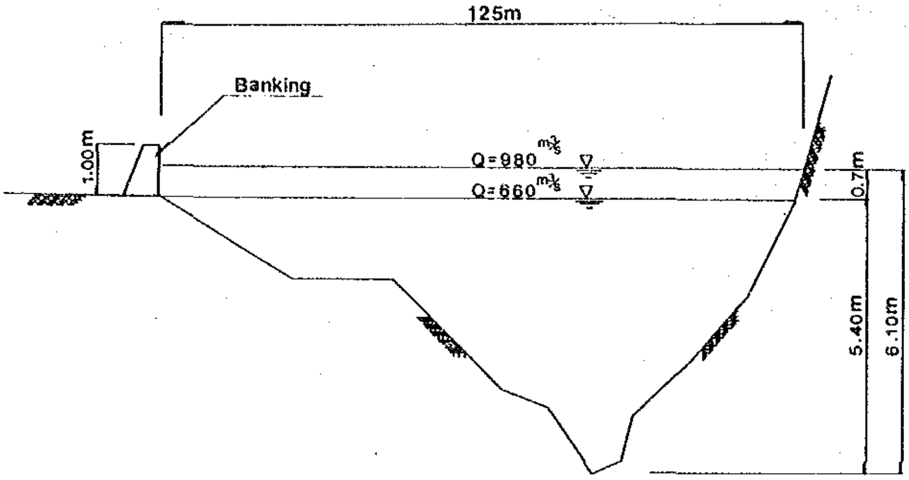
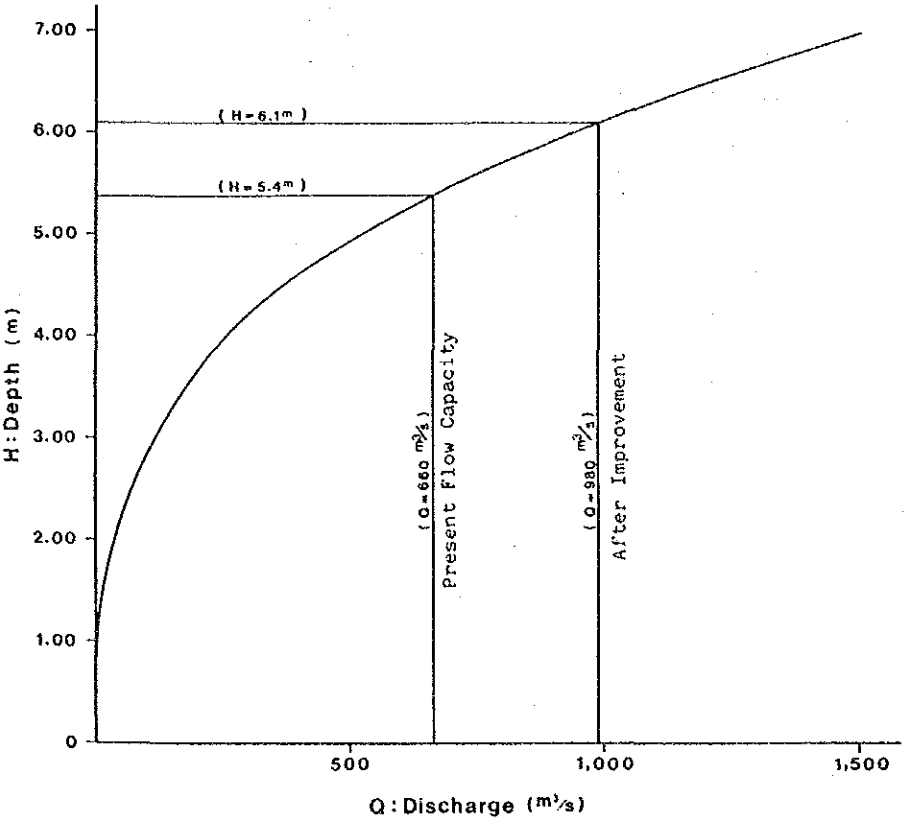


Fig A - 13 - 4 Longitudinal Profile of Colina River



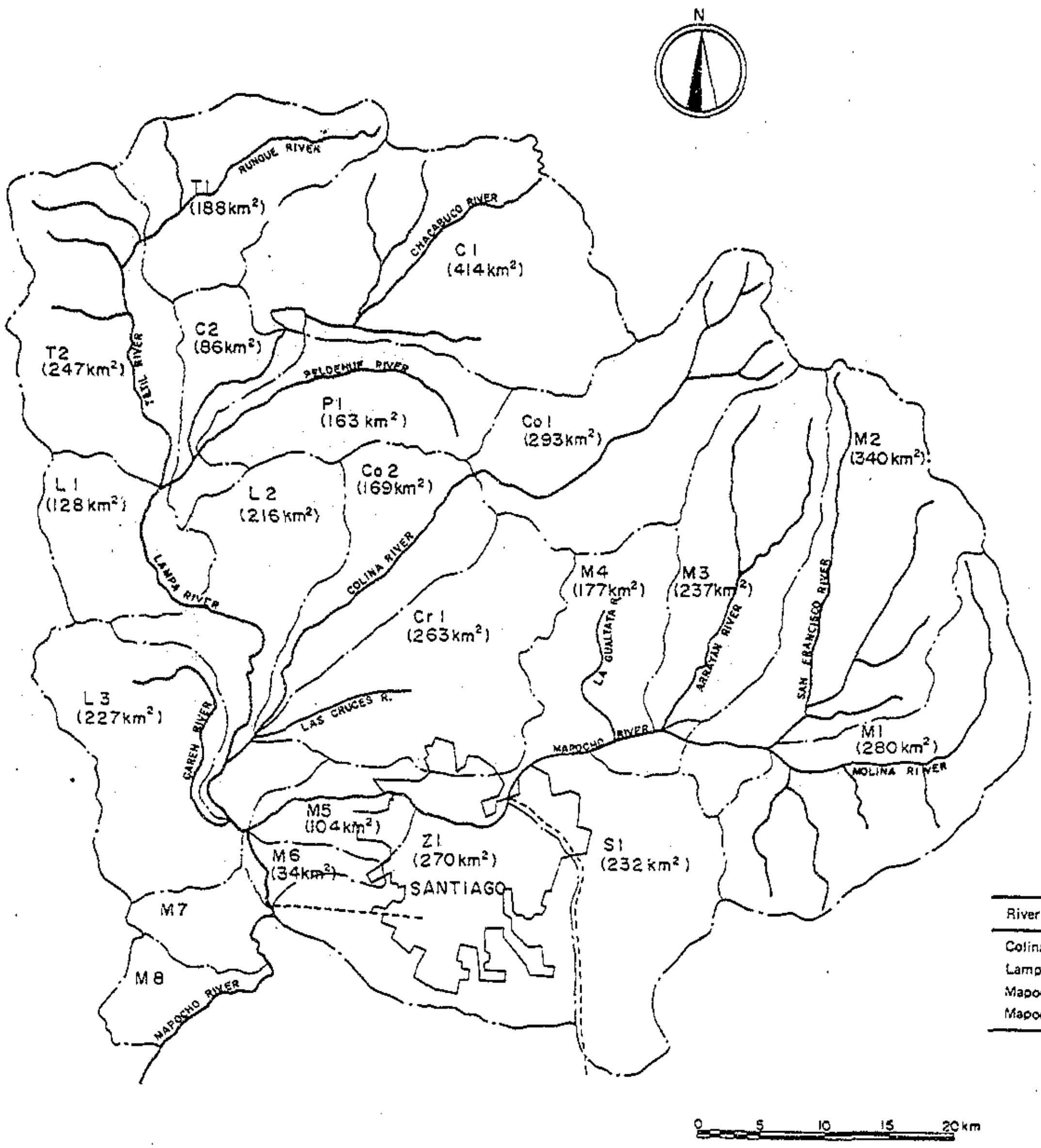


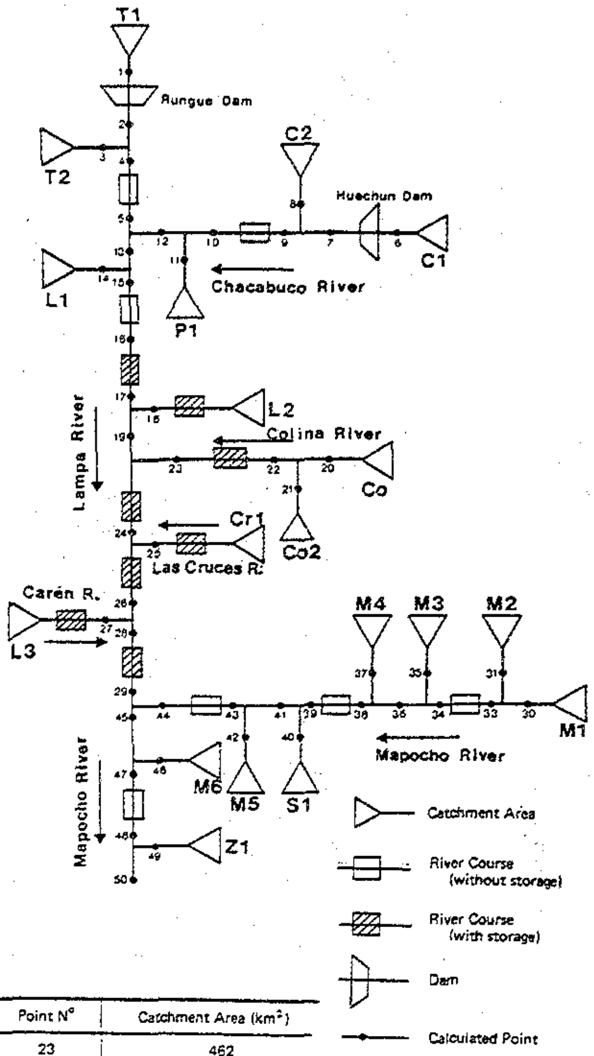
Section A-A



H-Q Curve

Fig A-13-5 Flow Capacity of Mapocho River at Point A





River	Point N°	Catchment Area (km²)
Colina R.	23	462
Lampa R.	29	2,394
Mapocho R.	44	1,370
Mapocho R.	50	4,068

Fig.A-13-6 Fluvial System and Catchment Area Division for Flood Simulation Model

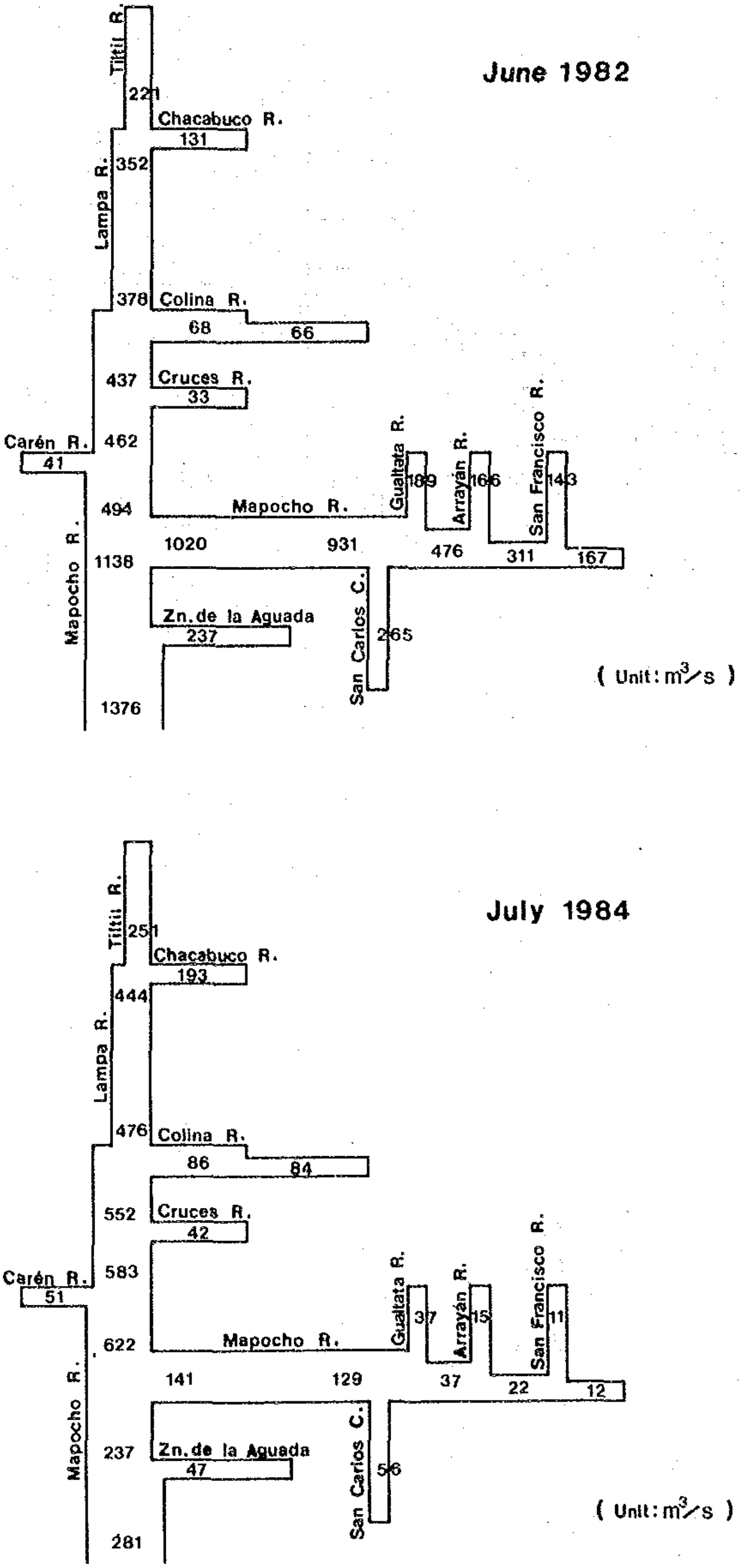


Fig A-13-7 Simulated Flood Discharge based on Observed Rainfall

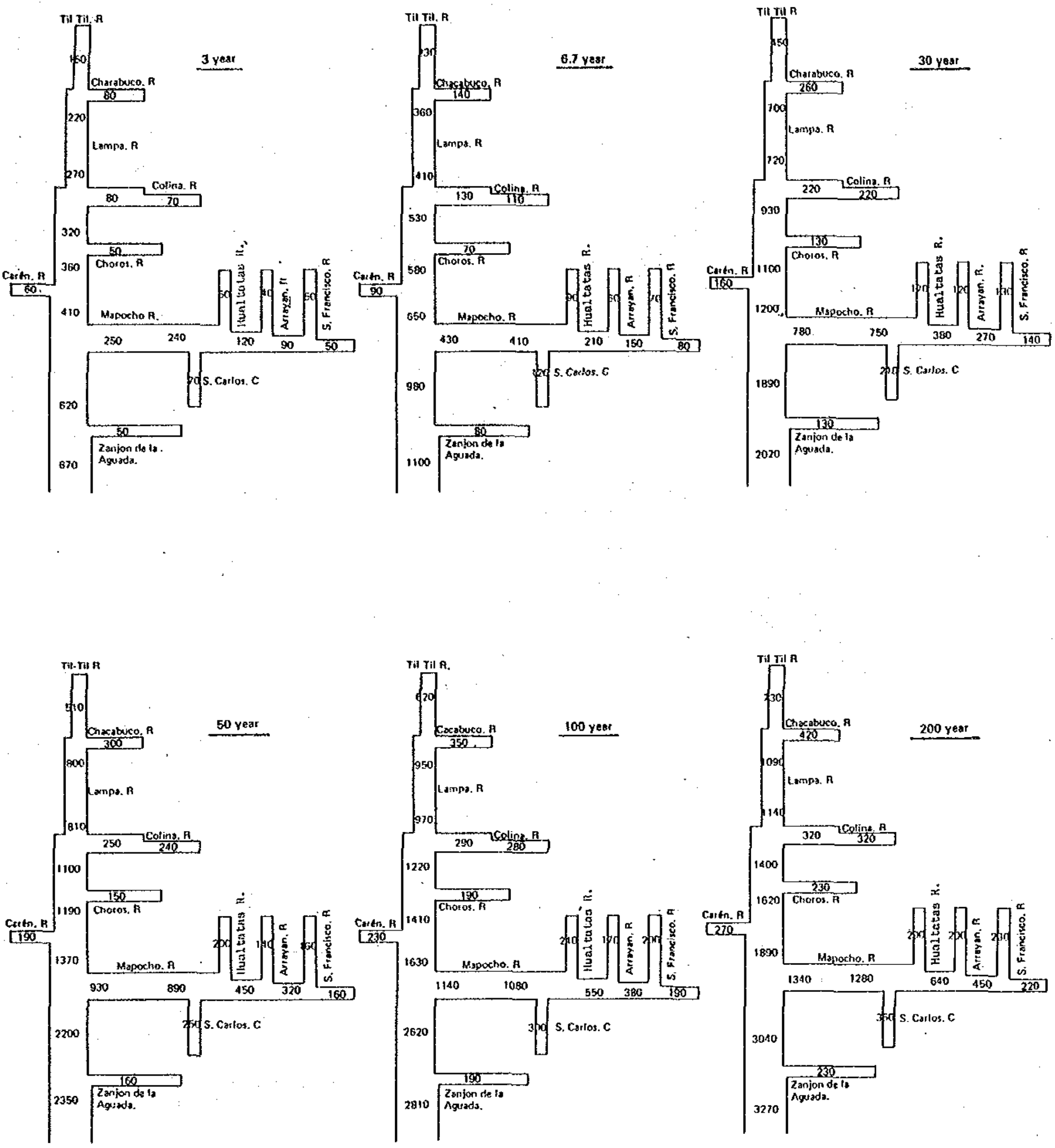


Fig.A-13-8 Basic Flood Discharge for Respective Return Period

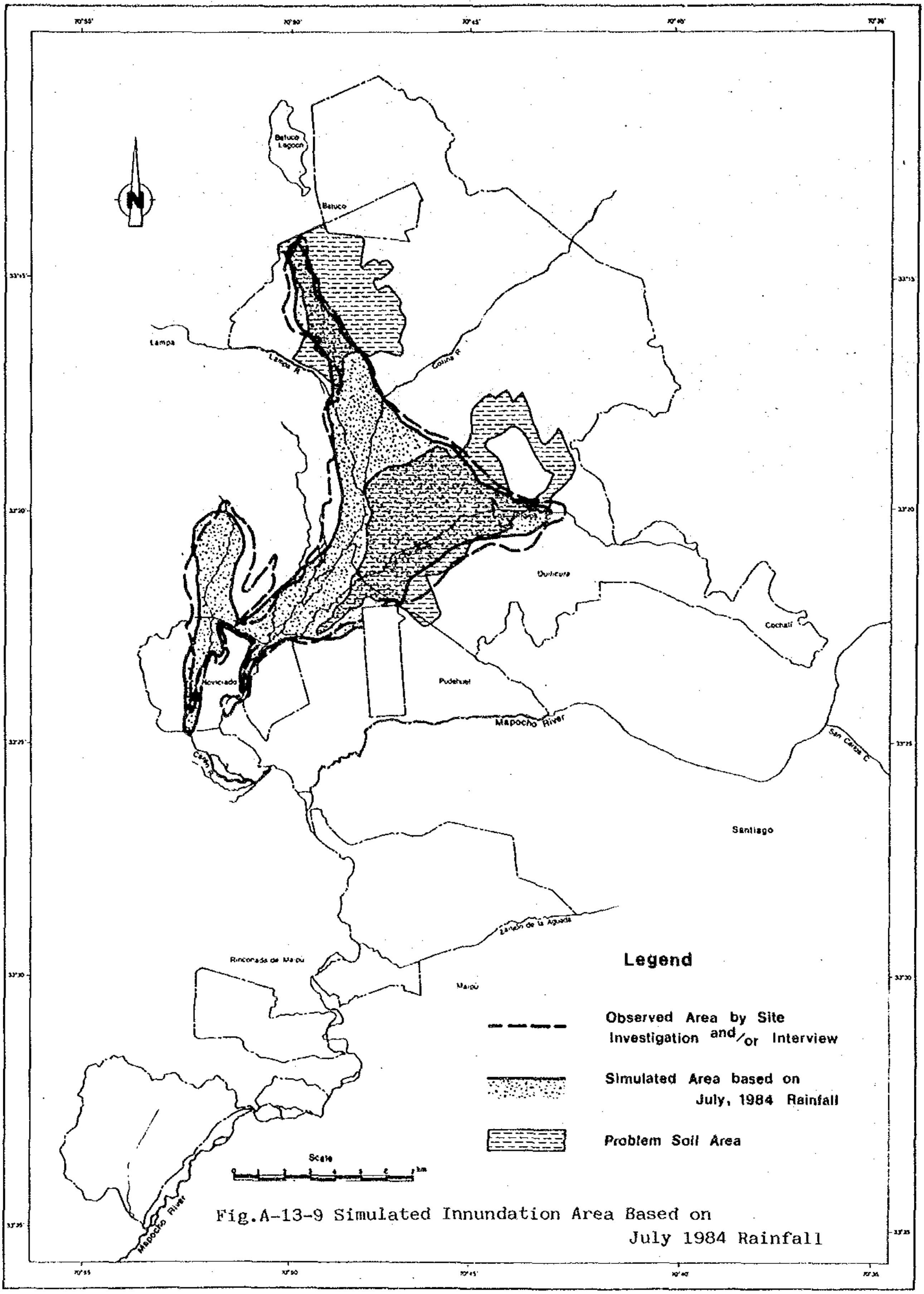


Fig.A-13-9 Simulated Innundation Area Based on July 1984 Rainfall

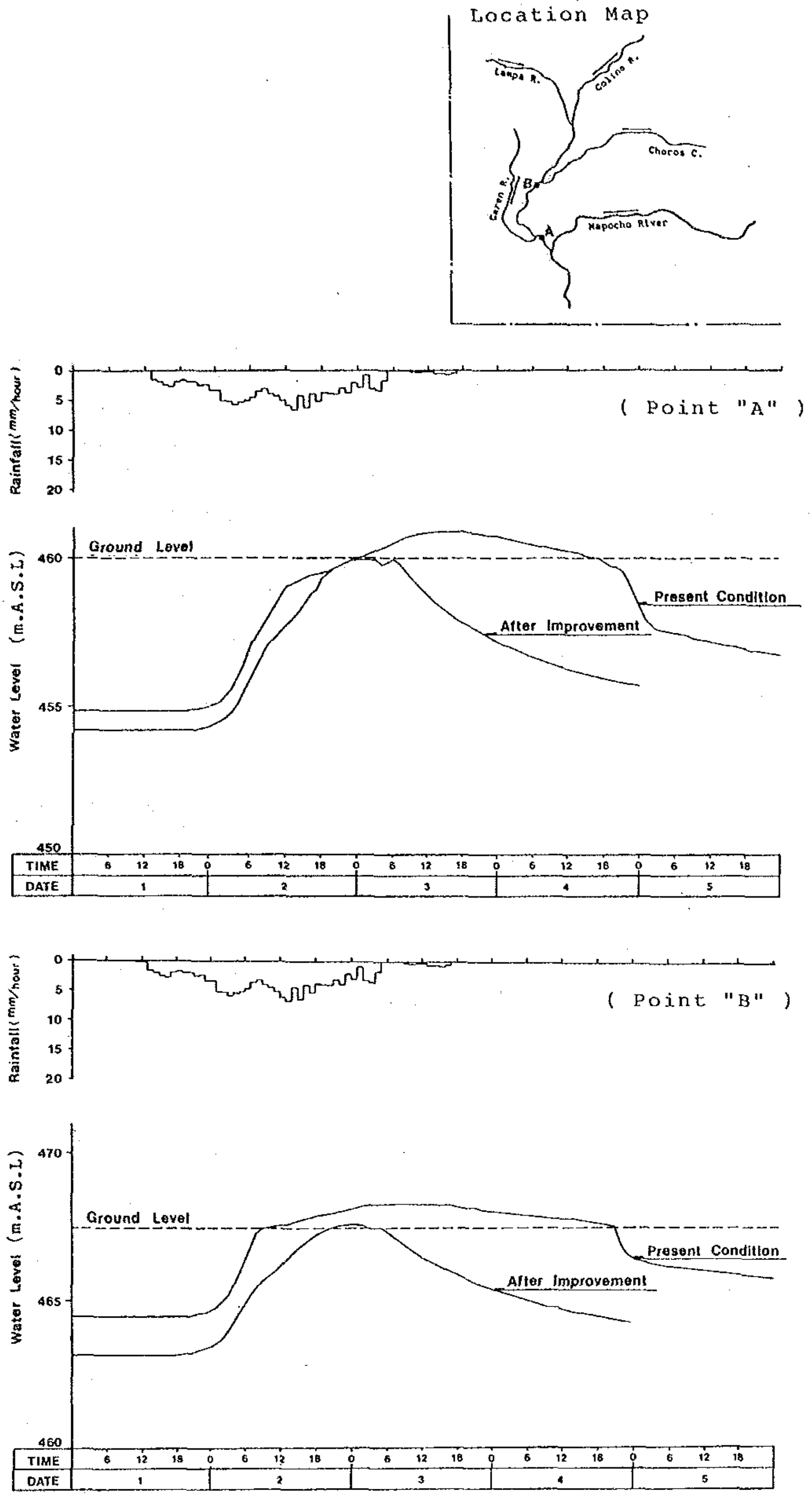


Fig A-13-10 Time-Water Level Curve

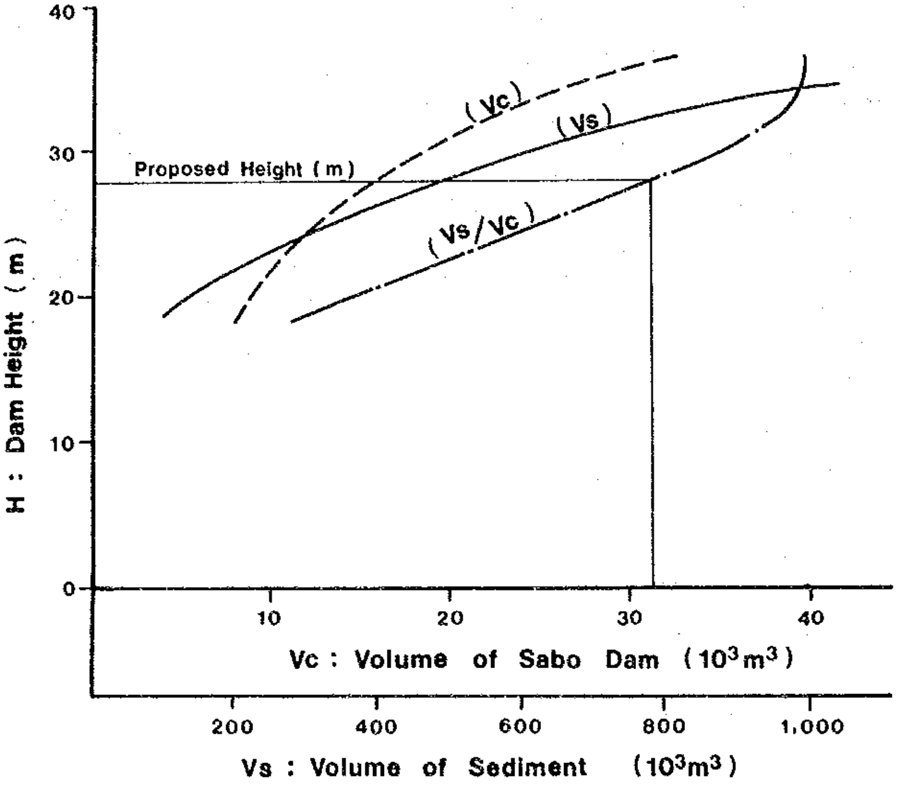
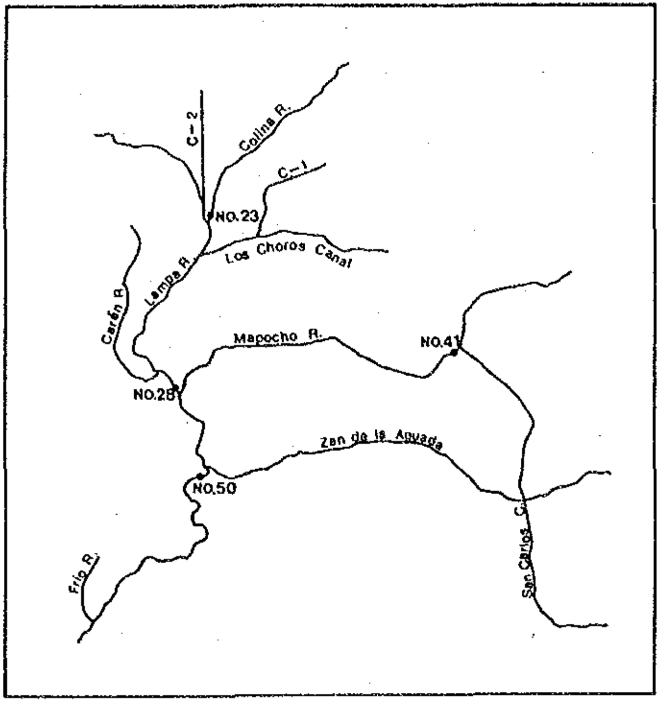


Fig A-13-11 Mapocho Sabo Dam Height-Volume of Sediment and Dam Body Curve



Flood Simulation Model

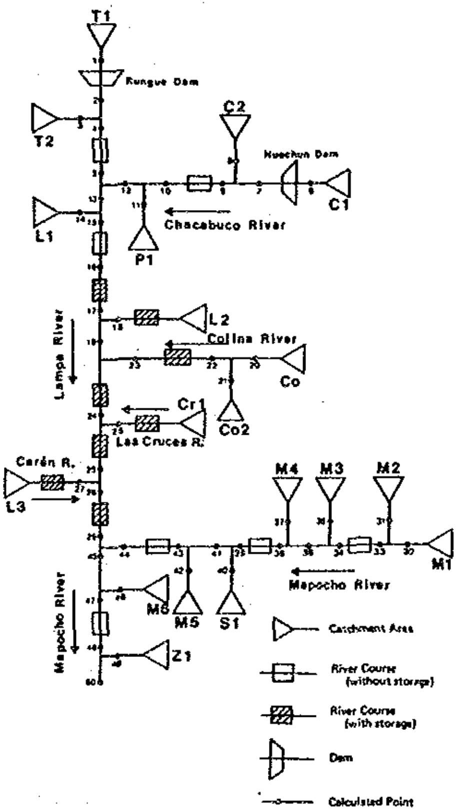
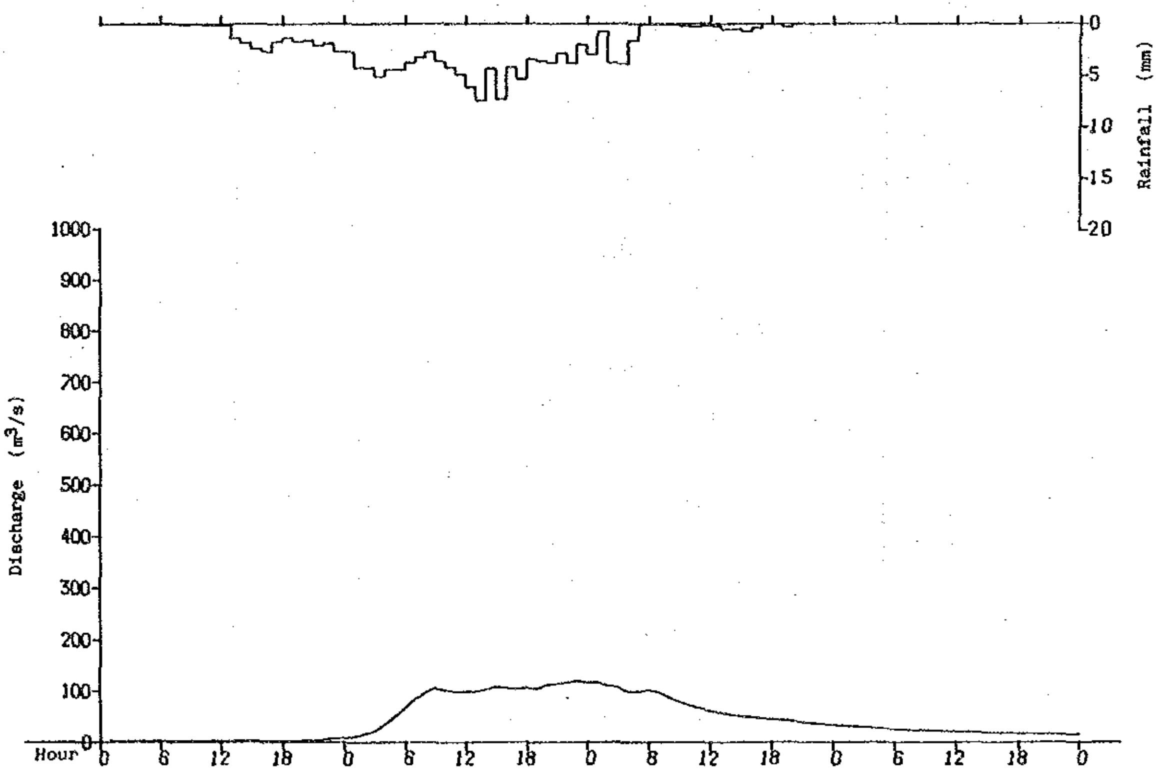


Fig A-13-12 Location Map of Gauging Station

RETURN PERIOD (6.7 year)

Station No 23



Station No 28

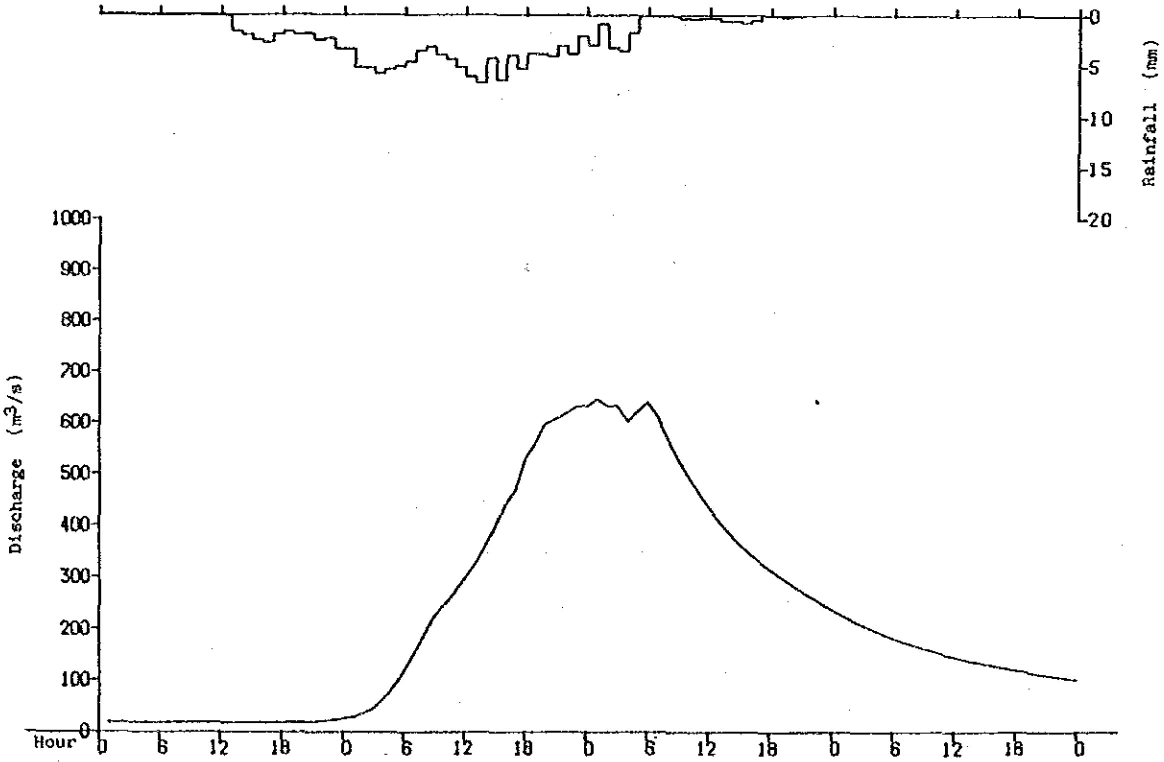
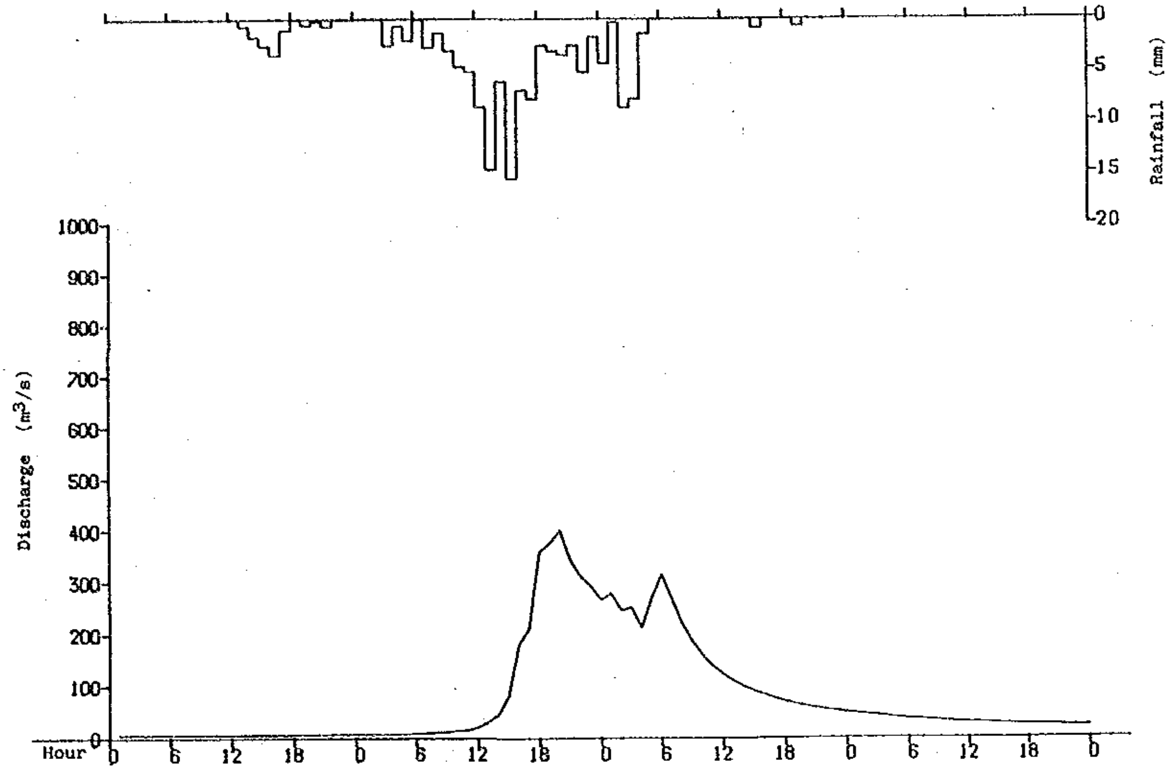


Fig A-13-13 (1) Simulated Hydrograph (1/4)

RETURN PERIOD (6.7 year)

Station No 41



Station No 50

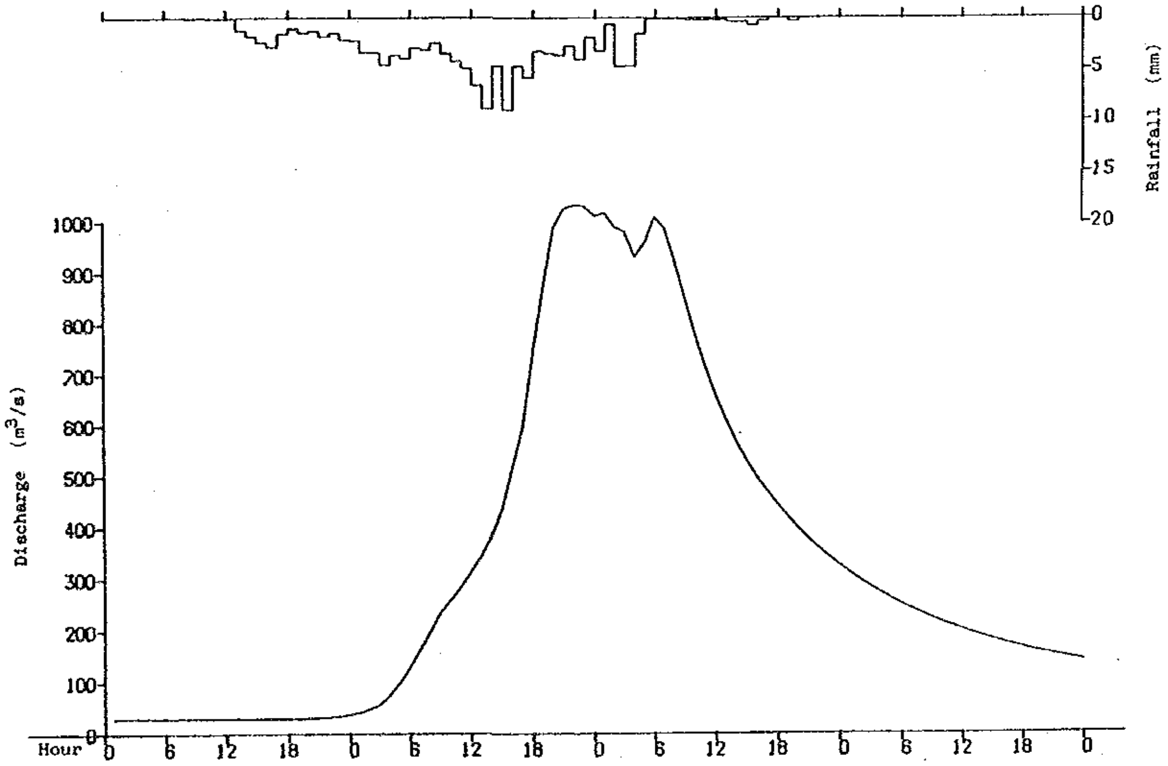
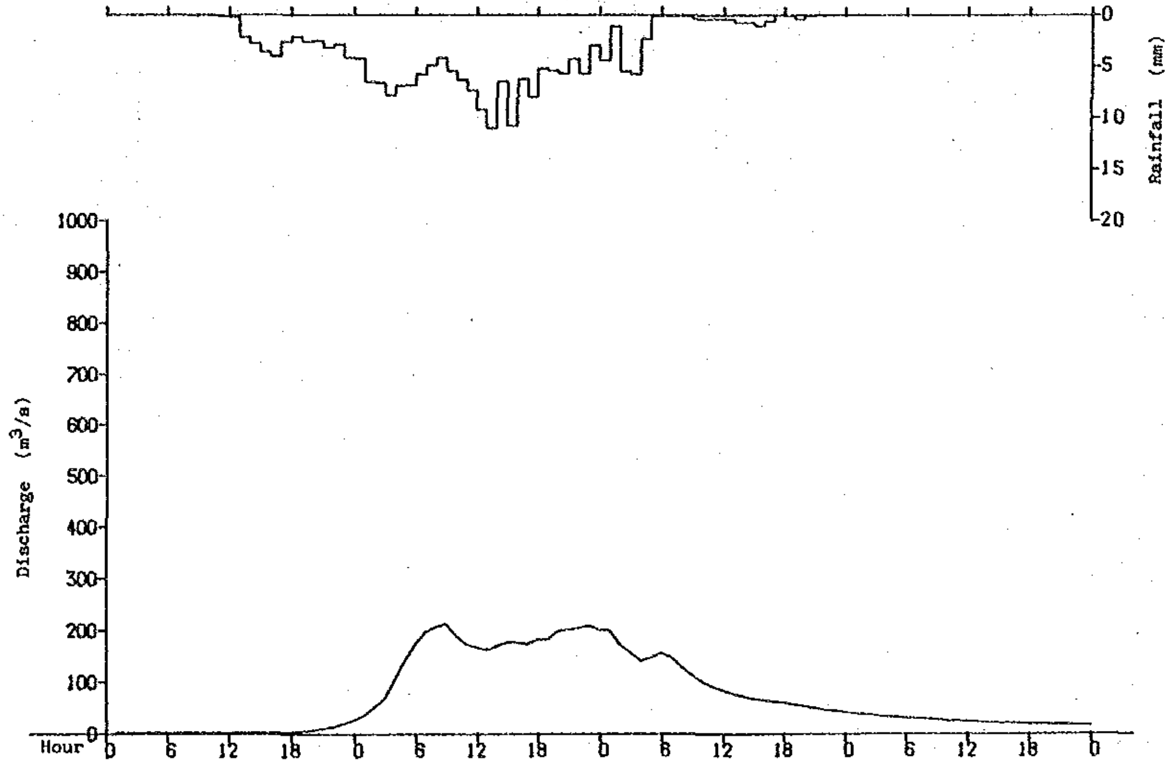


Fig A-13-13 (2) Simulated Hydrograph (2/4)

RETURN PERIOD (30 year)

Station No 23



Station No 28

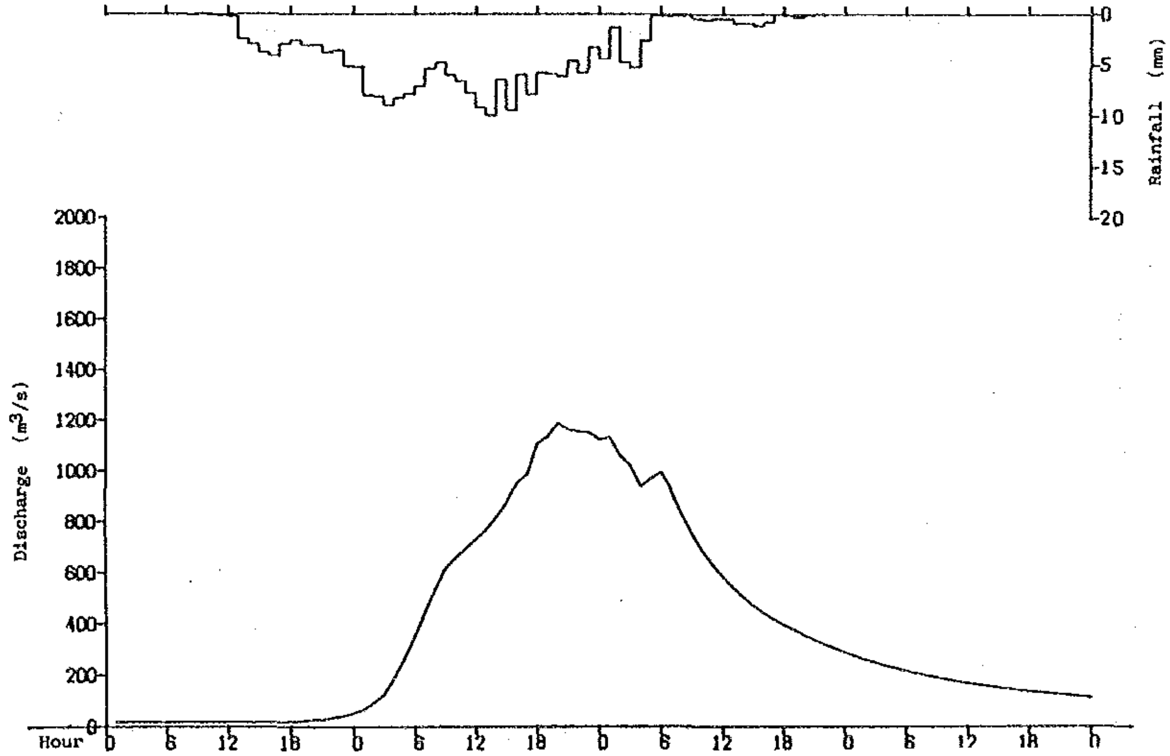
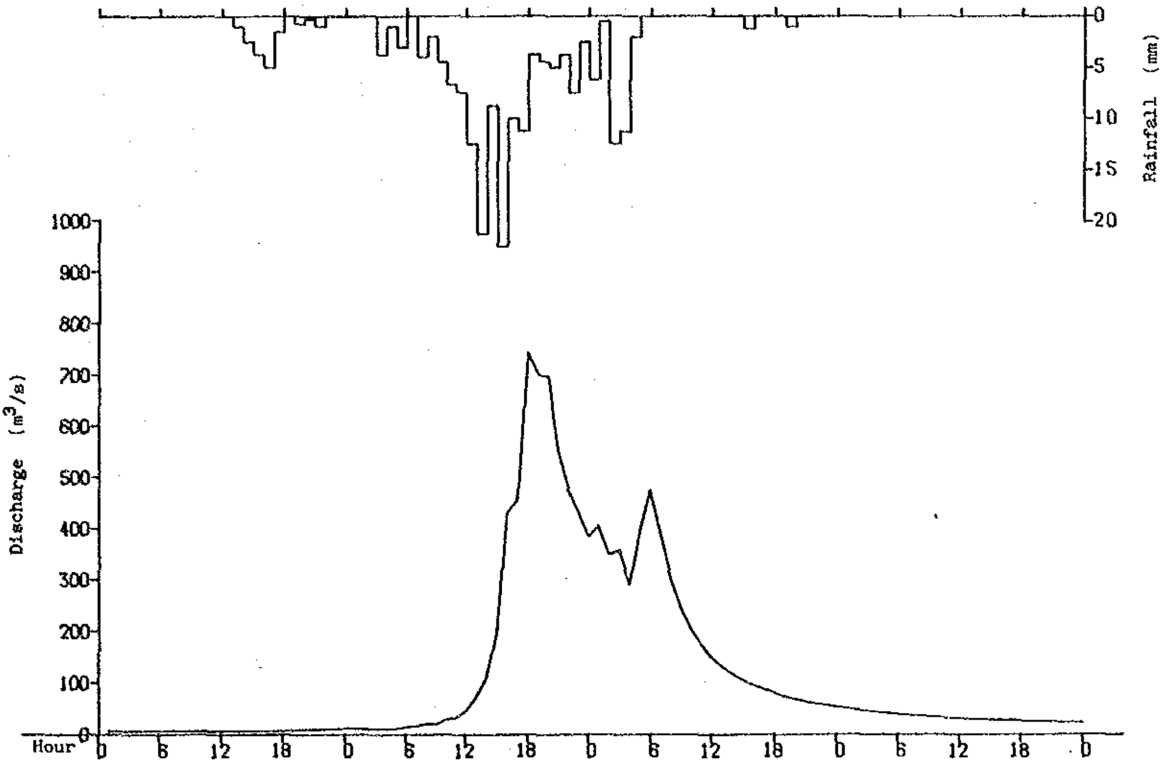


Fig A-13-13 (3) Simulated Hydrograph (3/4)

RETURN PERIOD (30 year)

Station No 41



Station No 50

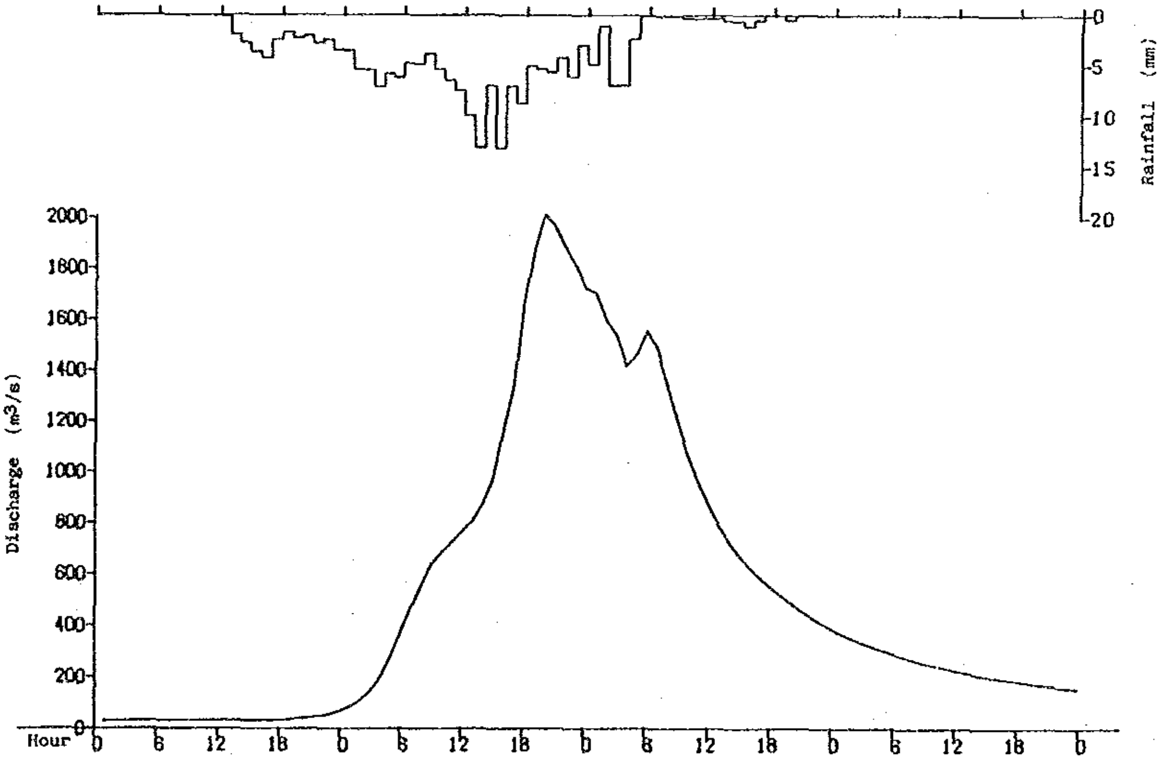


Fig A-13-13 (4) Simulated Hydrograph (4/4)

Appendix 14: Construction Cost

Summary of Construction Cost (Direct)

Block	Foreign Portion		Local Portion		Total
	Amount	%	Amount	%	Amount
1	477,435,400	76.2	149,047,460	23.8	626,482,860
2	763,271,680	88.5	98,702,280	11.5	861,973,960
3 and 4	7,634,099,800	68.2	3,551,486,410	31.8	11,185,586,290
Total	8,874,806,960	70.0	3,799,236,150	30.0	12,674,043,110

Summary of Labour Cost

(Unit : 10^6 Ch$)

Block	Unskilled	Semiskilled	Skilled	Total
Block-1	49.14	5.93	1.86	56.93
Block-2	66.2	9.22	3.57	78.99
Block-3,4	693.86	135.85	63.47	893.18
Total	809.2	151.0	68.9	1,029.1

Block-1

(1) Esperanza Haedworks (1/2)

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation, gravel	m^3	10,000	250	50	300	2,500,000	500,000	3,000,000	
2. Backlilling	"	3,500	400	80	480	1,400,000	280,000	1,680,000	
3. Embankment	"	10,000	400	80	480	4,000,000	800,000	4,800,000	
4. Hauling of excavated material	"	6,500	730	180	910	4,745,000	1,170,000	5,915,000	
Sub-total						12,645,000	2,750,000	15,395,000	
5. Plain concrete	m^3	500	6,500	2,900	9,400	3,250,000	1,450,000	4,700,000	
6. Reinforced concrete	"	5,100	6,800	3,100	9,900	34,680,000	15,810,000	50,490,000	
7.Reinforcing bar	ton	255	152,000	58,000	210,000	38,760,000	14,790,000	53,550,000	
8. Wooden form	m^2	3,500	220	710	930	770,000	2,485,000	3,255,000	
Sub-total						77,460,000	34,535,000	111,995,000	
9. Gabion	m^3	5,600	680	1,830	2,510	3,808,000	10,248,000	14,056,000	
10. Sluice gate	set	2	330,000	310,000	640,000	660,000	620,000	1,280,000	
11. Sluice gate	set	2	2,000,000	1,300,000	3,300,000	4,000,000	2,600,000	6,600,000	
12. Sheet pile	ton	*200*	*172,000*	*20,000*	*192,000*	*34,400,000*	*4,000,000*	*38,400,000*	1.8x1.0 5.0x1.5
Sub-total						42,868,000	17,468,000	60,336,000	

Block-1

Esperanza Haedworks (2/2)

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
13. Temporary Work									
(1) Sheet pile	ton	200	172,000	20,000	192,000	34,400,000	4,000,000	38,400,000	
(2) Driving of sheet pile	m	1,300	1,600	1,100	2,700	2,080,000	1,430,000	3,510,000	
(3) Withdrawing of sheet pile	"	1,300	600	400	1,000	780,000	520,000	1,300,000	
(4) Dewatering	day	400	1,400	1,200	2,600	560,000	480,000	1,040,000	
Sub-total						37,820,000	6,430,000	44,250,000	
14. Land acquisition	ha	3		380,000	380,000		1,140,000	1,140,000	
Sub-total							1,140,000	1,140,000	
Total						*170,793,000*	*62,323,000*	*233,116,000*	
15. Miscellaneous Works Grand Total	%	20				34,158,600	12,464,600	46,623,200	
						204,951,600	74,787,600	279,739,200	

Block-1

(2) Esperanza Canal

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation, common	m^3	9,000	190	40	230	1,710,000	360,000	2,070,000	
2. Embankment	"	4,000	400	80	480	1,600,000	320,000	1,920,000	
3. Hauling of excavated material	"	5,000	1,300	300	1,600	6,500,000	1,500,000	8,000,000	
Sub-total						9,810,000	2,180,000	11,990,000	
4. Enlargement of existing tunnel	"	220	1,000	1,240	2,240	220,000	272,800	492,800	
5. Hauling of excavated material	"	220	730	180	910	160,600	39,600	200,200	
6. Bridge	set	4	400,000	310,000	710,000	1,600,000	1,240,000	2,840,000	
7. Land acquisition	ha	4		380,000	380,000		1,520,000	1,520,000	
Sub-total						1,980,600	3,072,400	5,053,000	
Total						11,790,600	5,252,400	17,043,000	

Block-1

(3) Esperanza Diversion Works

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation, common	m^3	500	190	40	230	95,000	20,000	115,000	
2. Backfilling	"	240	400	80	480	96,000	19,200	115,200	
3. Hauling of excavated material	"	260	430	110	540	111,800	28,600	140,400	
Sub-total						302,800	67,800	370,600	
4. Reinforced concrete	"	90	6,800	3,100	9,900	612,000	279,000	891,000	
5. Reinforcing bar	ton	4	152,000	58,000	210,000	608,000	232,000	840,000	
6. Wooden form	m^2	300	220	710	930	66,000	213,000	279,000	
Sub-total						1,286,000	724,000	2,010,000	
7. Sluice gate	set	1				306,000	204,000	510,000	1.5mx1.7m
8. Sluice gate	"	1				252,000	168,000	420,000	1.4mx1.5m
Total						2,146,800	1,163,800	3,310,600	

Block-1

(4) Esperanza Chute

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation, common	m^3	700	190	40	230	133,000	28,000	161,000	
2. Backfilling	"	200	400	80	480	80,000	16,000	96,000	
3. Hauling of excavated material	"	500	730	180	910	365,000	90,000	455,000	
Sub-total						578,000	134,000	712,000	
4. Reinforced concrete	"	75	6,800	3,100	9,900	510,000	232,500	742,500	
5. Wooden form	m^2	260	220	710	930	57,200	184,600	241,800	
6. Reinforcing bar	ton	4.0	152,000	58,000	210,000	608,000	232,000	840,000	
Sub-total						1,175,200	649,100	1,824,300	
7. Land acquisition	ha	0.05		380,000	380,000		19,000	19,000	
Total						1,753,200	802,100	2,555,300	

Block-1

(5) Tertiary irrigation canal

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation and Sunfacing	m^3	2,000		500	500		1,000,000	1,000,000	
2. Miscellaneous Works	%	10					100,000	100,000	
Total							1,100,000	1,100,000	

Block-1

(6) Esperanza Treatment Plant (1/2)

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation, common	m^3	121,000	190	40	230	22,990,000	4,840,000	27,830,000	
2. Embankment	"	4,300	400	80	480	1,720,000	344,000	2,064,000	
3. Hauling of excavated material	"	116,700	730	300	1,030	85,191,000	35,010,000	120,201,000	
Sub-total						109,901,000	40,194,000	150,095,000	
4. Reinforced concrete	"	340	6,800	3,100	9,900	2,312,000	1,054,000	3,366,000	
5. Reinforcing bar	ton	14	152,000	58,000	210,000	2,128,000	812,000	2,940,000	
6. Wooden form	m^2	110	220	710	930	24,200	78,100	102,300	
Sub-total						4,464,200	1,944,100	6,408,300	
7. Aerator	set	9	3,800,000	45,000	3,845,000	34,200,000	405,000	34,605,000	
8. Float	"	9	2,900,000	90,000	2,990,000	26,100,000	810,000	26,910,000	
9. Chlorinator	"	5	1,300,000	45,000	1,345,000	6,500,000	225,000	6,725,000	
10. Switch board	L.S					7,425,000	300,000	7,725,000	135 kw
Sub-total						74,225,000	1,740,000	75,965,000	

Block-1

(6) Esperanza Treatment Plant (2/2)

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
11. Sluice gate	set	1				145,800	97,200	243,000	0.6mx0.6m
12. Land acquisition	ha	5.2		380,000	380,000		1,976,000	1,976,000	
13. Operation cum stock house	m^2	30		40,000	40,000		1,200,000	1,200,000	
14. Wiring		LS				800,000	400,000	1,200,000	
Sub-total						945,800	3,673,200	4,619,000	
Total						189,536,000	47,551,300	237,089,300	
15. Miscellaneous works	%	20				37,907,200	9,510,260	47,417,460	
Grand Total						227,443,200	57,061,560	284,504,760	

Block-1

(7) Improvement of Fifo River

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation, common	m^3	15,000	190	40	230	2,850,000	600,000	3,450,000	
2. Hauling of excavated material	"	15,000	1,300	300	1,600	19,500,000	4,500,000	24,000,000	
Total						22,350,000	5,100,000	27,450,000	

Block-1

(8) Farm Road Bridge (Type-B)

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
Type-B	set	6	600,000	330,000	930,000	3,600,000	1,980,000	5,580,000	
Type-C	set	10	340,000	180,000	520,000	3,400,000	1,800,000	5,200,000	
Total						7,000,000	3,780,000	10,780,000	

Block-2

(1) Ortuzano Treatment Plant (1/2)

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation, common	m^3	56,000	190	40	230	10,640,000	2,240,000	12,880,000	
2. Embankment	"	2,900	400	80	480	1,160,000	232,000	1,392,000	
3. Hauling of excavated material	"	53,100	730	300	1,030	38,763,000	15,930,000	54,693,000	
Sub-total						50,563,000	18,402,000	68,965,000	
4. Reinforced concrete	"	160	6,800	3,100	9,900	1,088,000	496,000	1,584,000	
5. Reinforcing bar	ton	6	152,000	58,000	210,000	912,000	348,000	1,260,000	
6. Wooden form	m^2	210	220	710	930	46,200	149,100	195,300	
Sub-total						2,046,200	993,100	3,039,300	
7. Aerator	set	18	3,800,000	45,000	3,845,000	68,400,000	810,000	69,210,000	
8. Float	"	18	2,900,000	90,000	2,990,000	52,200,000	1,620,000	53,820,000	
9. Chlorinator	"	10	1,300,000	45,000	1,345,000	13,000,000	450,000	13,450,000	
10. Switch board	L.S.					14,850,000	300,000	15,150,000	270kw
Sub-total						148,450,000	3,180,000	151,630,000	

Block-2

(1) Ortuzano Treatment Plant (2/2)

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
11. Sluice gate	set	1.0				145,800	97,200	243,000	0.6mx0.6m
12. Land acquisition	ha	2.6		380,000	380,000		988,000	988,000	
13. Operation cum stock house	m^2	30		40,000	40,000		1,200,000	1,200,000	
14. Wiring	L.S.					800,000	400,000	1,200,000	
Total						202,005,000	25,260,300	227,265,300	
15. Miscellaneous works	%	20				40,401,000	5,052,060	45,453,060	
Grand Total						242,406,000	30,312,360	272,718,360	

Block-2

(2) Rinconada Treatment Plant (1/2)

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation, common	m^3	71,300	190	40	230	13,547,000	2,852,000	16,399,000	
2. Embankment	"	3,700	400	80	480	1,480,000	296,000	1,776,000	
3. Hauling of excavated material	"	67,600	730	300	1,030	49,348,000	20,280,000	69,628,000	
Sub-total						64,375,000	23,428,000	87,803,000	
4. Reinforced concrete	"	290	6,800	3,100	9,900	1,972,000	899,000	2,871,000	
5. Reinforcing bar	ton	12	152,000	58,000	210,000	1,824,000	696,000	2,520,000	
6. *Wooden form*	m^2	*260*	*220*	*710*	*930*	*57,200*	*184,600*	*241,800*	
Sub-total						3,853,200	1,779,600	5,632,800	
7. Aerator	set	24	3,800,000	45,000	3,845,000	91,200,000	1,080,000	92,280,000	
8. Float	"	24	2,900,000	90,000	2,990,000	69,600,000	2,160,000	71,760,000	
9. Chlorinator	"	10	1,300,000	45,000	1,345,000	13,000,000	450,000	13,450,000	
10. Switch board	L.S.					19,800,000	300,000	20,100,000	360kw
11. Sluice gate	set	1				145,800	97,200	243,000	0.6mx0.6m
12. Operation cum stock house	m^2	30		4,000	4,000		1,200,000	1,200,000	

Block-2

(2) Rinconada Treatment Plant (2/2)

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
13. Wiring	L.S.					*800,000*	*400,000*	*1,200,000*	
Sub-total						194,545,800	5,687,200	200,233,000	
14. Land acquisition	ha	3.5		380,000	380,000		1,330,000	1,330,000	
Total						262,774,000	32,224,800	294,998,800	
15. Miscellaneous works	%	20				*52,554,800*	*6,444,960*	*58,999,760*	
Grand Total						315,328,800	38,669,760	353,998,560	

Block-2

(3) Loma Blanca Treatment Plant (1/2)

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation common	m^3	21,000	190	40	230	3,990,000	840,000	4,830,000	
2. Embankment	"	2,100	400	80	480	840,000	168,000	1,008,000	
3. Hauling of excavated material	"	18,900	730	300	1,030	13,797,000	5,670,000	19,467,000	
Sub-total						18,627,000	6,678,000	25,305,000	
4. Reinforced concrete	m^3	100	6,800	3,100	9,900	680,000	310,000	990,000	
5. Reinforcing bar	ton	4	152,000	58,000	210,000	608,000	232,000	840,000	
6. Wooden form	m^2	155	220	710	930	34,100	110,050	144,150	
Sub-total						1,322,100	652,050	1,974,150	
7. Aerator	set	7	3,800,000	45,000	3,845,000	26,600,000	315,000	26,915,000	
8. Float	"	7	2,900,000	90,000	2,990,000	20,300,000	630,000	20,930,000	
9. Chlorinator	"	5	1,300,000	45,000	1,345,000	6,500,000	225,000	6,725,000	
10. Switch board	L.S.					5,775,000	300,000	6,075,000	105 kw
11. Sluice gate	"	1				145,800	97,200	243,000	0.6mx0.6m
12. Operation cum stock house	m^2	30		40,000	40,000		1,200,000	1,200,000	

Block-2

(3) Loma Blanca Treatment Plant (2/2)

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
13. Wiring	L.S.					800,000	400,000	1,200,000	
14. Land acquisition	ha	1.2		380,000	380,000		456,000	456,000	
Sub-total						60,120,800	3,623,200	63,744,000	
Total						80,069,900	10,953,250	91,023,150	
15. Miscellaneous works	%	20				16,013,980	2,190,650	18,204,630	
Grand Total						96,083,880	13,143,900	109,227,780	

Block-2

(4) Encanado Treatment Plant (1/2)

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation, common	m^3	20,300	190	40	230	3,857,000	812,000	4,669,000	
2. Embankment	"	2,000	400	80	480	800,000	160,000	960,000	
3. Hauling of excavated material	"	18,300	730	300	1,030	13,359,000	5,490,000	18,849,000	
Sub-total						18,016,000	6,462,000	24,478,000	
4. Reinforced concrete	"	80	6,800	3,100	9,900	544,000	248,000	793,000	
5. Wooden form	m^2	185	220	710	930	40,700	131,350	172,050	
6. Reinforcing bar	ton	3	152,000	58,000	210,000	456,000	174,000	630,000	
Sub-total						1,040,700	553,350	1,594,050	
7. Aerator	set	7	3,800,000	45,000	3,845,000	26,600,000	315,000	26,915,000	
8. Float	"	7	2,900,000	90,000		20,300,000	630,000	20,930,000	
9. Chlorinator	"	10	1,300,000	45,000	1,345,000	13,000,000	450,000	13,450,000	
10. Switch board	L.S.					5,775,000	300,000	6,075,000	105kw
Sub-total						65,675,000	1,695,000	67,370,000	

Block-2

(4) Encanado Treatment Plant (2/2)

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
11. Sluice gate	set	1				145,800	97,200	243,000	0.6mx0.6m
12. Land acquisition	ha	1.2		380,000	380,000		456,000	456,000	
13. Operation cum stock house	m^2	30		40,000	40,000		1,200,000	1,200,000	
14. Wiring	L.S.					800,000	400,000	1,200,000	
Total						85,677,500	10,863,550	96,541,050	
15. Miscellaneous works	%	20				17,135,500	2,172,710	19,308,210	
Grand Total						102,813,000	13,036,260	115,849,260	

Block-2

(5) Farm Road Bridge (Type-B)

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
Type B	set	2	600,000	330,000	930,000	1,200,000	660,000	1,860,000	
Type C	"	16	340,000	180,000	520,000	5,440,000	2,880,000	8,320,000	
Total						6,640,000	3,540,000	10,180,000	

Block-3 and 4

(1) New Punta Canal (L = 14.7 km)

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation, (common)	m^3	300,000	190	40	230	57,000,000	12,000,000	69,000,000	
2. Hauling of excavated material	"	260,000	1,300	300	1,600	338,000,000	78,000,000	416,000,000	
3. Embankment	"	40,000	400	80	480	16,000,000	3,200,000	19,200,000	
4. Gavion	"	500	680	1,830	2,510	340,000	915,000	1,256,000	
5. Chute									
(1) Excavation	m^3	1,700	190	40	230	323,000	68,000	391,000	
(2) Backfilling	"	740	400	80	480	296,000	59,200	355,200	
(3) Reinforced concrete	"	670	6,800	3,100	9,900	4,556,000	2,077,000	6,633,000	
(4) Reinforcing bar	ton	34	152,000	58,000	210,000	5,168,000	1,972,000	7,140,000	
6. Land acquisition	ha	20		380,000	380,000		7,600,000	7,600,000	
Total						421,683,000	105,891,200	527,574,200	
7. Miscellaneous works	%	20				84,336,000	21,178,240	105,514,840	
Grand Total						506,019,600	127,069,440	633,089,040	

Block-3 and 4

(2) Siphon (Crossing Panamerican Highway, L=70m)

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation	m^3	1,000	500	300	800	500,000	300,000	800,000	
2. Backfilling	"	800	400	80	480	320,000	64,000	384,000	
3. Hauling of excavated material	"	200	1,300	300	1,600	260,000	60,000	320,000	
4. Reinforced concrete	"	700	6,800	3,100	9,900	4,760,000	2,170,000	6,930,000	
5. Reinforcing bar	ton	35	152,000	58,000	210,000	5,320,000	2,030,000	7,350,000	
6. Wooden form	m^2	1,700	220	710	930	374,000	1,207,000	1,581,000	
7. Dewatering	day	150	1,400	1,200	2,600	210,000	180,000	390,000	
Total						11,744,000	6,011,000	17,755,000	
8. Miscellaneous works	%	20				2,348,800	1,202,200	3,551,000	
Grand Total						14,092,800	7,213,200	21,306,000	

Block-3 and 4

(3) Siphon (Crossing railway, L = 40.4m)

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation	m^3	600	500	300	800	300,000	180,000	480,000	
2. Backfilling	"	500	400	80	480	200,000	40,000	240,000	
3. Hauling of excavated material	"	100	1,300	300	1,600	130,000	30,000	160,000	
4. Reinforced concrete	"	400	6,800	3,100	9,900	2,720,000	1,240,000	3,960,000	
5. Reinforcing bar	ton	20	152,000	58,000	210,000	3,040,000	1,160,000	4,200,000	
6. Wooden form	m^2	1,000	220	710	930	220,000	710,000	930,000	
7. Dewatering	day	100	1,400	1,200	2,600	140,000	120,000	260,000	
Total						6,750,000	3,480,000	10,230,000	
8. Miscellaneous works	%	20				1,350,000	686,000	2,046,000	
Grand Total						8,100,000	4,176,000	12,276,000	

Block-3 and 4

(4) Siphon (Mapocho River) (1/2)

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation (gravel)	m^3	4,000	500	300	800	2,000,000	1,200,000	3,200,000	
2. Backfilling	"	2,200	400	80	480	880,000	176,000	1,056,000	
3. Hauling of excavated material	"	1,800	1,300	300	1,600	2,340,000	540,000	2,880,000	
Sub-total						5,220,000	1,916,000	7,136,000	
4. Reinforcing bar	ton	70	152,000	58,000	210,000	10,640,000	4,060,000	14,700,000	
5. Wooden form	m^2	3,700	220	710	930	814,000	2,627,000	3,441,000	
6. Reinforced concrete	m^3	1,200	6,800	3,100	9,900	8,160,000	3,720,000	11,880,000	
Sub-total						19,614,000	10,407,000	30,021,000	
7. Temporary works									
(1) Sheet pile	ton	170	172,000	20,000	192,000	29,240,000	3,400,000	32,640,000	
(2) Driving of sheet pile	m	960	1,600	1,100	2,700	1,536,000	1,056,000	2,592,000	
(3) Withdrawing of sheet pile	m	960	600	400	1,000	576,000	384,000	960,000	
(4) Dewatering	day	350	1,400	1,200	2,600	490,000	420,000	910,000	
Sub-total						31,842,000	5,260,000	37,102,000	

Block-3 and 4

(4) Siphon (Mapocho River) (2/2)

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
8. Sluice gate	set	2	2,500,000	1,800,000	4,300,000	5,000,000	3,600,000	8,600,000	3.8mx4.0m
9. Sluice gate	"	2	*1,300,000*	*800,000*	*2,100,000*	*2,600,000*	*1,600,000*	*4,200,000*	2.3mx3.2m
Sub-total						7,600,000	5,200,000	12,800,000	
10. Miscellaneouce works	%	30				19,282,800	6,834,900	26,177,700	
Grand total						83,558,800	29,617,900	113,176,700	

Block-3 and 4

(5) Improvement of Carmen Type-A

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation (weathered rock)	m^3	30,000	810	1,200		24,300,000	36,000,000	60,300,000	
2. Backfill	"	18,000	400	80	480	7,200,000	1,440,000	8,640,000	
3. Hauling of excavated material	"	12,000	730	180	910	8,760,000	2,160,000	10,920,000	
4. *Lean concrete*	m^3	25,000	6,500	2,900	9,400	162,500,000	72,500,000	235,000,000	
5. Wooden form	m^2	100,000	220	710	930	22,000,000	71,000,000	93,000,000	
6. Reinforcing bar	ton	250	152,000	58,000	210,000	38,000,000	14,500,000	52,500,000	
Total						262,760,000	197,600,000	460,360,000	
7. Miscellaneous works	%	30				78,828,000	59,280,000	138,108,000	
Grand Total						341,588,000	256,880,000	598,468,000	

Block-3 and 4

(6) Improvement of Carmen Type-B

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation (weathered rock)	m^3	22,500	810	1,200	2,010	18,225,000	27,000,000	45,225,000	
2. Back fill	"	11,000	400	80	480	4,400,000	880,000	5,280,000	
3. Hauling of excavated material	"	11,500	730	180	910	8,395,000	2,070,000	10,465,000	
4. Lean concrete	"	22,500	6,500	2,900	9,400	146,250,000	65,250,000	211,500,000	
5. Wooden form	m^2	95,000	220	710	930	20,900,000	67,450,000	88,350,000	
6. Reinforcing bar	ton	225	152,000	58,000	210,000	34,200,000	13,050,000	47,250,000	
Total						232,370,000	175,700,000	408,070,000	
7. Miscellaneous works	%	30				69,711,000	52,710,000	122,421,000	
Grand Total						302,081,000	228,410,000	530,491,000	

Block-3 and 4

(7) Diversion device

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation, (common)	m^3	900	190	40	230	171,000	36,000	207,000	
2. Backfilling	"	350	400	80	480	140,000	28,000	168,000	
3. Hauling of excavated material	"	550	730	180	910	401,500	99,000	500,500	
4. Reinforced concrete	"	150	6,800	3,100	9,900	1,020,000	465,000	1,485,000	
5. Wooden form	m^2	450	220	710	930	99,000	319,500	418,500	
6. Reinforcing bar	ton	6	152,000	58,000	210,000	912,000	348,000	1,260,000	
Total						2,743,500	1,295,500	4,039,000	

Block-3 and 4

(8) Tunnel No. 1

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation (weathered rock)	m^3	2,000	1,500	2,000	3,500	3,000,000	4,000,000	7,000,000	L=630
2. Hauling of excavated material	"	2,000	730	180	910	1,460,000	360,000	1,820,000	
3. Reinforced concrete	"	230	6,800	3,100	9,900	1,564,000	713,000	2,277,000	
4. Wooden form	m^2	370	220	710	930	81,400	262,700	344,100	
5. Reinforcing bar	ton	18	152,000	58,000	210,000	2,736,000	1,044,000	3,780,000	80kg/m^3
Total						8,841,400	6,379,700	15,221,100	
6. Miscellaneous works	%	50				4,420,700	3,189,850	7,610,550	
Grand Total						13,262,100	9,569,550	22,831,650	

Block-3 and 4

(9) Tunnel No. 2, 3, 4 and 5

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation (weathered rock)	m^3	1,300	1,500	2,000	3,500	1,950,000	2,600,000	4,550,000	L=25+132 +15+28 =200
2. Hauling of excavated material	"	1,300	730	180	910	949,000	234,000	1,183,000	
3. Reinforced concrete	"	1,200	6,800	3,100	9,900	8,160,000	3,720,000	11,880,000	
4. Wooden form	m^2	1,800	200	710	910	360,000	1,278,000	1,638,000	
5. Reinforcing bar	ton	90	152,000	58,000	210,000	13,680,000	5,220,000	18,900,000	
Total						25,099,000	13,052,000	38,151,000	
6. Miscellaneous works	%	50				12,549,500	6,526,000	19,075,500	
Grand Total						37,648,500	19,578,000	57,226,500	

Block-3 and 4

(10) Tunnel No. 6,7, and 8

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation (weathered rock)	m^3	2,900	1,500	2,000	3,500	4,350,000	5,800,000	10,150,000	L=510+25 +170
2. Hauling of excavated material	"	2,900	730	180	910	2,117,000	522,000	2,639,000	
3. Reinforced concrete	"	250	6,800	3,100	9,900	1,700,000	775,000	2,475,000	
4. Wooden form	m^2	400	200	710	910	80,000	284,000	364,000	
5. Reinforcing bar	ton	20	152,000	58,000	210,000	3,040,000	1,160,000	4,200,000	
Total						11,287,000	8,541,000	19,828,000	
6. Miscellaneous works	%	50				5,643,500	4,270,500	9,914,000	
Grand Total						16,930,500	12,811,500	29,742,000	

Block-3 and 4

(11) Lampa River Improvement (1)

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation, (gravel)	m^3	629,000	500	100	600	314,500,000	62,900,000	377,400,000	
2. Embankment	"	222,000	400	80	480	88,800,000	17,760,000	106,560,000	
Total						403,300,000	80,660,000	483,960,000	
3. Miscellaneous works	%	12				48,396,000	9,679,200	58,075,200	
Grand Total						451,696,000	90,339,200	542,035,200	

Block-3 and 4

(12) Membrillo Bridge [Lampa River (1)]

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Reinforced concrete	m^3	660	6,800	3,100	9,900	4,488,000	2,046,000	6,534,000	
2. Reinforcing bar	ton	53	152,000	58,000	210,000	8,056,000	3,074,000	11,130,000	
3. Wooden form	m^2	1,010	220	710	930	222,200	717,100	939,300	
4. Demolishing of existing bridge	L.S.						4,500,000	4,500,000	
5. Foundation works	L.S.					3,830,000	3,101,000	6,931,000	
Sub-total						16,596,200	13,438,100	30,034,300	
6. Temporary works	L.S.					8,300,000	6,700,000	15,000,000	
Total						24,896,200	20,138,100	45,034,300	
7. Miscellaneous works	%	20				4,979,240	4,027,620	9,006,860	
Grand Total						29,875,440	24,165,720	54,041,160	

Block-3 and 4

(13) Noviciado Bridge [Lampa River (1)]

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Reinforced concrete	m^3	720	6,800	3,100	9,900	4,896,000	2,232,000	7,128,000	
2. Reinforcing bar	ton	60	152,000	58,000	210,000	9,120,000	3,480,000	12,600,000	
3. Wooden form	m^2	1,150	220	710	930	253,000	816,500	1,069,500	
4. Demolishing of existing bridge	L.S.						5,100,000	5,100,000	
5.Foundation works	L.S.					4,300,000	3,500,000	7,800,000	
Total						18,569,000	15,128,500	33,697,500	
6.Temporary works	L.S.					9,300,000	7,600,000	16,900,000	
Total						27,869,000	22,728,500	50,597,500	
7. Miscellaneous works	%	20				5,573,800	4,545,700	10,119,500	
Grand Total						33,442,800	27,274,200	60,717,000	

Block-3 and 4

(14) Bora Bridge [Lampa River (1)]

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Reinforced concrete	m^3	550	6,800	3,100	9,900	3,740,000	1,705,000	5,445,000	
2. Reinforcing bar	m^3	44	152,000	58,000	210,000	6,688,000	2,552,000	9,240,000	
3. Wooden form	m^2	870	220	710	930	191,400	617,700	809,100	
4. Demolishing of existing bridge	L.S.						4,200,000	4,200,000	
5.Foundation works	L.S.					3,200,000	2,700,000	5,900,000	
Sub-total						13,819,400	11,774,700	25,594,100	
6. Temporary works	L.S.					6,900,000	5,900,000	12,800,000	
Total						20,719,400	17,674,700	38,394,100	
7. Miscellaneous works	%	20				4,143,880	3,534,940	7,678,820	
Grand Total						24,863,280	21,209,640	46,072,920	

Block-3 and 4

(15) Lampa River Improvement (2) and (3)

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation, gravel [Lampa(2)]	m^3	888,200	500	100	600	444,100,000	88,820,000	532,920,000	
2. Embankment	m^3	226,500	400	80	480	90,600,000	18,120,000	108,720,000	
3. Excavation gravel [Lampa(3)]	"	332,200	500	100	600	166,100,000	33,220,000	199,320,000	
4. Embankment	"	472,800	400	80	480	189,120,000	37,824,000	226,944,000	
Total						889,920,000	177,984,000	1,067,904,000	
5, Miscellaneous works	%	12				106,790,400	21,358,080	128,148,480	
Grand Total						996,710,400	199,342,080	1,196,052,480	

Block-3 and 4

(16) Colina River Improvement (1)

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation, (gravel)	m^3	348,200	500	100	600	174,100,000	34,820,000	208,920,000	
Total						174,100,000	34,820,000	208,920,000	
2. Miscellaneous works	%	12				20,892,000	4,178,400	25,070,400	
Grand Total						194,992,000	38,998,400	233,990,400	

Block-3 and 4

(17) Casique Bridge [Colina River (1)]

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Reinforced concrete	m^3	450	6,800	3,100	9,900	3,060,000	1,395,000	4,455,000	
2. Reinforcing bar	ton	36	152,000	58,000	210,000	5,472,000	2,088,000	7,560,000	
3. Wooden form	m^2	670	220	710	930	147,400	475,700	623,100	
4. Demolishing of existing bridge	L.S.						2,300,000	2,300,000	
5. Foundation works	L.S.					2,600,000	1,900,000	4,500,000	
Sub-total						11,279,400	8,158,700	19,438,100	
6. Temporary works	L.S.					5,600,000	4,100,000	9,700,000	
Total						16,879,400	12,258,700	29,138,100	
7. Miscellaneous wprks	%	20				3,375,880	2,451,740	5,827,620	
Grand Total						20,255,280	14,710,440	34,965,720	

Block-3 and 4

(18) Primavera Bridge [Colina river (1)]

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Reinforced concrete	m^3	450	6,800	3,100	9,900	3,060,000	1,395,000	4,455,000	
2. Reinforcing bar	ton	36	152,000	58,000	210,000	5,472,000	2,088,000	7,560,000	
3. Wooden form	m^2	670	220	710	930	147,400	475,700	623,100	
4. Demolishing of existing bridge	L.S.						2,500,000	2,500,000	
5. Foundation works	L.S.					2,600,000	1,900,000	4,500,000	
Sub-total						11,279,400	8,358,700	19,638,100	
6. Temporary works	L.S.					5,600,000	4,200,000	9,800,000	
Total						16,879,400	12,558,700	29,438,100	
7. Miscellaneous works	%	20				3,375,880	2,511,740	5,887,620	
Grand Total						20,255,280	15,070,440	35,325,720	

Block-3 and 4

(19) Improvement of Los Choros Type-A

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation (common)	m^3	24,000	190	40	230	4,560,000	960,000	5,520,000	
2. Hauling of excavated material	"	24,000	1,300	300	1,600	31,200,000	7,200,000	38,400,000	
Total						35,760,000	8,160,000	43,920,000	
3.Miscellaneous works	%	10				3,576,000	816,000	4,392,000	
Grand Total						39,336,000	8,976,000	48,312,000	

Block-3 and 4

(20) Improvement of Los Choros Type-B

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation, (common)	m^3	27,000	190	40	230	5,130,000	1,080,000	6,210,000	
2. Hauling of excavated material	"	27,000	1,300	300	1,600	35,100,000	8,100,000	43,200,000	
Total						40,230,000	9,180,000	49,410,000	
3. Miscellaneous works	%	10				4,023,000	918,000	4,941,000	
Grand Total						44,253,000	10,098,000	54,351,000	

Block-3 and 4

(21) Improvement of Los Choros Type-C

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation (common)	m^3	22,000	190	40	230	4,180,000	880,000	5,060,000	
2. Hauling of excavated material	"	22,000	1,300	300	1,600	28,600,000	6,600,000	35,200,000	
Total						32,780,000	7,480,000	40,260,000	
3. Miscellaneous works	%	10				3,278,000	748,000	4,026,000	
Grand Total						36,058,000	8,228,000	44,286,000	

Block-3 and 4

(22) Improvement of Caren River Type-A

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation, (common)	m3	11,000	190	40	230	2,090,000	440,000	2,530,000	L=4,800m
2. Hauling of excavated material	"	11,000	1,300	300	1,600	14,300,000	3,300,000	17,600,000	
Total						16,390,000	3,740,000	20,130,000	
3. Miscellaneous works	%	10				1,639,000	374,000	2,013,000	
Grand Total						18,029,000	4,114,000	22,143,000	

Block-3 and 4

(23) Improvement of Caren River Type-B

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation (common)	m3	20,000	190	40	230	3,800,000	800,000	4,600,000	
2. Hauling of excavated material	"	20,000	1,300	300	1,600	26,000,000	6,000,000	32,000,000	
Total						29,800,000	6,800,000	36,600,000	
3. Miscellaneous works	%	10				2,980,000	680,000	3,660,000	
Grand Total						32,780,000	7,480,000	40,260,000	

Block-3 and 4

(24) Construction of Drainage Canal C-1

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation (hard)	m^3	205,000	810	1,200	2,010	166,050,000	246,000,000	412,050,000	
2. Hauling of excavated material	"	205,000	1,300	300	1,600	266,500,000	61,500,000	328,000,000	
3. Land acquisition	ha	7		380,000	380,000		2,660,000	2,660,000	
Total						432,550,000	310,160,000	742,710,000	
4. Miscellaneous works	%	10				43,255,000	31,016,000	74,271,000	
Grand Total						475,805,000	341,176,000	816,981,000	

Block-3 and 4

(25) Construction of Drainage Canal C-2

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation (hard)	m^3	306,000	810	1,200	2,010	247,860,000	367,200,000	615,060,000	
2. Hauling of excavated material	"	306,000	1,300	300	1,600	397,800,000	91,800,000	489,600,000	
3. Land acquisition	ha	25		380,000	380,000		9,500,000	9,500,000	
Total						645,660,000	468,500,000	1,114,160,000	
4. Miscellaneous works	%	10				64,566,000	46,850,000	111,416,000	
Grand Total						710,226,000	515,350,000	1,225,576,000	

Block-3 and 4

(26) Farm Road (Type A) (L=17.3km)

(Unit : Ch$)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Gravel	m^3	20,800	500	1,500	2,000	10,400,000	31,200,000	41,600,000	t=20cm
2. Embankment	"	84,900	1,200	300	1,500	101,880,000	25,470,000	127,350,000	
3. Land acquisition	ha			380,000	380,000		9,120,000	9,120,000	
Total						112,280,000	65,790,000	178,070,000	
4. Miscellaneous works	%	10				11,228,000	6,579,000	17,807,000	
Grand Total						123,508,000	72,369,000	195,877,000	

Block-3 and 4

(27) Farm Road (Type B) (L = 34.7 km)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Gravel	m^3	20,800	1,200	260	1,460	24,960,000	5,408,000	30,368,000	t=20cm
2. Embankment	"	79,500	1,200	300	1,500	95,400,000	23,850,000	119,250,000	
3. Land acquisition	ha	31		380,000	380,000		11,780,000	11,780,000	
Total						120,360,000	41,038,000	161,398,000	
4. Miscellaneous works	%	10				12,036,000	4,103,800	16,139,800	
Grand Total						132,396,000	45,141,800	177,537,800	

Block-3 and 4

(28) Farm Road Bridge

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Farm Road Bridge Type-A	Unit	1	1,800,000	900,000	2,700,000	1,800,000	900,000	2,700,000	
Type-B	"	7	600,000	330,000	930,000	4,200,000	2,310,000	6,510,000	
Type-C	"	28	340,000	180,000	520,000	9,520,000	5,040,000	14,560,000	
Total						15,520,000	8,250,000	23,770,000	

Block-3 and 4

(29) San Carlos Canal (Type-I) (1/2)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation, common	m^3	119,000	190	40	230	22,610,000	4,760,000	27,370,000	
2. Backfilling	"	83,000	400	80	480	33,200,000	6,640,000	39,840,000	
3. Hauling of excavated material	"	36,000	1,300	300	1,600	46,800,000	10,800,000	57,600,000	
Sub-total						102,610,000	22,200,000	124,810,000	
4. Lean Concrete	m^3	12,000	6,500	2,900	9,400	78,000,000	34,800,000	112,800,000	
5. Reinforced concrete	"	48,800	6,800	3,100	9,900	331,840,000	151,280,000	483,120,000	
6. Wooden form	m^2	134,000	220	710	930	29,480,000	95,140,000	124,620,000	
7. Reinforcing bar	ton	2,400	152,000	58,000	210,000	364,800,000	139,200,000	504,000,000	
Sub-total						804,120,000	420,420,000	1,224,540,000	
8. Temporary work									
(1) Purchase of sheet pile	ton	1,000	172,000	20,000	192,000	172,000,000	20,000,000	192,000,000	
(2) Driving of sheet pile	m	75,000	1,600	1,100	2,700	120,000,000	82,500,000	202,500,000	
(3) Withdrawing of sheet pile	m	75,000	600	400	1,000	45,000,000	30,000,000	75,000,000	
(4) Dewatering	days	550	1,400	1,200	2,600	770,000	660,000	1,430,000	
Sub-total						337,770,000	133,160,000	470,930,000	
Total						1,244,500,000	575,780,000	1,820,280,000	

Block-3 and 4

(29) San Carlos Canal (Type-I) (2/2)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
9. Miscellaneous works	%	20				248,900,000	115,156,000	364,056,000	
Grand Total						1,493,400,000	690,936,000	2,184,336,000	

Block-3 and 4

(30) San Carlos Canal (Type-II) (1/2)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation, common	m^3	50,000	190	40	230	9,500,000	2,000,000	11,500,000	
2. Backfilling	"	35,000	400	80	480	14,000,000	2,800,000	16,800,000	
3. Hauling of excavated material	"	15,000	1,300	300	1,600	19,500,000	4,500,000	24,000,000	
Sub-total						43,000,000	9,300,000	52,300,000	
4. Lean concrete	m^3	4,600	6,500	2,900	9,400	29,900,000	13,340,000	43,240,000	
5. Reinforced concrete	"	19,000	6,800	3,100	9,900	129,200,000	58,900,000	188,100,000	
6. Wooden form	m^2	52,000	220	710	930	11,440,000	36,920,000	48,360,000	
7. Reinforcing bar	ton	940	152,000	58,000	210,000	142,880,000	54,520,000	197,400,000	
Sub-total						313,420,000	163,680,000	477,100,000	
8. Temporary work									
(1) Purchase of sheet pile	ton	350	172,000	20,000	192,000	60,200,000	7,000,000	67,200,000	
(2) Driving of sheet pile	m	25,500	1,600	1,100	2,700	40,800,000	28,050,000	68,850,000	
(3) Withdrawing of sheet pile	"	25,500	600	400	1,000	15,300,000	10,200,000	25,500,000	
(4) Dewatering	days	540	1,400	1,200	2,600	756,000	648,000	1,404,000	
Sub-total						117,056,000	45,898,000	162,954,000	
Total						473,476,000	218,878,000	692,354,000	

Block-3 and 4

(30) San Carlos Canal (Type-II) (2/2)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
9. Miscellaneous works	%	20				94,695,200	43,775,600	138,470,800	
Grand Total						568,171,200	262,653,600	830,824,800	

Block-3 and 4

(31) San Carlos Canal (Type-III) (1/2)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation, common	m^3	75,000	190	40	230	14,250,000	3,000,000	17,250,000	
2. Backfilling	"	52,000	400	80	480	20,800,000	4,160,000	24,960.000	
3. Hauling of excavated material	"	23,000	1,300	300	1,600	29,900,000	6,900,000	36,800,000	
Sub-total						64,950,000	14,060,000	79,010,000	
4. Lean concrete	m^3	5,100	6,500	2,900	9,400	33,150,000	14,790,000	47,940,000	
5. Reinforced concrete	"	23,000	6,800	3,100	9,900	156,400,000	71,300,000	227,700,000	
6. Reinforcing bar	ton	1,100	152,000	58,000	210,000	167,200,000	63,800,000	231,000,000	
7. Wooden form	m^3	70,000	220	710	930	15,400,000	49,700,000	65,100 000	
Sub-total						372,150,000	199,590,000	571,740,000	
8. Temporary work									
(1) Purchase of sheet pile	ton	360	172,000	20,000	192,000	61,920,000	7,200,000	69,120,000	
(2) Driving of sheet pile	m	27,000	1,600	1,100	2,700	43,200,000	29,700,000	72,900,000	
(3) Withdrawing of sheet pile	"	27,000	600	400	1,000	16,200,000	10,800,000	27,000,000	
(4) Dewatering	days	540	1,400	1,200	2,600	756,000	648,000	1,404,000	
Sub-total						122,076,000	48,348,000	170,424,000	
Total						559,176,000	261,998,000	821,174,000	

Block-3 and 4

(31) San Carlos Canal (Type-III) (2/2)

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
9. Miscellaneous works	%	20				111,835,200	52,399,600	164,234,800	
Grand Total						671,011,200	314,397,600	935,408,800	

Block-3 and 4

(32) Sabo Dam

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation (rock)	m^3	4,600	1,300	1,200	2,500	5,980,000	5,520,000	11,500,000	
2 Excavation (gravel)	"	2,500	500	90	590	1,250,000	225,000	1,475,000	
3. Backfilling	"	1,000	400	80	480	400,000	80,000	480,000	
4. Plain concrete	"	15,300	6,500	2,900		99,450,000	44,370,000	143,820,000	
5. Hauling of excavated material	"	6,100	1,300	300	1,600	7,930,000	1,830,000	9,760,000	
6. Concrete pipe	m	150	2,000	200	2,200	300,000	30,000	330,000	ø900
7. Temporary works									
(1) Excavation (rock)	m^3	2,730	1,300	1,200	2,500	3,549,000	3,276,000	6,825,000	
(2) Excavation (common)	"	800	190	40	230	152,000	32,000	184,000	
(3) Plain concrete	"	1,220	6,500	2,900	9,400	7,930,000	3,538,000	11,468,000	
(4) Gate		L.S.				800,000	500,000	1,300,000	
(5) Coffer Dam		L.S.				4,000,000	6,000,000	10,000,000	
(6) Compensation		L.S.					15,000,000	15,000,000	
Sub-total						131,741,000	80,401,000	212,142,000	
8.Miscellaneous works	%	20				26,348,200	16,080,200	42,428,400	
Grand Total						158,089,200	96,481,200	254,570,400	

Block-3 and 4

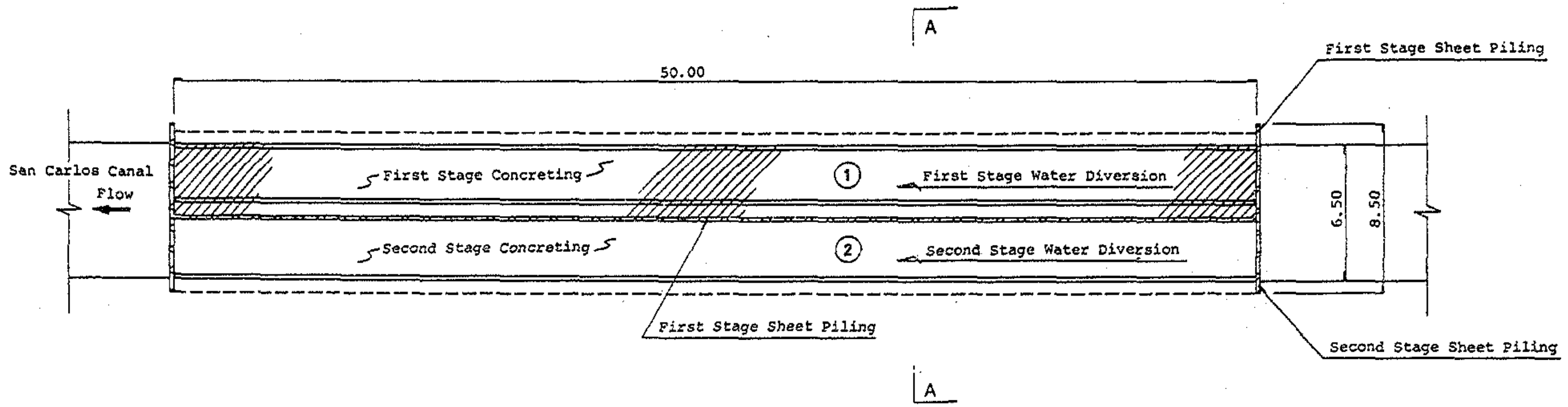
(33) Temporary Mapocho River Improvement

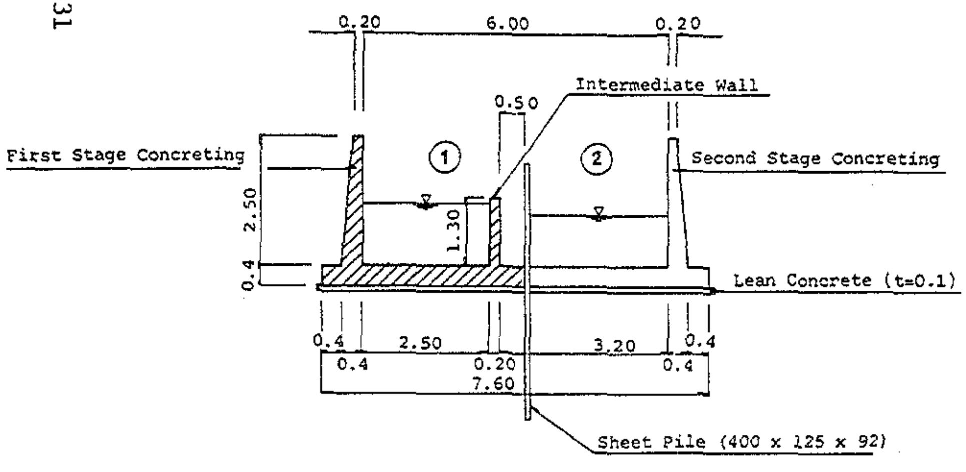
Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Embankment	m^3	14,000	1,130	260	1,390	15,820,000	3,640,000	19,460,000	
2. Miscellaneous works	%	10				1,582,000	364,000	1,946,000	
Grand Total						17,402,000	4,004,000	21,406,000	

Block-3 and 4

(34) Tertiary Irrigation Canal

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Excavation and Surfacing	m^3	62,000				500	31,000,000	31,000,000	
2. Miscellaneous works	%	10					3,100,000	3,100,000	
Grand Total							34,100,000	34,100,000	





SECTION A-A

Explanation

1. First stage sheet piling shall be done as shown in the Plan.
2. After the *first sheet piling, discharge of* Q = 7.0m^3/sec shall be carried through section 2.
3. First stage concreting shall be done as shown in Section A-A.
4. Sheet pile shall be extracted after first concreting.
5. Second stage sheet piling shall be done.
6. The discharge of Q = 7.0m^3/sec shall be carried through section 1.
7. Then, second stage concreting shall be carried out.
8. Center wall shall be *remained* as it is ever after whole concreting is finished for the convenience of maintenance of finished canal.
9. The working pattern explained in the above shall be followed repeatedly to the whole length of the canal.

Proposed Construction Method of San Carlos Canal