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TECNOLOGIA APROPIADA PARA EL TRATAMIENTO DE AGUA Y AGUAS RESIDUALES

Del 11 al 15 de Agosto 1980.

HORA	LUNES	MARTES	MIERCOLES	JUEVES	VIERNES
9:00 a 11:00	Inauguración Transferencia de Tecnología. Tecnología Apropiada. Dr.George W. Reid	Relaciones Cliente-Donador. Problemas Oportunidades. Dr.George W. Reid Tratamiento de Agua. Objetivos. Clasificación Dr. George W. Reid	Tratamiento de Aguas Negras. Procesos. Sistemas. Dr.Joseph F. Malina	Experiencia Histórica. Aceptación del Consumidor Dr.George W. Reid	Tratamiento in-situ. Irrigación. Acuacultivos. Dr.George W. Reid
11:00 a 11:30	C A F E				
11:30 a 13:00	Modelo Predictivo. Tecnología Apropiada. Dr. George W. Reid	Tratamiento de Aguas Negras. Objetivos. Clasificación Dr.George W. Reid	Tratamientos de Aguas Negras. Costos De Equipo Detalles Dr. Joseph F. Malina	Modelo Predictivo Ejemplo de Cálculo Dr.George W. Reid	Caso Histórico Dr. George W. Reid
13:00 a 14:30	C O M I D A				
14:30 a 16:00	Problemática de la Ingeniería Sanitaria en México Dr.Ubaldo Bonilla D	Tratamiento de Aguas. Procesos. Sistemas. Operación Ing.Arnulfo Paz S.	Procesos Indígenas de Tratamiento de Agua y Aguas Negras Dr. George W. Reid	Experiencia Mexicana en Tratamiento de Agua Ing. Valentín Pérez	Aplicación del Modelo a un caso en la República Mexicana Dr. Raúl Cuellar Ch.
16:00 a 16:30	C A F E				
16:30 a 18:00	Modelo de Prioridades Dr.Ubaldo Bonilla D.	Tratamiento de Aguas. Costos de Equipo. Detalles Ing.Arnulfo Paz S.	Programas y Modelos. Aspectos Económicos. Manejo. Sensibilidad Dr.George W. Reid	Experiencia Mexicana en Tratamiento de Aguas Negras Dr. Raúl Cuellar Ch.	Clausura

TECNOLOGIA APROPIADA PARA EL TRATAMIENTO DE AGUA Y AGUAS RESIDUALES

PROBLEMATICA DE LA INGENIERIA SANITARIA EN LA REPUBLICA MEXICANA

DR. UBALDO BONILLA DOMINGUEZ

AGOSTO, 1980

PROBLEMATICA DE LA INGENIERIA SANITARIA EN LA REPUBLICA MEXICANA

Ubaldo Bonilla Domínguez *

agosto 1980

* Secretario Académico de la División de Estudios de Posgrado de la Facultad de Ingeniería

C O N T E N I D O

PROBLEMATICA DE LA INGENIERIA SANITARIA EN LA REPUBLICA MEXICANA

1. Ingeniería Ambiental y Sociedad

Las obras de ingeniería ambiental ejercen una influencia positiva en el nivel social del individuo y las agrupaciones humanas: contribuyen al binestar, dignifican su existencia, elevan el nivel y calidad de vida, y significan una etapa de superación en el desarrollo de las actividades.

Desde el punto de vista económico, incrementan el períodc productivo de los individuos al reducir las tasas de morbilidad y mortalidad y, como en el caso del abastecimiento de agua potable, representan el suministro de una materia prima para numerosos procesos industriales.

Los objetivos fundamentales de las sociedades primitivas son la procuración de alimentos y techo y la satisfacción de la función sexual, mientras que en las sociedades desarrolladas se busca además, permanentemente, el logro de una mejor calidad de vida, para lo cual la conservación y mejoramiento del medio ambiente es condición indispensable. Resulta pues, evidente, que existe una relación determinante entre el grado de desarrollo de una sociedad y los objetivos que esta se fije en cuanto a la calidad del ambiente en que viva. El apoyo de una sociedad a los programas dirigidos al control de la calidad del ambiente, serán aceptados por ésta en el grado en que estén de acuerdo con su estado de desarrollo.

Los países en desarrollo, como es el caso de México, presentan notables diferencias entre los medios rural y urbano, tanto por lo que se refiere a la capacidad económica de la población como a la disponibilidad de bienes y servicios, nivel cultural, etc. Mientras en el medio rural los más graves problemas se refieren a carencias de habitación adecuada, abastecimiento de agua potable, sistemas de alcantarillado, etc., en el medio urbano, además de ciertas carencias en los barrios desfavorecidos se sienten, y a veces llegan a niveles peligrosos, problemas propios de los países industrializados, tales como la contaminación atmosférica, el ruido, etc.

Mientras en ciertas áreas rurales muchos recursos naturales permanecen inexplotados, en algunas áreas industriales urbanas los recursos se han sobreexplotado o sus fuentes degradado a tal punto por la actividad humana, que resultan inadecuadas para algunos usos; tal es el caso de algunos de nuestras corrientes, cuyas aguas no pueden ser ya usadas con fines de piscicultura. También, muchas áreas de cultivo se han perdido debido a su explotación irracional con métodos arcaicos y al uso de aguas inadecuadas para el riego.

El problema de la conservación del medio en los países en desarrollo presenta una aparente paradoja: o estos países continuan su proceso de industrialización a bajo costo desentendiéndose de los costos de conservación del ambiente, para poder competir con sus productos en los mercados nacionales e internacionales tratando de elevar así el ingreso per-capita de sus habitanes, o se resignan a continuar siendo colonias económicas, escencialmente de estructura agrícola primitiva. Obviamente, la solución a tal paradoja es una planeación adecuada tanto de la explotación de los recursos como de la conservación del ambiente, de acuerdo tanto con el grado de desarrollo del país como con sus objetivos de desarrollo posterior.

La importancia relativa de cada uno de los múltiples problemas de los países en desarrollo: la insalubridad, la desnutrición, la incultura, la pobreza, etc., que se interrelacionan entre sí, es díficil de establecer, pero resulta obvio que para su resolución se requiere un enfoque simultáneo y armónico que los considere como un todo. De igual manera, resultaría ilógico jerarquizar los problemas de insalubridad, tanto del individuo como del ambiente, y dirigir los recursos económicos a la resolución de alguna de los componentes. Sin embargo, para el conocimiento de estos problemas y la planeación de su resolución integral, es muy conveniente recurrir a los indicadores que representan su nivel de gravedad.

2. Algunos Indicadores del Problema Sanitario en la República Méxicana

Según datos correspondientes al año de 1973, proporcionados por la Secretaría de Salubridad y Asistencia, la tasa de mortalidad general en el país fué de 840/100 000; la primera causa de mortalidad fué la debida a neumonías, influenza y otras infecciones respiratorias agudas, 141.1/100 000; y la segunda a enteritis y otras enfermedades diarreícas, 107.0/100 000.

Estas dos causas de mortalidad, asociadas indudablemente con la insalubridad del ambiente, representaron casi el 30% de la mortalidad en ese año en el país. En cuanto a la morbilidad por todas las causas, la tasa en 1972 fue de 1405.8/100 000; la primera causa de morbilidad correspondió a parasitosis intestinales no especificadas, 585.8/100 000, la segunda a influenza, 166.1/100 000 y la tercera a amibiasis 104.9/100000.

Obsérvese que tan solo la parasitosis, enfermedades relacionadas con la escasez, contaminación del agua, y la deficiente disposición de los excreta, representaron más del 40% de los casos de enfermedad en la República.

Desafortunadamente, las tasas de morbilidad de estas enfermedades muestran tendencia creciente, por ejemplo, la tasa para diarreas fue de 314.0/100 000 en 1967 y de 454.0/100 000 en 1972.

En el año de 1975, la población de la República Mexicana era de 58 210 000 habitantes, de los cuales 36 664 000 correspondían a la población urbana, 62.8%, y 21 546 000 a la población rural. Según datos proporcionados por la Oficina Sanitaria Panamericana, solamente 24 962 000 habitantes urbanos contaban con conexión intradomiciliaria de agua potable y 775000 tenían acceso a surtidores públicos, cuya suma representa el 70% de la población urbana, servida en tal fecha. Por lo que respecta a la población rural, 10 497 000 habitantes, 49%, estaba conectada o tenía facilidades de acceso a servicios de agua potable.

En relación con la eliminación de excreta, la situación era aún más adversa. Solamente el 28.8% de la población urbana estaba conectada a servicios de alcantarillado, y apenas el 14% de la rural contaba con instalaciones de letrinas o fosas sépticas.

Debido a que los datos levantados en el censo de 1980 no han sido aún procesados, no es posible determinar la situación actual del país en materia sanitaria; sin embargo, debido al crecimiento de la población y al colapso económico de 1976, es evidente que no han habido progresos substanciales.

Según el documento oficial No. 118 de la Oficina Sanitaria Panamericana, "Los Ministerios de la Salud, así como otros ministerios interesados en el desarrollo económico y los organismos internacionales que conceden préstamos, han otorgado urgente prioiridad a la meta de la Carta de Punta del Este referente al abastecimiento de agua al 70% de la población urbana y al 50% de la población rural durante el presente decenio, como mínimo" (se refiere al decenio que terminó en 1970). Por lo que puede observarse de los datos anteriores, para nuestro país no fué posible satisfacer la meta establecida para el medio rural. No cabe duda de que el notable contraste en la disponibilidad de servicios sanitarios, en los medios urbano y rural, ha favorecido la afluencia de campesinos hacia las ciudades, con lo que se ha entorpecido el desarrollo armónico del país.

El fracaso en la consecución de los objetivos establecidos para América Latina en Punta del Este y en otras reuniones similares para otras regiones, ha llevado a los organismos internacionales a pugnar por una mayor coordinación entre países, organismos internacionales, etc, para resolver este tipo de problemas. Como consecuencia, en la reunión internacional de 1977 en Mar de Plata, Argentina, se recomendó designar al período 1981-1990 como Decenio Internacional del Abastecimiento de Agua y del Saneamiento, lo cual fué aceptado por la Organización de las Naciones Unidas. Es de esperarse que, debido a los compromisos contraidos por nuestro país a este respecto, en el futuro será dedicada mayor atención a estos problemas.

Si bien los prolemas enumerados pueden causar alarma, esto no significa en manera alguna que las autoridades respectivas no hayan actuado y actuen para resolverlos. Baste señalar que en el año de 1910 la esperanza de vida en nuestro país era de 28 años, contra 65 años en 1975, según lo expuesto por el Subsecretario de Mejoramiento del Ambiente en la IV Reunión Nacional de Salud Pública.

En cuanto al estado de los cuerpos de agua del país, según datos publicados por la Secretaría de Agricultura y Recursos Hidráulicos en 1977, existen en la República Mexicana 320 cuencas hidrológicas. A 11 de ellas corresponden el 59 porciento de la población, el 52 porciento de la superficie de riego, el 77 por ciento del valor bruto de la producción industrial, y el 59 porciento de la carga orgánica producida; estas cuencas requieren acciones inmediatas de saneamiento. A otras 43 corresponden el 22 porciento de la población, el 45 porciento de la superficie de riego el 9 porciento del valor bruto de la producción industrial y el 41 porciento de la carga orgánica producida; estas cuencas sufrirán, hacia 1983, niveles inaceptados de contaminación para los usos actuales. El resto de las cuencas no presenta niveles de contaminación significativos.

3. Recursos Humanos

Se estima que número de ingenieros mexicanos que han cursado estudios de posgrado en ingeniería sanitaria es de unos cuatrocientos. Esta cifra es aún muy baja, si se considera la tasa establecida por la Oficina Sanitaria Panamericana (1 ingeniero sanitario/50000 habitantes) y la población del país (aproximadamente 68 x 10^6 habitantes), según lo cual se requerirían unos 1350.. Sin embargo, desde el año de 1951, en que se estableció la maestría en esta rama de la ingeniería en la Universidad Nacional Autónoma de México, la producción de ingenieros sanitarios ha aumentado progresivamente, gracias además a la fundación de esta maestría en instituciones del interior del país (Universidad Autónoma de Nuevo León, Instituto Tecnológico de Monterrey y Universidad de Yucatán); se espera, por tanto, que hacia el año de 1995 el número de ingenieros sanitarios en existencia para entonces podrá satisfacer a una población estimada en poco más de 100 x 10^6 habitantes.

Mientras tanto, resulta obvio que el déficit de ingenieros sanitarios deba ser cubierto por ingenieros civiles y otros profesionales que, mediante cursos intensivos de actualización y entrenamiento se preparen para trabajar en aspectos específicos de la ingeniería sanitaria. Existen en nuestro país diversos programas institucionales de este tipo, tanto en Secretarías de Estado (Agricultura y Recursos Hidráulicos, Asentamientos Humanos y Obras Públicas) como en la Universidad Nacional Autónoma de México.

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PROBLEMATICA DE INGENIERIA SANITARIA
EN EL DISTRITO FEDERAL Y AREA URBANA
DE LA CIUDAD DE MEXICO

Ubaldo Bonilla Domínguez *

agosto 1980

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C O N T E N I D O

1. INTRODUCCION

1.1 Concentración Industrial y de Población

El desarrollo tecnológico, iniciado en Inglaterra en el siglo XVIII con la invención de la máquina de vapor, aunado a otros factores, ha traido como consecuencia la tendencia de la población a concentrarse en grandes ciudades. Se estima que en el año de 1960 el 33 por ciento de la población mundial vivía en zonas urbanas, y que para el año de 1990 esta cifra crecerá hasta el 50 por ciento.

Por otro lado, los rápidos avances de la medicina y del saneamiento ambiental han reducido las tasas de mortalidad y aumentado las expectancias de vida, lo que unido a la elevada fecundidad ha determinado el crecimiento acelerado de la población mundial observado en las últimas décadas

Se estima que la población humana, en 1972 era de más de --- 3 mil millones de habitantes, será de unos 6 mil millones hacia el año 2000.

Por lo que respecta a la República Mexicana, la tasa de crecimiento medio anual se ha venido incrementando aceleradamente, pues en tanto que en el periodo de 1930-1940 fue de 1.7 por ciento en la década de 1960 a 1970 fue del 3.4 por ciento. La población, que en 1930 era de 16.5 millones de habitantes sobrepasó los 50 millones en 1970 y casi llegó a los 70 millones en 1980, de tal manera que, de continuar el ritmo acelerado de crecimiento, la población del país llegará a los 100 millones de habitantes hacia el año de 1990.

Simultáneamente al crecimiento de la población global del país, en la República Mexicana se ha observado una muy alta tendencia a la concentración en ciudades que actuan como polos de atracción, principalmente en México, Guadalajara y Monterrey, y en menor grado en Juárez, Puebla, León, Tijuana, Mexicali y Chihuahua. El área urbana de la ciudad de México, que en el año de 1930 tenía una población de 1 millon 701 mil habitantes, se ha convertido en una de los núcleos más populosos del mundo; en 1972 ocupó el séptimo lugar por este concepto con una población de 9 millones de habitantes, mientras que en 1980 ocupa el tercer lugar, con una población estimada en cerca de 15 millones de habitantes. En el año de 1950 la población urbana del país era del 42% y hacía 1970 llegó al 60 por ciento, observándose un ritmo ascendente en la tendencia a la concentración. Actualmente tan solo la población del Distrito Federal sobrepasa los 9 millones de habitantes.

Paralelamente al crecimiento de la población,en los núcleos urbanos se ha observado una muy alta tendencia a la concentración industrial. En el año de 1960 se localizaba en la zona urbana del Valle de México el 46.9 por ciento de la industria nacional, en 1955 el 48 por ciento, y en 1969 el 55 por ciento. No obstante los esfuerzos del gobierno para controlar esta situación, este fenómeno continua observándose.

1.2 Problemas de Ingeniería Ambiental

Junto a las inegables ventajas que el desarrollo industrial y la concentración de la población en los núcleos urbanos han reportado a la humanidad, han surgido múltiples problemas de tipo sanitario como son los relativos al abastecimiento y control de la calidad del agua, transporte y disposición de desechos líquidos y sólidos, habitación y urbanismo, y contaminación atmosférica. La resolución de estos problemas no es fácil; se trata de problemas dinámicos que crecen paralelamente al desarrollo de las grandes ciudades y que, aun en los países más ricos, se encuentran siempre presentes en mayor o menor grado. Por otro lado, la faceta sanitaria es solo una parte del problema, tal vez la que puede ser más fácilmente evaluada, pero desde luego existen también implicaciones de orden social que escapan a toda valoración econó-

En nuestro país, la manifestación de los problemas anteriores es más notable en el área urbana de la ciudad de México, y alcanza ya cierta relevancia en las ciudades de Guadalajara y Monterrey.

Ante los enormes costos que resultan de la satisfacción de las necesidades vitales en las grandes conglomeraciones humanas, y las múltiples dificultades económicas y técnicas que presentan para resolver los problemas de contaminación del ambiente generados dentro de ellas mismas, parece evidente que la solución inmediata más adecuada consiste en la creación, debidamente planeada, de nuevas ciudades industriales que descongestionen la actividad de los grandes núcleos existentes y en estos, la aplicación de medidas correctivas de acción inmediata, que no interfieran con el proceso de desarrollo económico, y permitan la obtención de metas de mejoramiento en la calidad del medio ambiente.

Se considera que, sin restar importancia a otros problemas de ingeniería ambiental, los problemas relativos al abastecimiento de agua potable al área urbana de la ciudad y el aprovechamiento de las aguas pluviales y negras del Valle de México, demandan especial atención, dada su peculiar situación geohidrográfica, ya que se encuentra alejado de los principales recursos hidráulicos del país, en un valle naturalmente cerrado.

2. EL AREA URBANA DE LA CIUDAD DE MEXICO

La ciudad de México está localizada en la esquina suroeste del Valle del mismo nombre, que ocupa el borde sur de la mesa central. El meridiano 99°8' W y el paralelo 19°24' N cruzan la ciudad, que tiene una altitud media de 2240 msnm.

El área urbana de la ciudad de México inlcuye a la ciudad de México, dividida en 16 delegaciones, así como a la parte urbanizada de los municipios de Ecatepec, Morelos, Naucalpan de Juárez, Tlalnepantla y Netzahualcoyotl del Estado de Mexico.

La zona así integrada constituye el principal complejo urbano-industrial del país y en especial de la cuenca del Valle de México. La ciudad de México es además el asiento de los gobiernos del país y del Distrito Federal.

Por lo que toca a la expansión del área urbana, se ha observado que la población de la ciudad de México ha crecido con tasas inferiores a las del Distrito Federal, de donde se infiere que la población se va desplazando hacia la periferia, haciendo crecer al área urbana.

El crecimiento de la superficie del área urbana ha sido paralelo al crecimiento de la población; en el año de 193(la superficie cubierta era de 60.05 Km^2, en tanto que en 1970 llegó a los 450 Km^2 (excluyendo la zona de Netzahualcoyotl), mientras que actualmente es de más de 560 Km^2

La zona industrial representa cerca del 16 por ciento de la cifra anterior y se localiza principalmente hacia el norte del área urbana.

La cuenca del Valle de México constituye una zona cerrada por montañas, sin escurrimientos naturales hacia el mar, y tiene una extensión de 9 600 Km^2.

La precipitación pluvial es variable en las distintas zonas de la cuenca, con extremos de precipitación media anual de 1085 mm en Churubusco (sur-oeste del área urbana) y 501 mm en Pachuca (norte de la cuenca), en tanto que a la ciudad de México corresponden 822 mm. El ciclo lluvioso, de mayo a octubre, no es favorable para el aprovechamiento de las aguas sino que, al contrario, propicia el escurrimiento de avenidas.

La intensidad máxima de precipitación registrada en la ciudad de México es de 53 mm en un período de una hora. La evaporación anual en la cuenca varía entre 900 y 2100 mm por año, y es evidente que sobrepasa a la precipitación anual.

La velocidad media de los vientos procedentes del NE y NW, es de 10 Km/h, con extremos de 94 Km/h.

La producción de tormentas de polvo sobre el área urbana, debidas a la acción de vientos rasantes en los lechos desecados de los lagos de Texcoco, Chalco y Tlahuac, es frecuente en los meses de enero a marzo (estiaje), observándose un promedio de 68 tolvaneras por año.

Numerosas corrientes de caracter torrencial que se originan en los límites de la cuenca tienden a desaguar en los vasos desecados de los lagos, pero la mayor parte de los escurrimientos son conducidos mediante el Gran Canal del Desagüe y el Emisor Central, que atraviesan las montañas al noreste de la cuenca, para descargar posteriormente a diversas corrientes con salida natural al mar.

La parte norte y central de la ciudad de México está construida sobre estratos de arcilla volcánica extraordinariamente compresible, lo que ha determinado hundimientos del terreno hasta de 50 cm por año (de 1948 a 1959) lo cual, además de haber producido numerosos problemas en la cimentación de los edificios, ha dislocado el sistema de alcantarillados de la ciudad y elevado el nivel de la plantilla del Gran Canal respecto a la cota de los puntos más bajos de la ciudad.

3. ABASTECIMIENTO DE AGUA

3.1 Datos Históricos

La ciudad de México, fundada en el año de 1325 en una isla del centro del lago de texcoco, no tuvo en un principio problemas de abastecimiento de agua, ya que estaba asegurado por las entonces aguas puras del lago y algunos manantiales que brotaban en el centro del islote; sin embargo, ya para la época del ascenso del rey Chimalpopoca al trono, el crecimiento de la población había reducido y casi agotado el agua de los manantiales; por otra parte, las aguas de la laguna se encontraban contaminadas por los desechos de la propia ciudad. Para resolver esta situación el rey Chimalpopoca pidió permiso a su abuelo Tezozomoc, rey de Azcapotzalco, para usar las aguas de los manantiales de Chapultepec.

Obtenido el permiso, las obras fueron realizadas bajo la dirección de Netzahualcoyotl, a la sazón desterrado de su reino de Texcoco; para ello hubo de construir una calzada a través del lago, sobre la cual se alojo la conducción; esta obra fue reconstruida 50 años más tarde por el mismo Netzahualcoyotl y perduró hasta después de la conquista. Hernán Cortés refiere que la conducción era de dos caños paralelos, tan anchos como dos pasos cada uno, por los cuales venía un golpe de agua dulce muy buena, del gordor del cuerpo de un hombre, que se distribuía en la ciudad por fuentes y estanques de las que se servían todos, pero solo los nobles tenían agua dentro de sus casas y palacios.

Otra de las grandes obras de Netzahualcoyotl, a quien debe llamarse el primer ingeniero ambiental de América, fue la construcción de un dique que cruzaba el lago, y que tenía por objeto el doble propósito de separar las aguas salobres del norte, y proteger a la ciudad contra inundaciones.

Al establecerse los conquistadores en la Nueva España, los pueblos y ciudades adquirieron mayor importancia. Los abastecimientos de agua fueron los puntos básicos para el crecimiento de los centros de población existentes y la fundación de nuevas ciudades. En lo que respecta a la ciudad de México y poblados aledaños, reconstruyeron los acueductos que habían sido destruidos durante la conquista, y captaron y aprovecharon las aguas de otras fuentes.

El primer abastecimiento moderno para la ciudad de México se inició en la época del Porfiriato con la captación de los manantiales de Xochimilco, pero no fue sino hasta 1917, en pleno período revolucionario, cuando se inició la construcción de la red de distribución. Debido a la alta calidad de estas aguas y al desarrollo de las actividades de la población, el consumo diario per-capita aumentó de 160 l, en 1912, a 240 l a fines de 1913.

El rápido crecimiento de la ciudad en el período posrevolucionario obligó, primero, a la ampliación de las obras de Xochimilco, después, a la perforación de pozos dentro de la ciudad, con lo cual se agravó el problema de los asentamientos del terreno en gran parte de ésta y, finalmente, al aprovechamiento de fuentes cada vez más lejanas, a tal grado que en la actualidad se contempla la necesidad de importar agua a distancias mayores a 100 Km, para satisfacer las necesidades crecientes de una población que en el año de 1990 sobrepasará a los 20 millones de habitantes, con demandas de más de 400 l per-capita por día.

3.2 Estado Actual y Proyectos al Futuro

Debido a las condiciones topográficas y a la situación de las fuentes que abastecen al área urbana de la ciudad de México, existen varios sitemas que distribuyen el agua en las distintas zonas. La llamada red primaria cubre el área urbanizada abajo de la cota 2268 msnm, excepto las zonas correspondientes a Tlalpan, Xochimilco y la Magdalena Contreras, y los municipios de Ecatepec, Naucalpan, Tlalnepantla y Netzahualcoyotl; estas, y las zonas arriba de la cota 2268 msnm cuentan con redes de distribución independientes.

En el año de 1975 la disponibilidad de agua en el área urbana del Distrito Federal fue de más de 38 m^3/seg, en los que se consideran la explotación de las fuentes existentes y el gasto para riego de parques y jardines recuperado de las aguas negras tratadas. Esta disponibilidad representó una dotación de más de 370 l per-capita por día en tal año, y se aumentado hasta unos 42 m^3/seg.

Las estimaciones de población futura en el área urbana de la ciudad de México y en otras poblaciones de la cuenca, aunadas al desarrollo previsto para la zona, permiten suponer que en el año de 1990 el consumo medio en el área urbana de la ciudad de México será 92 m^3/seg y en el total de las zonas urbanas de la cuenca ascenderá a 102 m^3/seg.

Por otro lado, como los estudios geohidrológicos e hidrológicos señalan la imposibilidad de satisfacer las necesidades futuras de la población con los recursos propios de la cuenca, se estima indispensable la importación de agua de otras regiones.

El aprovechamiento de las fuentes futuras de abastecimiento de agua requiere indudablemente de la consideración integral de las necesidades de las poblaciones de la cuenca del Valle de México. Para satisfacer este objeto las autoridades gubernamentales han propuesto y realizado estudios para determinar las fuentes analizadas más factibles de explotar, en orden de obtener la máxima economía en su financiamiento, construcción y operación.

Asimismo, se han realizado diversos estudios tendientes a definir las extensiones y modificaciones necesarias a efectuar en la red primaria para su correcto funcionamiento en el año 1990.

Para resolver de manera coordinada el problema del abastecimiento de agua a las poblaciones del Valle de México, el gobierno del país creó una Comisión formada por representantes del gobierno federal y las entidades afectadas, que fija políticas y explota los recursos para abastecer a las poblaciones del Valle.

Entre los nuevos proyectos de explotación de fuentes, destacan los del aprovechamiento por intercambio de las aguas profundas del lago de Texcoco, que es parte de un proyecto integral de regeneración de esa zona, y los de explotación de las aguas del río Cutzamala.

3.3 Control de la Calidad del Agua Potable.

El control de la calidad del agua potable en el Distrito Federal se realiza en base a las normas de calidad establecidas en el "Reglamento sobre Obras de Previsión de Agua Potable"

Hasta el presente, el agua que abastece a la ciudad proviene de mantos subterráneos y es, en general, de superior calidad desde los puntos de vista físico, químico y bacteriológico, por lo que en la mayoría de los casos, y por razones de seguridad, se da solamente tratamiento de desinfección a base de cloro, el cual se dosifica en los tanques de regulación y almacenamiento.

Solamente en casos específicos se da tratamiento especializado a las aguas crudas, para lo cual se cuenta con plantas como la "Ing. Marroquín y Rivera" situada en el oeste de la ciudad, que remueve dureza; la planta "Ing. Roberto Gayol", situada en el sureste del Distrito Federal, que al igual que la planta "Ing. Francisco de Garay", en el noreste de la ciudad, remueve olor y sabor.

Los programas de explotación de fuentes futuras de abastecimiento de agua incluyen el aprovechamiento de fuentes superficiales, por lo que se ha considerado la potabilización de todos los caudales que así lo requieran;por ejemplo, la planta de Cutzamala tratará 24 m^3/seg.

Los análisis rutinarios de calidad de las aguas potables son efectuados por el Departamento del Distrito Federal en los laboratorios instalados en las plantas potabilizadoras; los análisis relativos a la supervisión de la calidad, son efectuados en los laboratorios centrales de la Secretaría de Salubridad y Asistencia, ya que por ley le corresponde esta función.

4. AGUAS EXCEDENTES

4.1 Datos Históricos

El Valle de México, hasta antes de la erupción de los volcanes que forman la sierra de Chichinautzi, era un Valle que drenaba libremente sus aguas por el sur, hacia Cuernavaca.

Al cerrarse la única salida, las cenizas producto de la actividad volcánica se flocularon y sedimentaron en los lagos, (hoy practicamente desecados), constituyendo el suelo de alta compresibilidad sobre el que se asienta la ciudad de México. El pueblo Azteca, que fundó la ciudad de México en un islote del entonces gran lago de Texcoco sufrió las calamidades de las inundaciones producidas en épocas de intensa precipitación pluvial, por lo cual hubieron de construir a través del lago diques de contención y regulación de niveles, el primero de los cuales, construido por Netzahualcoyotl en 1446, tenía una longitud de 16 Km y protegía a la ciudad contra las aguas del norte de la cuenca; posteriormente se construyeron los diques de Tlahuac y Mexicaltzingo que controlaban las aguas fluviales del sur.

Durante la época Virreinal, se construyó el dique de San Cristobal, que cerró la garganta por la cual derramaban sus aguas las lagunas de Zumpango, Xaltocan y San Cristobal al lago de Texcoco. Las grandes inundaciones ocurridas en 1604 y 1607, dieron lugar al primer proyecto para dar salida a las aguas excedentes del Valle, del cual fue autor el cosmógrafo alemán Enrico Martínez. Las aguas del río Cuautitlán fueron desviadas por el primer túnel de Nochistongo, al norte de la cuenca, con lo cual el Valle tuvo su primera salida artificial, en el año de 1608

Este túnel operó solo durante unos cuantos meses, pues quedó inutilizado debido a numerosos derrumbes, no siendo sino hasta el año de 1789 cuando se inició la transformación de la obra, para convertirla en un tajo, y dar salida permanente a las aguas del río Cuautitlán.

A raíz de las inundaciones de 1856 se inició la construcción del Gran Canal del Desague y del primer túnel de Tequisquiac, obras que se terminaron en el año de 1900, con lo que se tuvo la segunda salida para las aguas de la cuenca. Con la construcción del segundo túnel de Tequisquiac, iniciado en 1940, desde 1956 la cuenca del Valle de México tuvo salida a la cuenca del río Moctezuma, afluente del Pánuco, que desagua en el Golfo de México a la altura del Puerto de Tampico.

Estas obras se proyectaron y construyeron para trabajar por gravedad; sin embargo, la explotación de los mantos acuíferos de la ciudad de México aceleró el hundimiento general del Valle, provocando retracciones hasta de 8 m en algunos puntos de la ciudad, lo cual dió lugar a la dislocación de las plantillas de la red de alcantarillado e inclusive del Gran Canal, por lo que las autoridades de la ciudad se vieron obligados a instalar en los puntos críticos del sistema cárcamos de almacenamiento y plantas de bombeo, lo cual representó un notable incremento en los costos de operación y mantenimiento del sistema.

4.2 Situación Actual y Proyectos al Futuro

El Canal del Desagüe fue construido para conducir un gasto de 5 m^3/seg en sus primeros 5 Km y 17.5 m^3/seg en los restantes; fue ampliado en sus bordes para conducir gastos hasta de 130 m^3/seg. Los vasos de algunos lagos se han utilizado como almacenamiento para regular las aguas excesivas.

El interceptor del poniente, recibe y desaloja los escurrimientos de la zona alta del poniente de la cuenca, arriba de la cota 2260 msnm, y las conduce al lago de Zumpango o al lago de Nochistongo, mientras que el antiguo río Churubusco (entubado en su cruce por la ciudad), conduce los escurrimientos del sur al lago de Texcoco, donde se regularizan los caudales para ser enviados al Gran Canal, aguas bajo del Km 17.

No obstante las obras descritas, el peligro de inundaciones de la ciudad de México con aguas sucias y negras persistía, por lo que las autoridades competentes desarrollaron un proyecto para resolver definitivamente el problema; este proyecto, que se inauguró en su primera etapa en el año de 1975, incluye los interceptores Central y del Oriente, que desajojarán los escurrimientos de la ciudad, y el Emisor Central, que recogerá las aguas de ambos interceptores, para enviarlas por gravedad hasta la Presa Requena.

El Interceptor Central es un conducto circular de concreto con longitud de 25 Km, diámetro de 4 m en los primeros 12 Km y 5 m en los restantes, gasto máximo de 90 m^3/seg y profundidad media de plantilla de 30 m, que drenará un área de 11,217 Ha. El Interceptor de Oriente, con longitud de 27 Km, diámetro de 4 m en los primeros 11 Km y 5 m en los restantes, llevará un gasto máximo 110 m^3/seg, correspondiente a un área drenada de 20,436 Ha, tiene una profundidad media de 30 m de plantilla. El Emisor Central tiene 6.5 m de diámetro, longitud de 50 Km, área transversal de 32.2 m^2 y gasto máximo de 220 m.

Actualmente se trabaja en la extensión de estos interceptores y en el establecimiento de las conexiones de la red de alcantarillado con el sistema profundo.

4.3 Uso de las Aguas Excedentes

El sistema de alcantarillado del área urbanizada del Distrito Federal, es del tipo combinado, es decir conduce tanto aguas negras como pluviales. Aproximadamente 1 m^3/seg de los desechos líquidos se tratan en las plantas de "Chapultepec", "Ciudad Deportiva", y "San Juan de Aragón", cuyos efluentes se destinan al riego de parques y jardines en época de estiaje.

De las aguas negras conducidas por el Gran Canal, una pequeña parte, de 0.5 a 1 m^3/seg, es tratada y usada para fines de enfriamiento en la planta termo-eléctrica del Valle de México. Para otros fines, el uso de aguas negras tratadas es todavía muy restringido, pero se están realizando esfuerzos, y existen programas, para substituir el uso de aguas claras en diversas industrias.

De tiempo atrás, la irrigación ha sido el uso más importante de las aguas excedentes, sin tratamiento previo. La planta "Cerro de la Estrella", con capacidad de 2.5 m^3/seg, con opción a ser ampliada a 5 m^3/seg, fue construida con el objeto de aprovechar terrenos del antiguo lago de Texcoco.

Las industrias localizadas dentro del Valle de México descargan sus desechos al sistema de desagüe del Valle de México, en general sin tratamiento previo. No se tienen cifras exactas de los volúmenes descargados por este concepto, pero se estima que la industria localizada en el Distrito Federal consume más del 20% de la dotación a esta entidad.

4.4 Control de la Calidad de las Aguas Excedentes

El Código Sanitario de los Estados Unidos Mexicanos" señala a la autoridad competente para dictar medidas generales sobre obras de alejamiento, tratamiento y destino de los desechos; prohibición a autoridades, empresas o particulares para suspender los servicios tanto de agua potable como de avenamiento;

obligación de los usuarios a devolver el agua sin alteración nociva a la salud y bienes de los habitantes que las usen posteriormente; fijando responsabilidad civil y criminal a los infractores; prohibición de descarga de albañales y conductos que a juicio de la Secretaría de Salubridad y Asistencia no conduzcan aguas tratadas convenientemente, en mantos de agua usados para el consumo doméstico, balnearios, o criaderos de fauna acuática.

La "Ley Federal para Prevenir y Controlar la Contaminación Ambiental", expedida el 3 de marzo de 1971, amplía, refuerza y especifica los conceptos anteriores, y se completa, en el aspecto de desechos líquidos, con el "Reglamento Federal para Prevenir y Controlar la Contaminación del Agua".

Indudablemente, la política tarifaria de agua potable del Departamento del Distrito Federal ha contribuido ha reducir los volúmenes de contaminantes descargados por la industria al sistema de alcantarillado, ya que al imponer tarifas más elevadas al agua potable para ser usada en fines industriales y a mayor volumen consumido, en muchos casos resulta más económico para los propietarios consumir aguas negras tratadas o tratar y recircular las aguas usadas, y recuperar materiales antes descargados al drenaje.

Los exámenes de calidad de las aguas negras del Distrito Federal son efectuados en los laboratorios existentes en las diversas plantas de aguas negras de la ciudad de México, y las del Valle de México en los laboratorios de la Secretaría de Agricultura y Recursos Hidráulicos o en los de la Secretaría de Salubridad, según el propósito a que estén encaminados.

Para resolver los problemas de contaminación ambiental y en particular los relativos al control de la calidad del agua, se crearon, a principios de los años setenta, nuevas estructuras administrativas de nivel nacional; dentro de la

Secretaría de Salubridad, la Subsecretaría de Control y Mejoramiento del Ambiente y, dentro de la ahora Secretaría de Agricultura y Recursos Hidráulicos, la Dirección General de Usos y Control de la Contaminación del Agua. Además, a principios de este sexenio, como consecuencia de la Reforma Administrativa, se efectuaron algunos cambios estructurales en diversas Secretarías de Estado, sin embargo, no han afectado al status de los problemas sanitarios de la Ciudad y el Valle de México.

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TECNOLOGIA APROPIADA PARA EL TRATAMIENTO DE AGUA Y AGUAS RESIDUALES

AGOSTO, 1980

University of Oklahoma

Appropriate Methods of Treating Water and Wastewater in Developing Countries

-- Workbook --

NOTE

This workbook is basically a outline of lectures to be presented at the University of Oklahoma's workshop on Appropriate Methods of Treating Water and Wastewater in Developing Countries. The purpose of the workbook is to assist participants of the workshop in the assimilation of the information presented at the workshop. The workbook itself is not an independent entity. Detailed information in reference to the workbook can be found in the text:

"Appropriate Methods of Treating Water and Wastewater in Developing Countries",

the University of Oklahoma Bureau of Water and Environmental Resources Research, Norman, Oklahoma, 1978.

WORKSHOP LECTURE FORMAT

Day / SESSION	1	2	3	4	5
1	REGISTRATION OPENING CEREMONIES OVERVIEW	RECAP & TIE-IN LOCAL-SETTING	WATER TREATMENT GOALS	SEWAGE TREATMENT GOALS	RECAP & TIE-IN LAND APPL. AQUACULTUR ONSITE TREATMENT
2	SCIENCE AND TECHNOLOGY	PRIORITIZATION MODEL	WATER TREATMENT SYSTEMS	SEWAGE TREATMENT SYSTEM	POLICY/ SENSITIVITY ANALYSIS
3	PREDICTIVE MODEL	HISTORY CONSUMER ACCEPTANCE	COMPUTATION MODEL EXAMPLE	COMPUTER DEMO. MINI & HAND COMBINED EXAMPLE	DISCUSSION PANAMA & INDONESIA DEMONSTRATION
4	CLIENT/DONOR RELATIONSHIP	MODEL APPLICATION	COST EQUIPMENT	CASE HISTORY	SUMMATION
AFTER MEETING OR EVENING		WORK SESSION CONSULTATION			

Faculty

Session 1.1

Title: Workshop Overview

ABSTRACT

(excerpt from text, p. ix-x)

For many years developing countries have been working, with external assistance, to promote development of water treatment and waste disposal systems in their cities and towns. Adequate quantities of safe water and adequate sanitation measures are considered to be a necessary but not a sufficient condition for social and economic development; however, up to this time programs simply have not succeeded in keeping pace with the problem of water and sanitation in LDC's. A breakdown has occurred where there have been direct technology transfers which resulted in the selection of treatment processes too sophisticated or costly for in-country construction, maintenance, or operation.

A basic problem, then, relates to site-specific selection of appropriate technology in LDC's. This volume, in part the result of an in-depth study sponsored by the United States Agency for International Development and in part the result of additional and related efforts, is concerned with this problem. Chapters I and II outline the difficulties encountered in donor/client relationships and technology transfer. Chapter III explains a methodology for selecting the most appropriate technology for water and wastewater treatment for a particular LDC site and at a particular time, according to the material and manpower resource capabilities available. Chapter IV presents a mathematical model for LDC's in Africa, Asia, and Latin America, to predict water and wastewater demand, as well as construction and operation and maintenance cost estimates for slow sand filters, rapid sand filters, stabilization lagoons, aerated lagoons, activated sludge systems, and trickling filters. The basic technique used in developing this model was step-wise multiple regression working from LDC in-country cost data. Chapter V presents a methodology for setting priorities among LDC water supply programs. Chapters VI, VII, VIII, IX, and X constitute state of the art chapters (for application particularly to LDC's) on past, present, and future technologies for water and wastewater, including on-site disposal and treatment concepts.

The purpose of this volume is to support donor/client efforts to reduce health problems through proper selection of processes and projects, realizing that much of the solution is educational in nature.

WORKSHOP OVERVIEW

I. Problem Statement - the inappropriate use of water and wastewater treatment systems in developing countries.

A. Appropriate fit of the water and wastewater treatment systems results in:

1. Most economical system to construct

2. Most economical system to operate in terms of:

a. Labor
b. Chemicals used
c. Energy
d. Maintenance demands

B. Inappropriate use manifests itself in several ways.

1. Systems do not operate as designed

2. Systems in disrepair fail to effectively treat water or wastewater

3. Systems require redesign and retrofitting to assure quality treatment when used with existing equipment.

C. Tool used in the selection concept of this workshop

1. Development and conceptual use of the predictive model.

2. Development and conceptual use of the prioritizing model.

3. Discussion of the dissemination concepts of the client/donor relationship.

II. Program Development by the University of Oklahoma

A. Market contact in the Developing countries.

1. Americas
2. Turkey
3. Kenya
4. Thailand
5. Indonesia
6. Philippines
7. Taiwan

B. Prioritizing Model

C. Prediction Model testing projects for a possible refin process. Results comparison.

1. Indonesia
2. Africa
3. Asia

III. Workshop Format

A. Staff Introductions

B. Materials used identification

1. text

2. workbook

3. Vendors catalog

C. Workshop

1. Pace

2. overview of scope.

15

Session 1.2

Title: Science, Technology, Technology Transfer, and Appropriate Technology 12

Objective: To develop the basic concept of science, technology transfer, and aid in the selection process of appropriate technologies in developing countries.

Technology Transfer, Adaptation, and Utilization

(excerpt from Chapter II, p. 23 in text)

Direct transplanting of water and wastewater treatment technologies has not led to satisfactory utilization of either foreign or domestic resources. The use of innovative techniques to coordinate existing technology to new technologies to upgrade life, to take advantage of local manpower, materials, and remain sensitive to the socio-economic goals of that country. The main emphasis of the chapter is to obtain a grasp of the total picture, putting pieces together in a practic and usable way. International health organizations, lending agencies, and national, regional, and local institutions can develop a viable planning tool.

This session presents some key elements in approaching the problem of selecting appropriate technologies: (1) systematic evaluation of the importance and interrelationships of all relevant aspects of the problem, such as technical, economic, social, political, and cultural factors; (2) assessment of alternative courses of action; and (3) analysis of benefits and costs or cost effectiveness on the basis of which policies can be determined and decisions made.

Schumacher has said that "for developing countries there is a very low level of technology which does not keep people going except in relative misery, and in developed countries exists a technology which is beyond the technical support capability of the lesser developed country at this point in time.

SESSION OUTLINE:

I. Introduction

A. Historical Development of technology

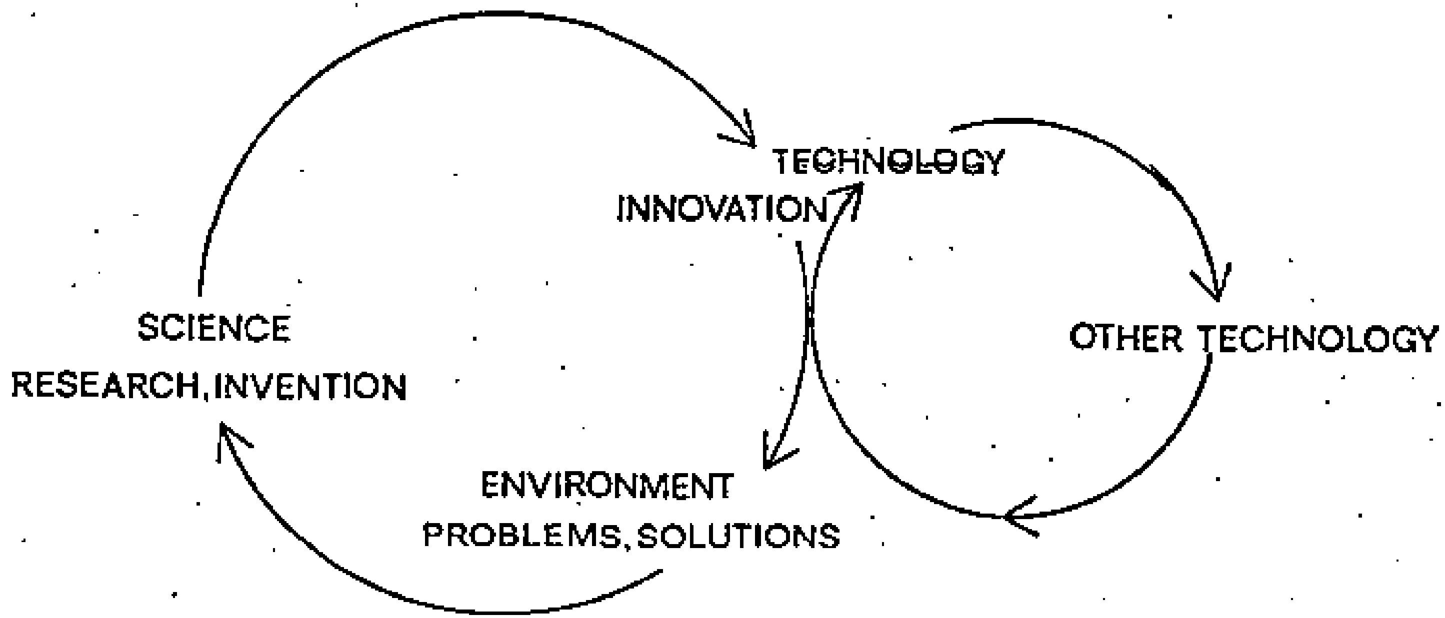
B. Concept of essentiality of water to economic development

II. Defining the process of technology transfer, and the selection of appropriate technologies

A. Defining of terms used

1. Science
2. Technology
3. Appropriate Technology
4. Retrogressive Technology
5. Acceptance

(Refer to Figure II.1)



Interrelationships among science, technology, and problems and solutions in the environment.

Figure II. 1

III. Contributory Breakdown of Donors (Technology Transfer)

A. USA
B. UK
C. Germany
D. France
E. Other Western countries

TABLE II.1
TECHNOLOGICAL BALANCE OF PAYMENTS
ESTIMATES FOR 1964

	Receipts (percentage of world total)[a]	Payments (percentage of world total)[a]
U.S.A.	57%	12%
U.K.	12%	11%
Germany (F.R.)	6%	14%
France	5%	11%
Other Western European Countries	18%	25%
Japan	1%	13%
Other Developed Countries	1%	6%
Developing Countries	1%[b]	8%

SOURCE: C.D.G. Oldham, C. Freeman, and E. Turkcan, Transfer of Technology to Developing Countries, Study of the Science Policy Research Unit of the University of Sussex, for the U.N. Conference on Trade and Development, Second Session, TD/28/Supp. I (November 10, 1967). (Based on Office of Economic Cooperation and Development data.)

[a]Excluding transactions among socialist countries and between those countries and developing countries.

[b]Receipts of developing countries were negligible and in any case less than 1 percent.

IV. Recognition of the failures that have occurred due to the direct transfer of inappropriate technologies

V. Historic development and the time lag between DC's and LDC's

A. Europe

B. USA

C. Russia

D. China, etc.

(Refer to Figures II.2 - II.3)

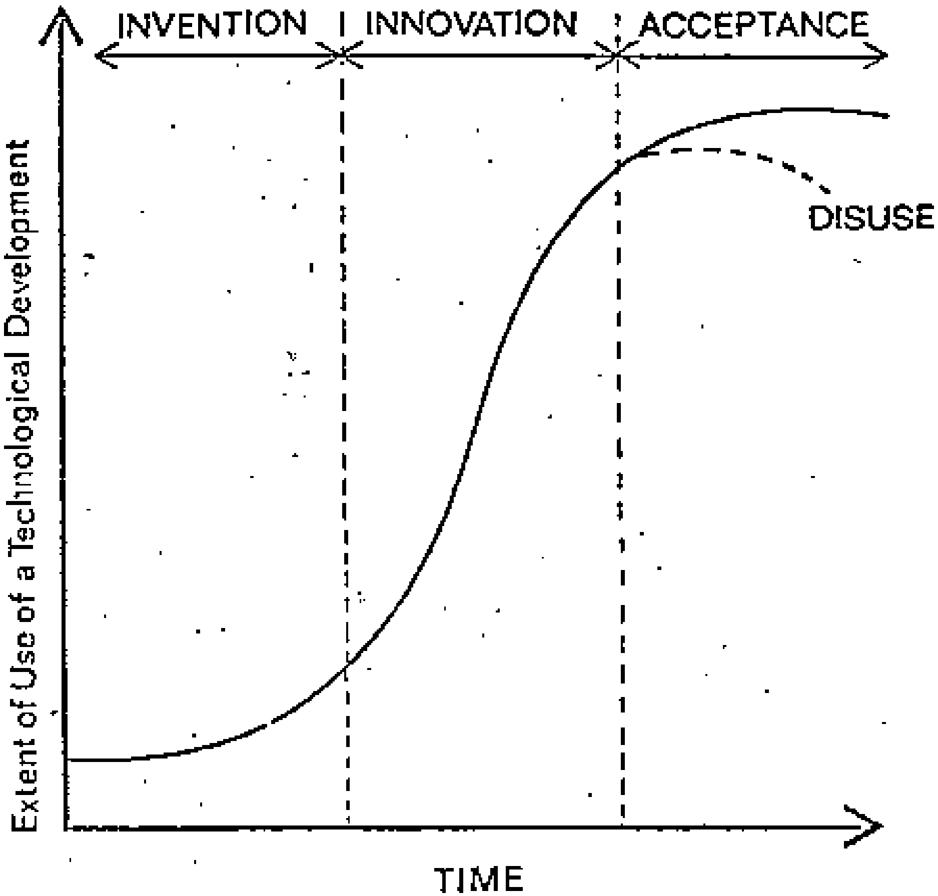


Figure II.2a PROCESS OF TECHNOLOGY DEVELOPMENT.

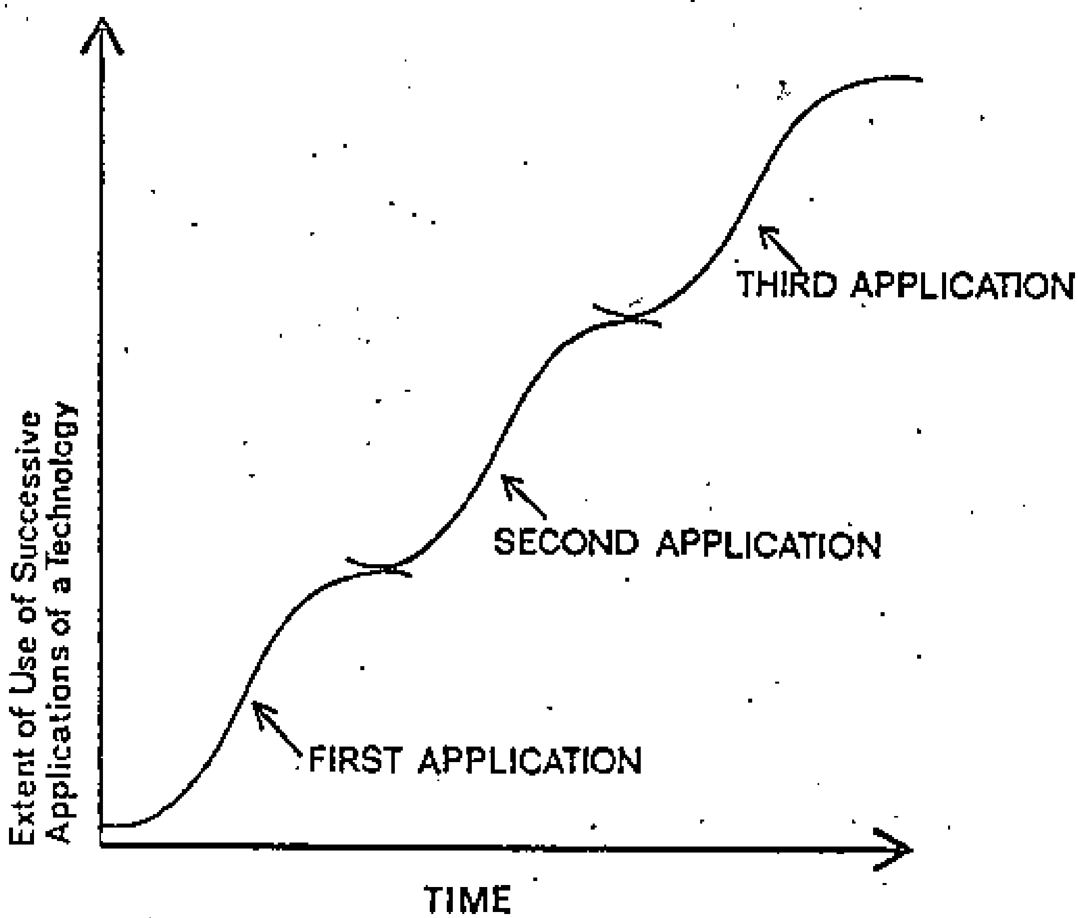

Extent of Use of Successive Applications of a Technology
THIRD APPLICATION
SECOND APPLICATION
FIRST APPLICATION
TIME

Figure II.2b

WATER TREATMENT TECHNOLOGY

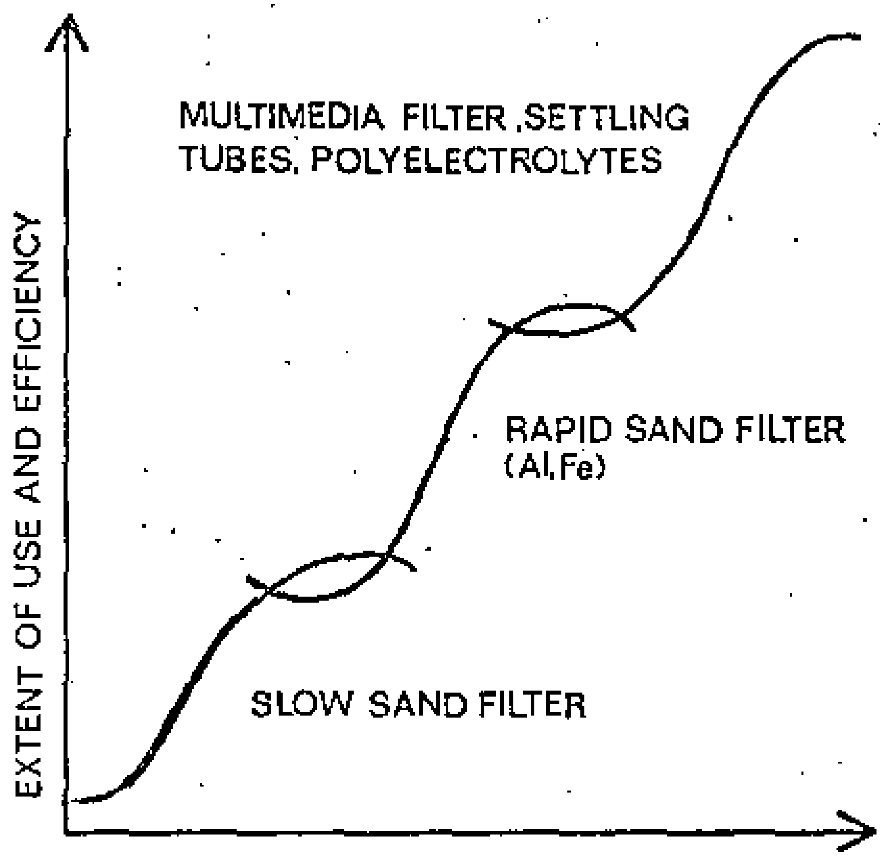


Figure. II 3.a TIME (URBANIZATION AND INCREASED RESOURCE USE)

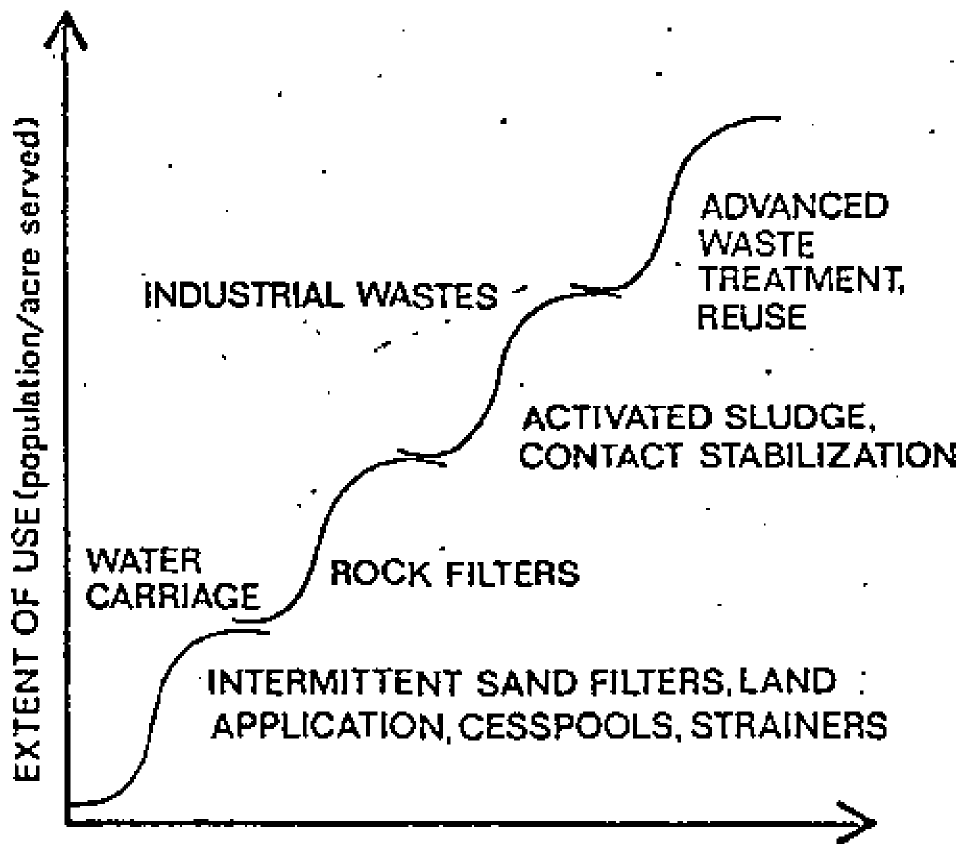


Figure II 3.b TIME (Urbanization and increased resource use)

VI. Most successful innovations are derived from need

A. Appropriate adaptations of progressive "DC" technologies to the currently existing technology of the "LDC"

VII. LDC Characteristics

A. Unskilled labor

B. Unemployment

C. Smaller domestic market

D. Lower purchasing power

VIII. Concept of Economic scaling

A. Refer to Figure II.4

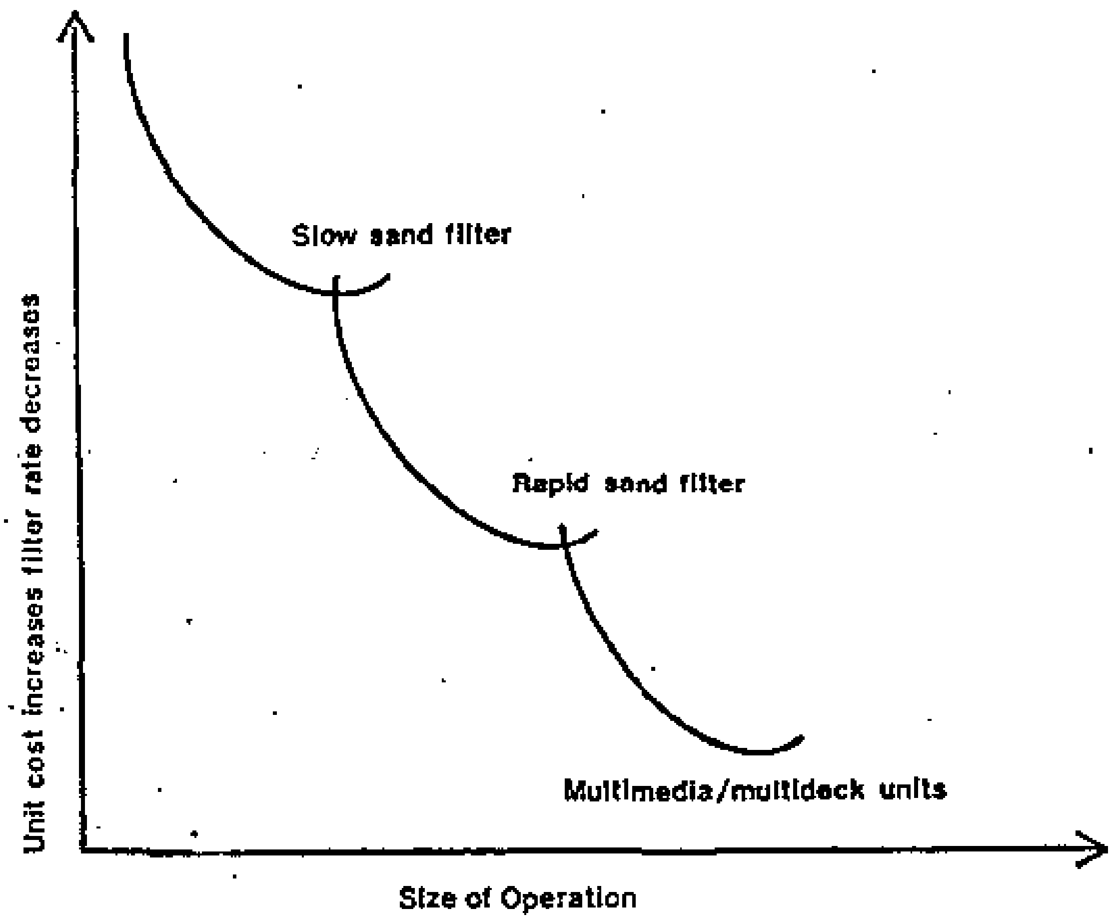


Figure II. 4 The effect of economy of scale in water treatment.

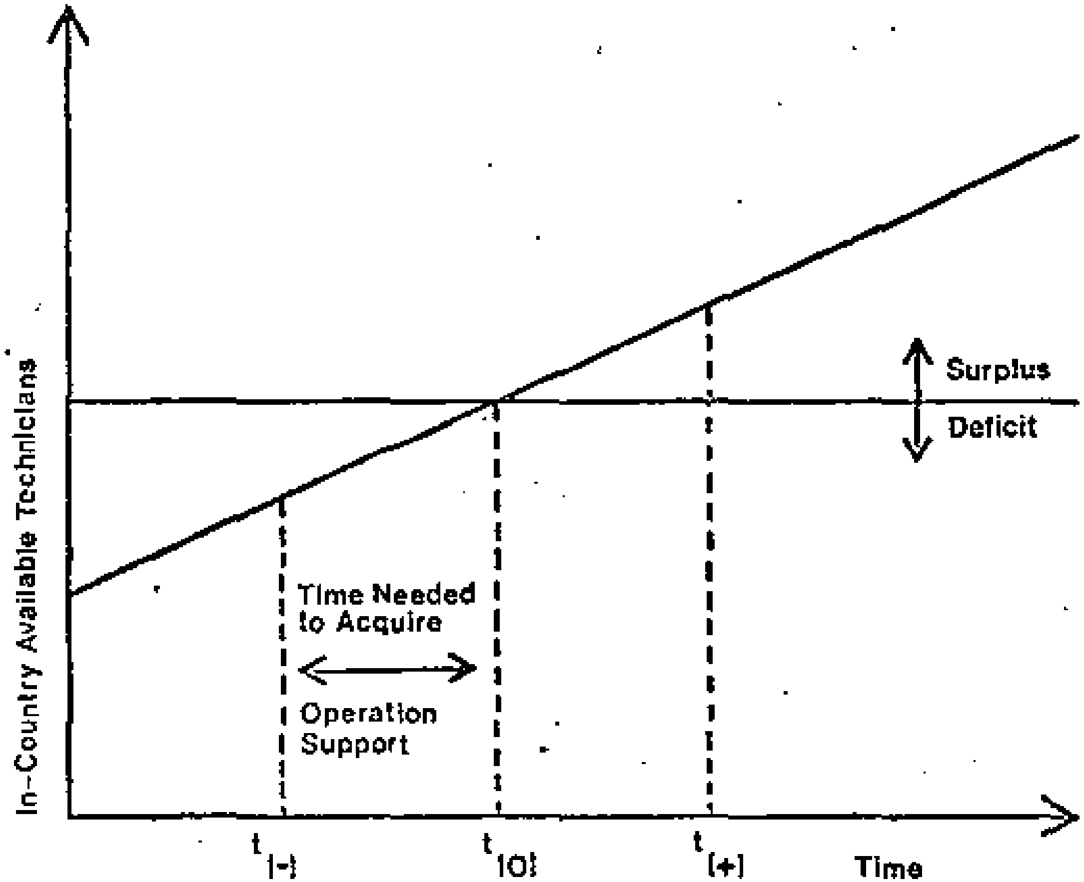


Figure II. 5 Change in availability of in-country technicians with time.

IX. Application of Technology Concept

A. Hard and Soft

B. Grading

1. High

2. Intermediate

3. Low

X. Goal Realization

A. Background information needed to understand successful technology

1. Local tradition

2. Regional Goals

3. Social & Economic Impact

XI. Examples of Appropriate & Inappropriate Technology

A. Developed Countries

1. Norman, Oklahoma - conventional sewage plant; settling basins; trickling filters; sludge digestor; s beds.

2. Muskogee, Oklahoma - high technology, particularly sludge handling, thickness, cyclone, centrifuge, incinerator - all automated; never (in 3 years) functioned correctly; 180 critical items ~~not~~ out at any time.

B. Developing Countries

1. Turkey - aerator for sewage--homemade, no bearings; chlorine for water, no source.
2. Indonesia - family fish ponds; cultivation of vascular plants; food.
3. Peru - automated (tape); shallow filter.
4. Thailand - coconut fiber/char rice hulls; slow sand filters; rapid sand filters.
5. Colombia - dynamic filters; multimedia; declining head filter.
6. Dominica - chlorine; 6-month turn-around.

Title: Predictive Model

Objective: To develop the basic model to assist in the selection of appropriate technology - using a system approach to arrive at a low technology solution

Prediction Methodology for Selection of Suitable Water and Wastewater Processes

(excerpt from CHAPTER III, p. 39 text)

The three sections included in this chapter are shortened and revised versions of the original publications which they represent. In them is presented an ordered method of selecting the most appropriate technology for water and wastewater treatment for a particular site and at a particular time, according to the material and manpower resource capabilities available. The primary concern is drinking water and wastewater for organized communities, including those for which management systems for on-site processes would be appropriate.

In the first section explanation is made of the selection methodology which involves the systems approach and aggregate modelling. The systems approach permits the analyst to look at various interrelationships and decision options at one time while aggregate modelling uses average values for attributes of the real-life situation under study. The attributes for LDC modelling must be representative and must be based on available data on the LDC site either obtained directly or through the aid of a surrogate.

The output of the model displays compatible water supply and sewerage treatment alternatives for a specified community in the base year and at the end of each of four increments of five years. For the alternatives provided, information is given on capital and maintenance costs, manpower requirements, the population to be served, and the plant scale which would be required.

In the second section of this chapter, data forms are included which were designed to use in collecting the basic information needed for the use of the predictive model, while the third section provides a manual computation application of the model together with an example problem which has been worked out step by step. This manual method will suffice in most instances, although a computerized version has been developed.

THE PROCESS-SELECTION MODEL

37

The purpose of this model is to provide the decision-maker with a tool that will assist in the selection of a technology for water and wastewater treatment which is most appropriate to the community's capabilities.

The responses and combinations which result from this exercise provide a series of applications which would achieve the desired levels of treatment based upon local conditions. From these alternatives, the final selection may be made by the decision-makers.

The model is designed for nucleated systems and for comprehension of the process by non-engineers. Engineers will find it useful as a tool for a coarse sort and sensitivity analysis.

CONCEPTUAL APPROACH

38

The model screens all known processes for social-economic attributes, resource attributes, comparable process costs, and aggregate processes (systems) for further consideration.

Those systems which emerge through this process are those which are most appropriate to meeting designated goals.

TYPES OF SCREENING INVOLVED IN THE SELECTION OF A COMPATIBLE LOWEST COST COMBINATION OF TREATMENT PROCESSES

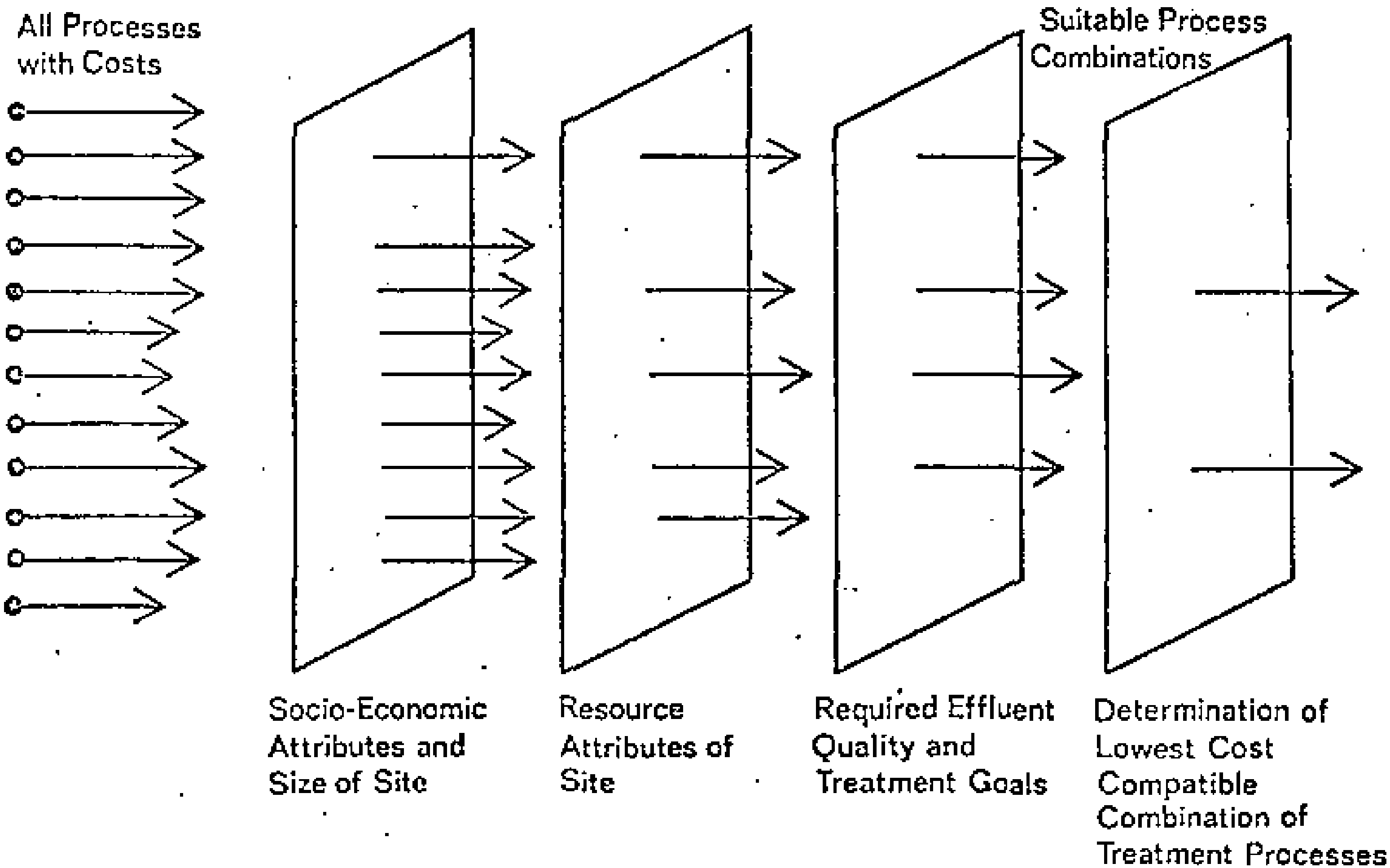
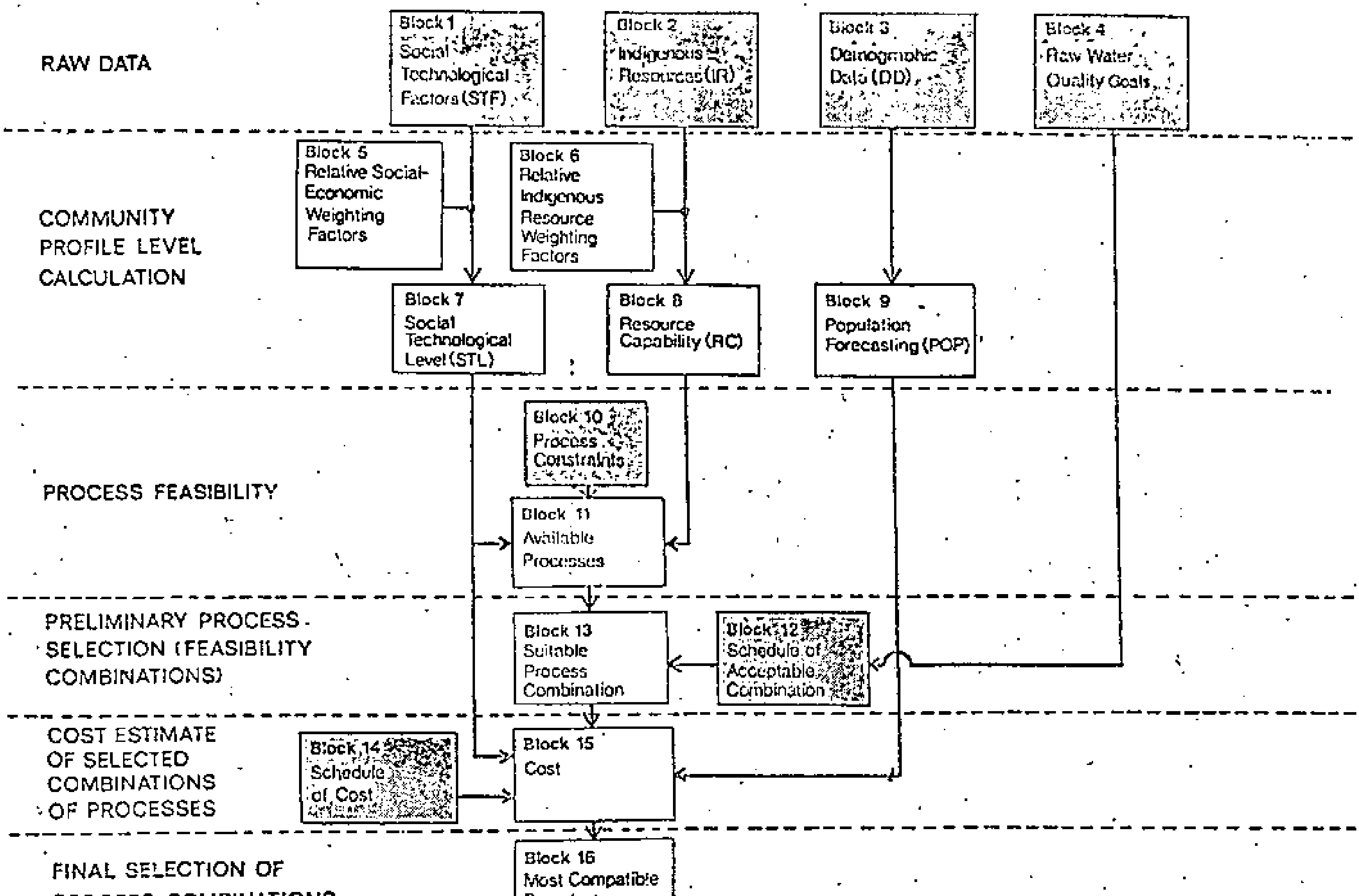


Figure I. 3

COMPLETE INFORMATION FLOW FOR THE PREDICTIVE MODEL



BASIC REQUIREMENTS

1. A Classification of Water & Wastewater Processes:

   PW 1 etc. and PS 1 etc.

   (Detailed process classifications on pages 53-61 in text)

2. By Manpower Requirements

   - Unskilled
   - Skilled
   - Professional

3. By Resource Requirements

   - Equipment
   - Materials
   - Supplies: Maintenance

     Chemical

PROCESS CONSTRAINTS

WATER TREATMENT PROCESSES WITH ESSENTIAL MANPOWER

& RESOURCES REQUIRED FOR OPERATION

TREATMENT METHODS	PROCESS NUMBER	PROCESS REQUIREMENTS						
		MANPOWER			RESOURCES REQUIRED			
		UNSKILLED	SKILLED	PRO-FESSIONAL	OPERATION EQUIPMENT	PROCESS MATERIALS	MAINT SUPPLIES	CHEMICAL SUPPLIES
NO TREATMENT	PW1*	X			X	X	X	
PRE-TREATMENT	PW2	X			X		X	
SLOW SAND FILTRATION	PW3	X				X	X	
RAPID SAND FILTER (Conv.)	PW4	X	X	X	X	X	X	X
RAPID SAND FILTER (Adv.)	PW5	X	X	X	X	X	X	X
SOFTENING	PW6	X	X	X	X	X	X	X
DISINFECTION	PW7	X	X		X	X	X	X
TASTE, ODOR-Fe, Mn	PW8	X	X		X	X	X	X
DESALTING-SALT	PW9	X	X	X	X	X	X	X
DESALTING-BRACKISH	PW10	X	X	X	X	X	X	X
CONTAINMENT FILTER	PW11[a]	X				X	X	
DISINFECTANT FILTER	PW12	X						X

* Water Source
(Groundwater Availability)

[a] Listed for completeness only, not actually available as a model output at this time.

PROCESS CONSTRAINTS

SEWAGE TREATMENT PROCESSES WITH ESSENTIAL MANPOWER

& RESOURCES REQUIRED FOR OPERATION

TREATMENT METHODS	PROCESS NUMBER	PROCESS REQUIREMENTS						
		MANPOWER			RESOURCES REQUIRED			
		UNSKILLED	SKILLED	PRO-FESSIONAL	OPERATION EQUIPMENT	PROCESS MATERIALS	MAINT SUPPLIES	CHEMICAL SUPPLIES
PRIMARY (Conv.)	PS1	X			X	X	X	
PRIMARY-Stabilization Pond	PS2	X				X	X	
SLUDGE (Conv.)	PS3	X	X		X	X	X	
SLUDGE (Adv.)	PS4	X	X	X	X	X	X	X
SLUDGE-Combined (Imhoff)	PS5	X			X	X	X	
SECONDARY-Standard Filter	PS6	X	X		X	X	X	
SECONDARY-High Rate Filter	PS7	X	X		X	X	X	X
SECONDARY-Activated Sludge	PS8	X	X	X	X	X	X	
EXTENDED AERATION	PS9	X	X		X	X	X	
ROTATING BIOL. CONTACTOR	PS10	X	X		X	X	X	
DISINFECTION	PS11		X		X	X	X	X
LAND APPLICATION	PS12	X	X		X	X	X	
AQUA CULTURE	PS13[a]	X						
INDIVIDUAL	PS14[a]	X						
INDIVIDUAL (Adv.)	PS15[a]		X		X		X	

[a]Listed for completeness only, not actually available as a model output at this time.

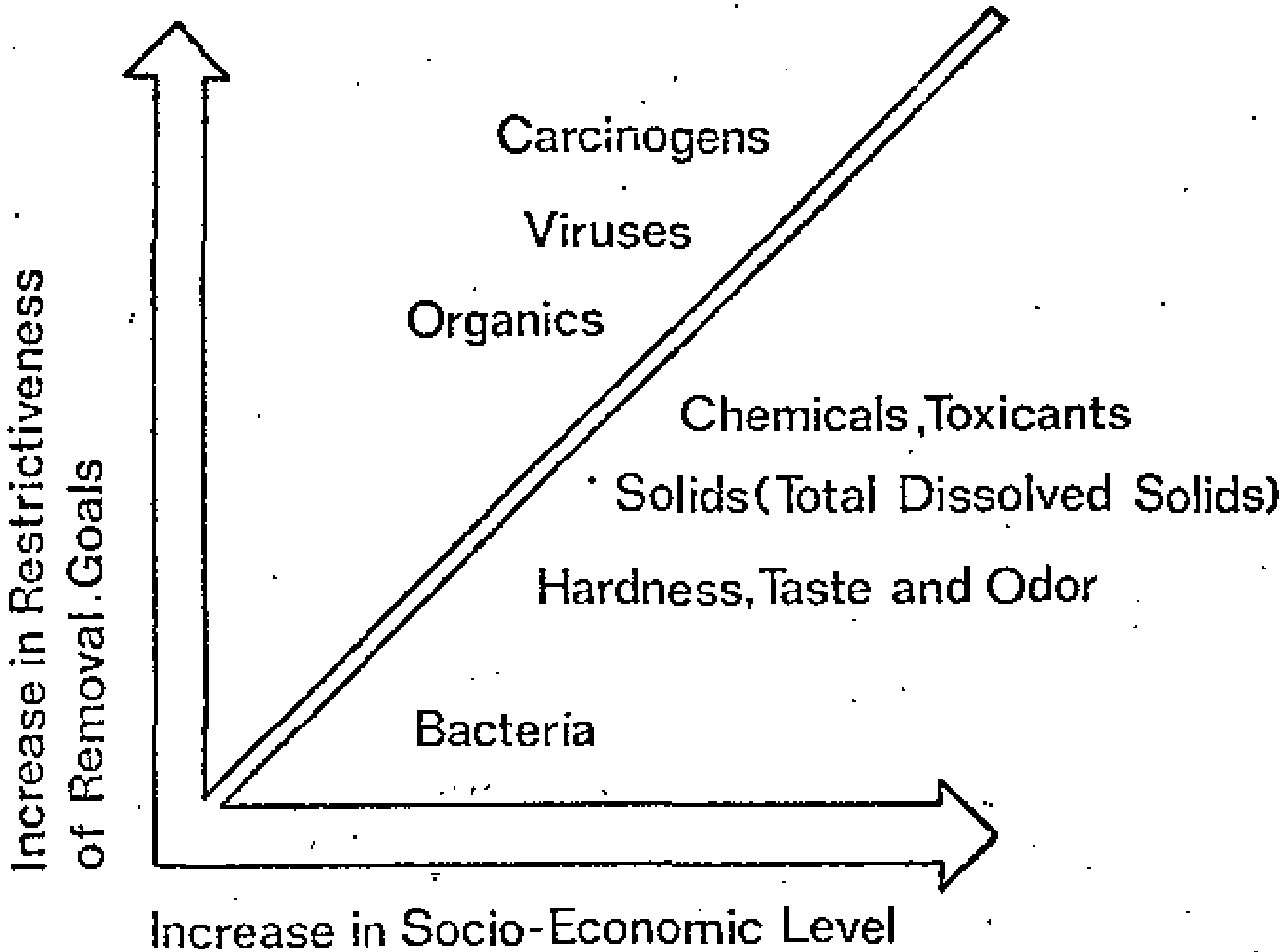
BASIC DATA PROCESSING

1. Establishment of Social-Economic Levels I, II, III, IV, from a Variety of (19) Parameters to Codify Community Capabilities.

2. Establishment of Resource and Manpower Levels of the Site and Associating These With 1, Above.

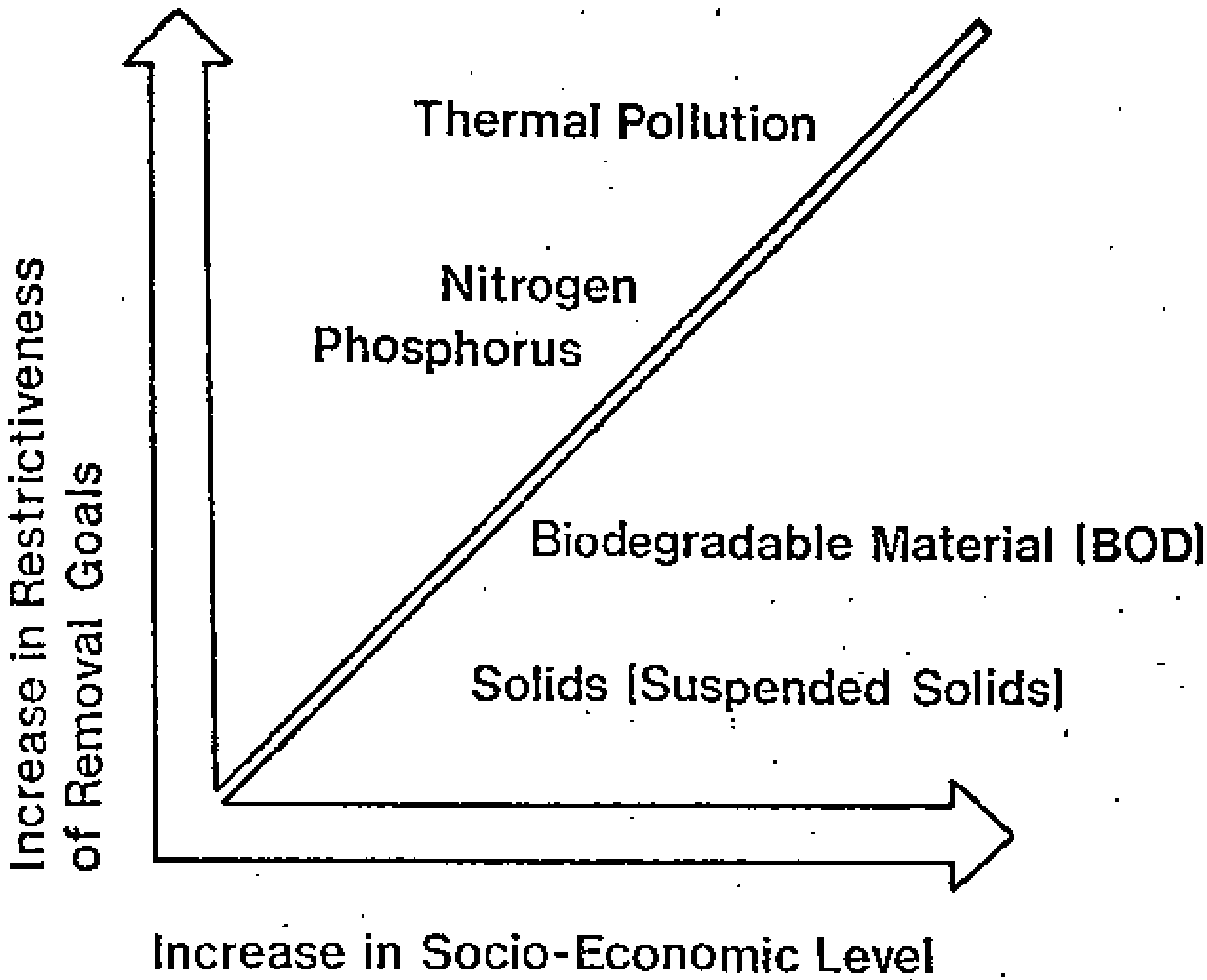
3. Determination of Costs and Cost Ratios by Levels Derived in 1 and 2 Above. (There will be an entire lecture on costing later.)

4. Development of Acceptable Combinations of Processes to Meet Established Goals. These Goals Will Change With Increased Levels.



CONSTITUENTS TO BE REMOVED IN WATER TREATMENT

Figure III. 1



CONSTITUENTS TO BE REMOVED IN WASTEWATER TREATMENT

Figure III. 2

WATER TREATMENT

ACCEPTABLE COMBINATIONS OF TREATMENT PROCESSES, ACCORDING TO RAW WATER QUALITY OR DEGREE OF DILUTION AVAILABLE TO WASTE FLOWS

CODE FOR PROCESS COMBINATIONS	PROCESS COMBINATIONS	CRITERIA LEVELS — RAW WATER CONCENTRATION		
		COLIFORM BACTERIA (MPN/100 ml)	SOLIDS	
			TURBIDITY (JTU)	OTHER (mg/1)
W1	PW1	1-2 [a]	10	
W2	PW3	200	100	
W3	PW11	300	800	
W4	PW1 + PW7	500	10	
W5	Pw2 + PW3	1,000	800	
W6	PW2 + PW12	3,000	800	
W7	PW3 + PW7	5,000	100	
W8	PW2 + PW3 + PW7	10,000	1,000	
W9	PW4 + PW7	10,000	100	
W10	PW2 + PW4 + PW7	10,000	1,000	
W11	PW5 + PW7	10,000	100	
W12	PW2 + PW5 + PW7	10,000	1,000	
W13	(any one of W1 to W12)+PW6			300 hardness
W14	(any one of W1 to W12)+PW8			1-3 Fe & Mn
W15	(any one of W1 to W12)+PW9			3000 TDS[a]
W16	(any one of W1 to W12)+PW10			2000 TDS[a]

[a] This represents standards for developed countries; different standards may be more appropriate for developed countries.

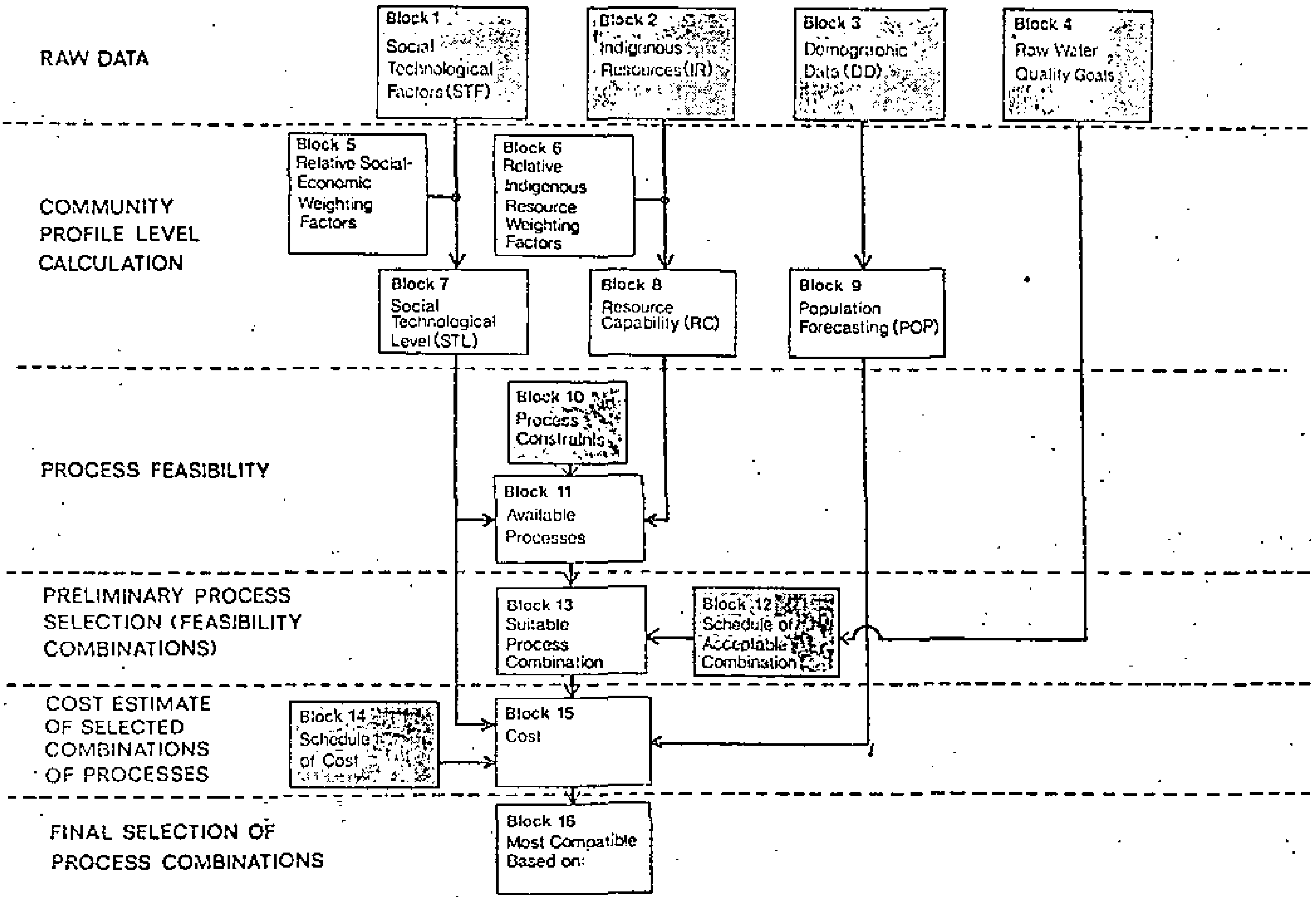
SEWAGE TREATMENT

ACCEPTABLE COMBINATIONS OF TREATMENT PROCESSES, ACCORDING TO RAW WATER QUALITY OR DEGREE OF DILUTION AVAILABLE TO WASTE FLOWS

CODE FOR PROCESS COMBINATIONS	PROCESS COMBINATIONS	RECEIVING WATER VOLUME (7-day low flow level)WASTE VOLUME	
		BASED ON BOD	BASED ON COLIFORM
S1	PS5	20	160
S2	PS1 + PS3	20	160
S3	PS2	10	16
S4	PS9	3	16
S5	S2 + PS10	5	32
S6	S2 + PS6	6	32
S7	S2 + PS7	5	32
S8	S2 + PS8	4	32
S9	PS1 + PS12	0	0
S10	S4 + PS12	0	0
S11	PS2 + PS13	5	16
S12	S1 + PS11	20	2
S13	S2 + PS11	20	2
S14	S3 + PS11	10	2
S15	S4 + PS11	3	2
S16	S5 + PS11	5	2
S17	S6 + PS11	6	2
S18	S7 + PS11	5	2
S19	S8 + PS11	4	2

These represent standards for developed countries; different standards may be more appropriate for developing countries.

COMPLETE INFORMATION F--W FOR THE PREDICTIVE MODEL



SITE DATA REQUIRED

Social-Economic Determinants (Block 1)

Resource Determinants (Block 2)

Demographic Determinants (Block 3)

Goals for Water Quality (Block 4)

PROCESS DATA REQUIRED

Process Constraints (Block 10)

Acceptable Combinations (Block 12)

THE BALANCE OF THE FUNCTIONS IN THE MODEL REPRESENT CALCULATIONS TO ARRIVE AT COMBINATIONS AND PREDICTIONS UPON WHICH DECISIONS CAN BE MADE.

BLOCK 1

SOCIAL TECHNOLOGICAL FACTORS (STF)

- Level of Education
- Distribution of Labor Force
- Income Characteristics
- Percent Non-Indigenous Workers In Government & Industry
- School Operations
- Highest Grade Offered by Local School
- Nearest High School
- Availability of In-Service Training Programs
- Local College or University
- Chemistry in Local College
- Community Fiscal Level
- Unemployment Level
- Availability of Extension Services
- Schools of Local College Students
- Level of Technology Available
- Government as Labor Users
- Availability of Employment Services

(These factors used to determine one of the four levels: I, II, III, IV)

↓

To Block 7

Examples of Data Catagories Used in Gathering Social-Technical Factors (STF)*

(1) Average level of education obtained by inhabitants living in the community.

Level	None	Primary	High School	Technical Institute	College	Weighting Factor
1	95%	4%	1%	0%	0%	0
2	70%	19%	7%	3%	1%	5
3	55%	22%	14%	6%	3%	10
4	9%	34%	42%	8%	7%	15

(2) Average distribution of labor force in the community.

Level	Unskilled	Semi-skilled	Professional	Weighting Factor
1	97%	2%	1%	0
2	80%	16%	4%	5
3	61%	27%	12%	10
4	45%	30%	25%	15

(3) Annual average income per family in local currency:

Amount _______ Unit _______

Check approximate U.S. dollars equivalent of this amount:

Income	Weighting Factor
Less than $100	0
$100 - $500	4
$500 - $1,000	8
$1,000 - $3,000	12
Greater than $3,000	15

*(see page 75 of the text)

BLOCK 2
INDIGENOUS RESOURCES (IR)

I - Operation Equipment
II - Process Materials
III - Maintenance Supplies
IV - Chemical Supplies

↓

To Block 8

<u>Indigenous Resources Data</u> FOR EXAMPLE

Category	Check If Not Available	Calculations
(20) Operation Equipment (OE)		Critical Level for Operation Equipment 3.
• Meters; water, gas, recording devices, such as thermostats, water meters	________	
• Sheet metal fabrication, etc.	________	Sum of Items Not Available ________
• Gauges; cacuum, flow, etc.	________	
• Laboratory equipment such as test tubes. etc. as found in high shcool chemistry labs, medical offices, and hospitals	________	Availability of Operation Equipment ________ (yes = 1, No = 0)
• Portable power plants such as gasoline powered electric generators	________	
• Motors such as 1-3 horsepower electric motors	________	
• Pumps, fans, etc.	________	

BLOCK 3

DEMOGRAPHIC DATA (DD)

- Present Population
- Average Growth Rate

To Block 9

BLOCK 4

RAW WATER QUALITY

- Number of Coliform Bacteria
- Suspended Solids
- Receiving Water Dilution Available
- BOD - Organic Waste Measurements
- Fe & Mn Minerals
- TDS - Total Dissolved Solids

To Block 13

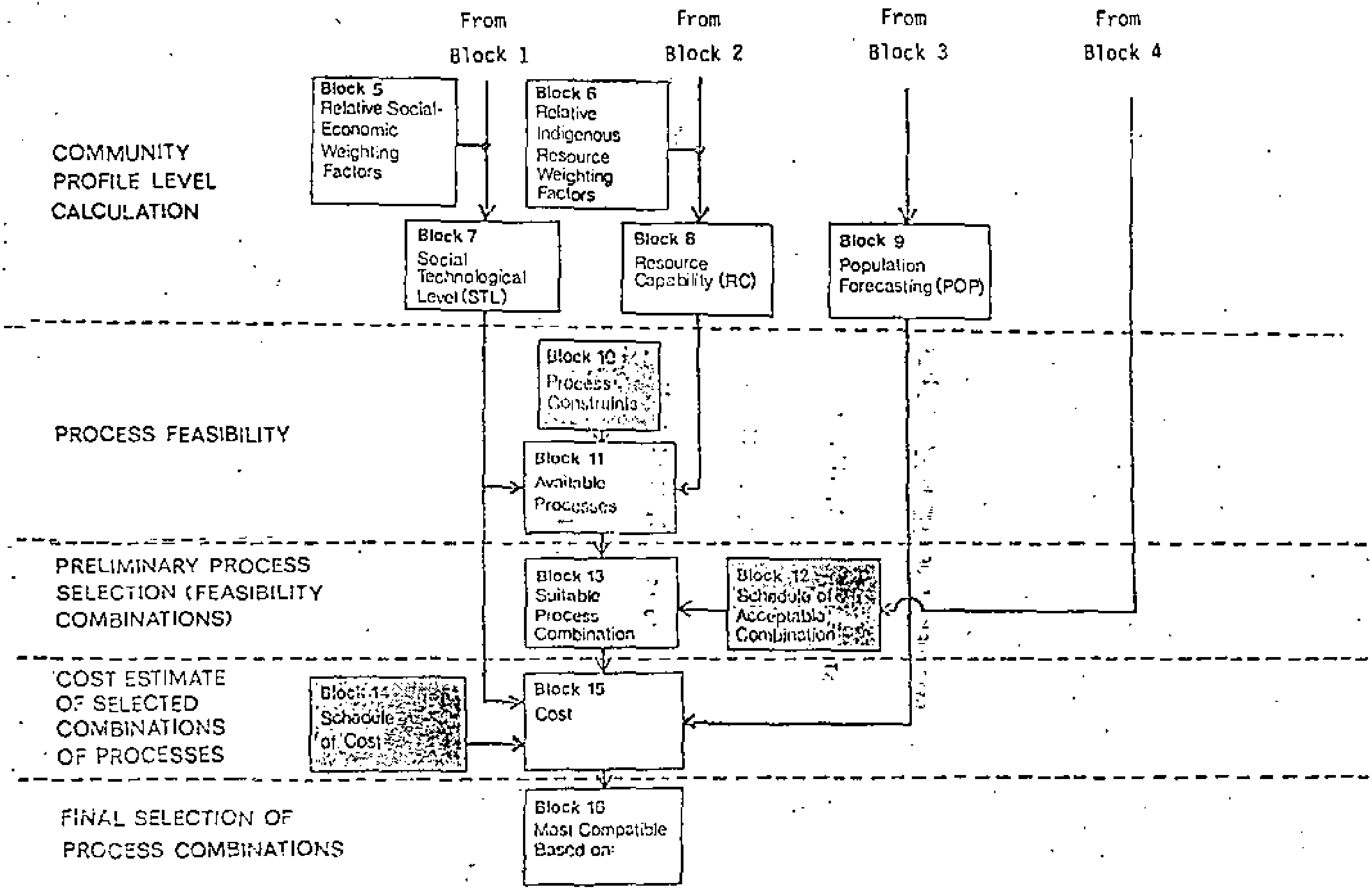
DEVELOPMENT OF COMMUNITY PROFILES

STL Level I, II, III, or IV

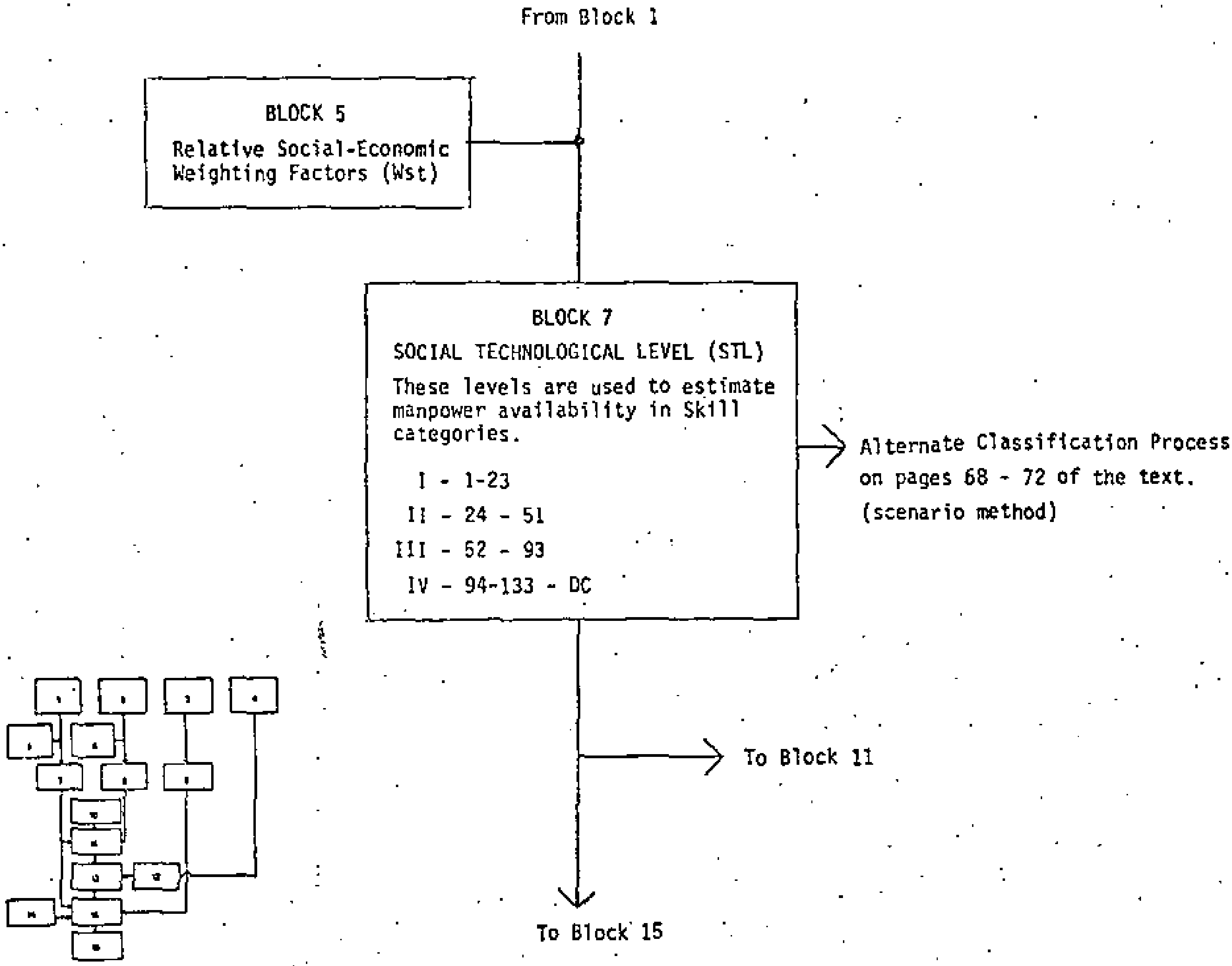
Manpower I, II, III, IV

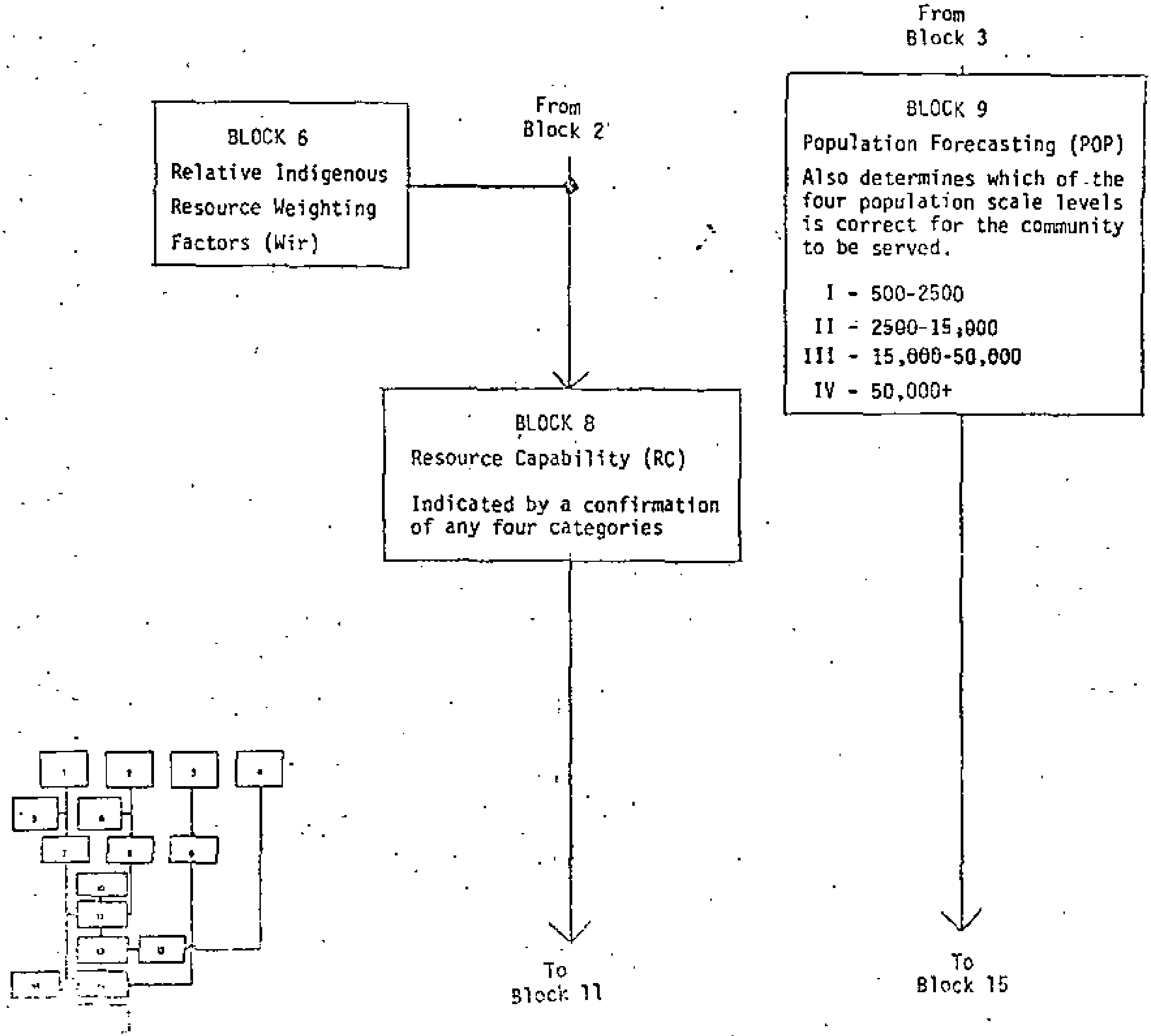
Resources I, II, III, IV

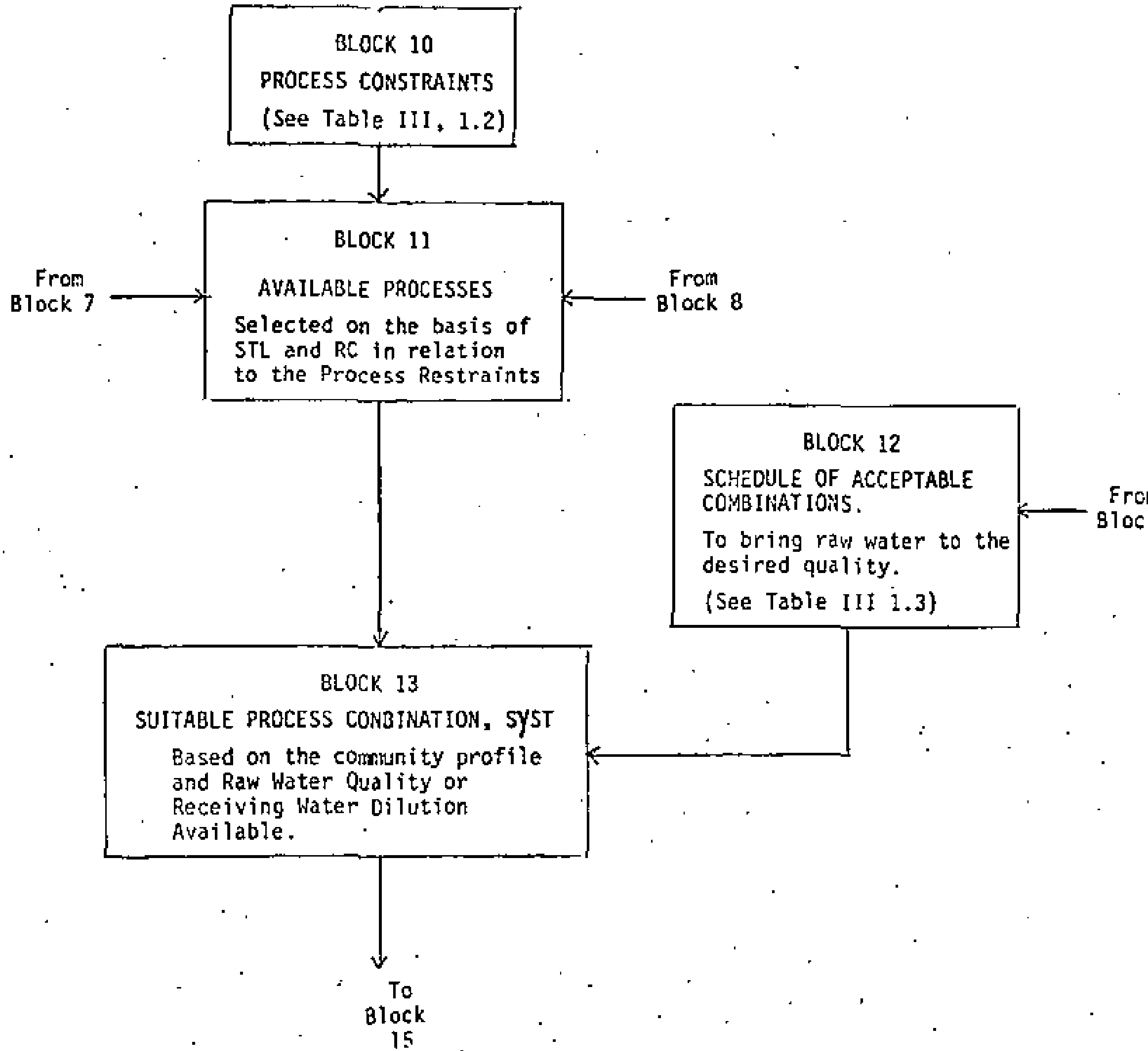
Size I, II, III, IV

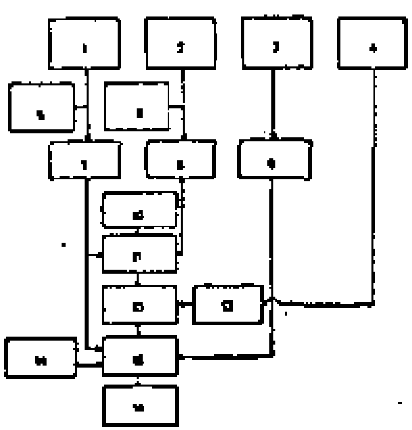


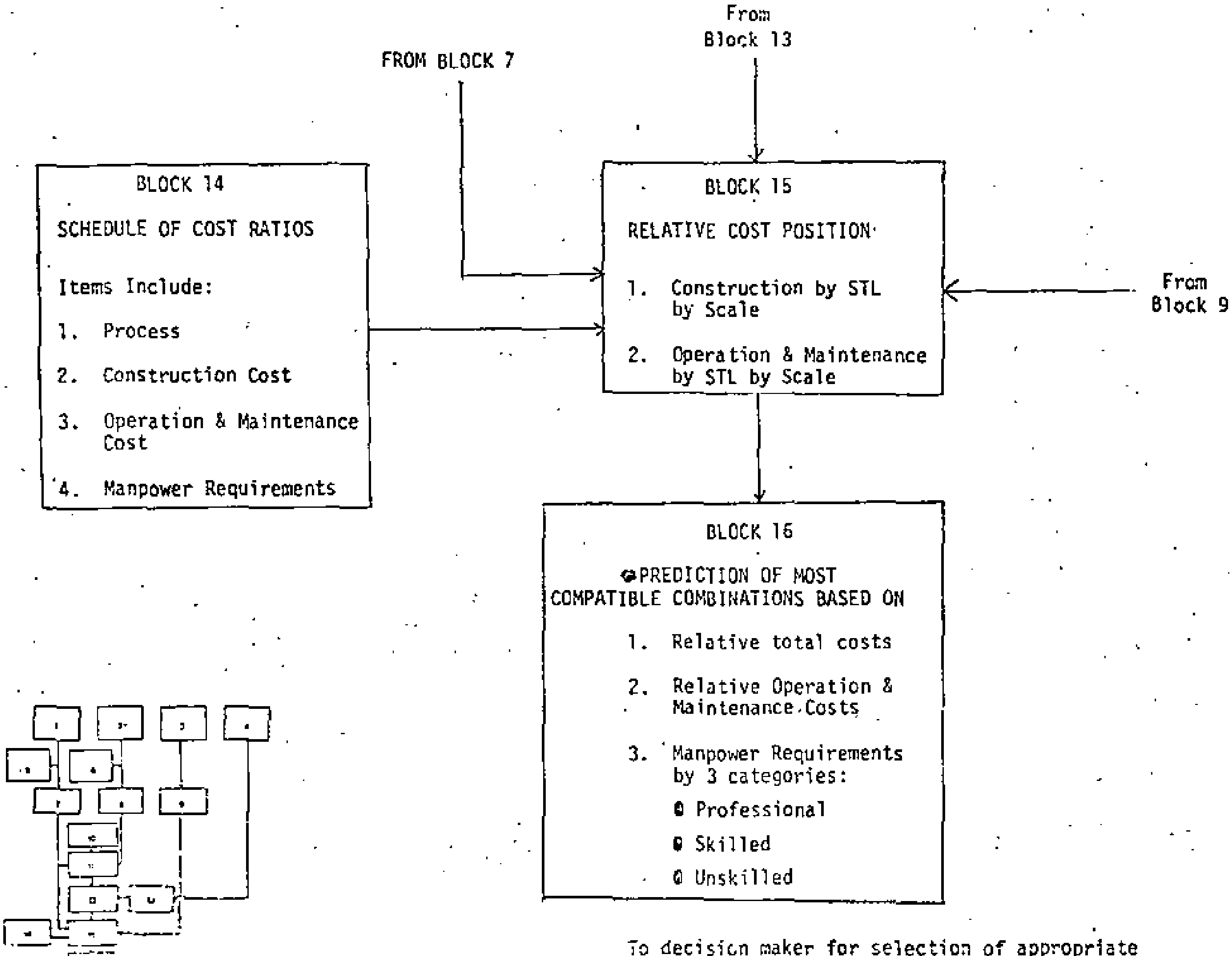
From Block 1
From Block 2
From Block 3
From Block 4
COMMUNITY PROFILE LEVEL CALCULATION
Block 5 Relative Social-Economic Weighting Factors
Block 6 Relative Indigenous Resource Weighting Factors
Block 7 Social Technological Level (STL)
Block 8 Resource Capability (RC)
Block 9 Population Forecasting (POP)
PROCESS FEASIBILITY
Block 10 Process Constraints
Block 11 Available Processes
PRELIMINARY PROCESS SELECTION (FEASIBILITY COMBINATIONS)
Block 13 Suitable Process Combination
Block 12 Schedule of Acceptable Combination
COST ESTIMATE OF SELECTED COMBINATIONS OF PROCESSES
Block 14 Schedule of Cost
Block 15 Cost
FINAL SELECTION OF PROCESS COMBINATIONS
Block 16 Most Compatible Based on:


From Block 1
BLOCK 5
Relative Social-Economic Weighting Factors (Wst)
BLOCK 7
SOCIAL TECHNOLOGICAL LEVEL (STL)
These levels are used to estimate manpower availability in Skill categories.
I - 1-23
II - 24 - 51
III - 52 - 93
IV - 94-133 - DC
Alternate Classification Process on pages 68 - 72 of the text. (scenario method)
To Block 11
To Block 15


From Block 3
BLOCK 6
Relative Indigenous Resource Weighting Factors (Wir)
From Block 2
BLOCK 9
Population Forecasting (POP)
Also determines which of the four population scale levels is correct for the community to be served.
I - 500-2500
II - 2500-15,000
III - 15,000-50,000
IV - 50,000+
BLOCK 8
Resource Capability (RC)
Indicated by a confirmation of any four categories
To Block 11
To Block 15


BLOCK 10
PROCESS CONSTRAINTS
(See Table III, 1.2)
From
Block 7
BLOCK 11
AVAILABLE PROCESSES
Selected on the basis of STL and RC in relation to the Process Restraints
From
Block 8
BLOCK 12
SCHEDULE OF ACCEPTABLE COMBINATIONS.
To bring raw water to the desired quality.
(See Table III 1.3)
BLOCK 13
SUITABLE PROCESS CONBINATION, SYST
Based on the community profile and Raw Water Quality or Receiving Water Dilution Available.
To
Block
15





To decision maker for selection of appropriate
[illegible]nology based on assessment of local objectives

TABLE 4. POPULATION SCA[illegible] (2,500 - 14,999)
PER CA[illegible]ITA [illegible]OST RATIOS
CONSTRUCTION/OPERATION AND MAINTENANCE

Process			Social-Technological Levels (STL) I	II	III	IV
(No Treatment)	PW1	Construction	2.70	2.43	1.48	1.37
		Operation and Maintenance	1.75	2.01	3.01	3.53
(Pre-Treatment)	PW2	Construction	2.20	2.50	3.00	3.25
		Operation and Maintenance	6.74	7.17	7.67	8.15
(Slow S.F.)	PW3	Construction	11.29	13.48	14.66	15.00
		Operation and Maintenance	2.94	5.71	6.06	6.45
(R.S.F. - Conv.)	PW4	Construction	22.00	19.89	14.45	11.00
		Operation and Maintenance	4.90	8.27	9.93	10.45
(R.S.F. - Adv.)	PW5	Construction	70.94	59.57	50.00	40.88
		Operation and Maintenance	43.13	41.68	40.22	38.77
(Softening)	PW6	Construction	115.86	90.49	65.12	39.75
		Operation and Maintenance	38.48	37.52	36.57	35.61
(Disinfection)	PW7	Construction	3.81	3.57	2.94	2.80
		Operation and Maintenance	18.47	15.65	12.54	11.42
(Odor, Taste, Fe, Mn)	PW8	Construction	91.34	80.44	70.53	59.63
		Operation and Maintenance	51.00	49.28	47.56	45.84
(Desalting - Salt)	PW9	Construction	146.94	129.63	117.31	95.00
		Operation and Maintenance	24.77	25.17	23.92	22.26
(Desalting - Brackish)	PW10	Construction	120.04	105.53	91.01	77.50
		Operation and Maintenance	37.87	36.59	35.31	34.03
(Disinfectant Filter)	PW12	Construction	30.25	28.55	26.74	24.12
		Operation and Maintenance	27.78	25.45	23.25	20.64

Note: Complete cost ratio tables may be found under Session 3.4, "Manpower, Costs, and Equipment".

Level (Block 7)	Unskilled	Skilled	Professional
I	X		
II	X	X	
III (pop. < 50,000)	X	X	
IV	X	X	X

WATER PROCESSES VS. MANPOWER REQUIREMENTS FOR POPULATION LEVELS

MANPOWER REQUIREMENTS / PROCESS	Level	Unskilled	Skilled	Professional
PW 1	1	1		
	2	2		
	3	4		
	4	8		
PW 2	1	1	1	
	2	1	1	
	3	3	2	
	4	5	2	
PW 3	1	1		
	2	2		
	3	5		
	4	5		
PW 4	1	1	1	
	2	1	1	1
	3	8	2	1
	4	10	3	1
PW 5	1	1	1	1
	2	1	1	1
	3	6	2	2
	4	10	5	2
PW 6	1	1	1	1
	2	1	1	1
	3	6	2	2
	4	10	5	2
PW 7	1	1		
	2	1	1	
	3	2	1	1
	4	4	1	1
PW 8	1	1	1	1
	2	1	1	1
	3	6	2	2
	4	10	5	2
PW 9	1	1	1	1
	2	1	1	1
	3	6	2	2
	4	10	5	2
PW10	1	1	1	1
	2	1	1	1
	3	6	2	2
	4	10	5	2
PW11	1			
	2			
	3			
	4			

SOLUTION PROCESS REVIEWED

STEP ONE

Determine the social technological level, indigenous resources, Scale, Goals.

STEP TWO

Use the indigenous resources, social technological level to find available processes.

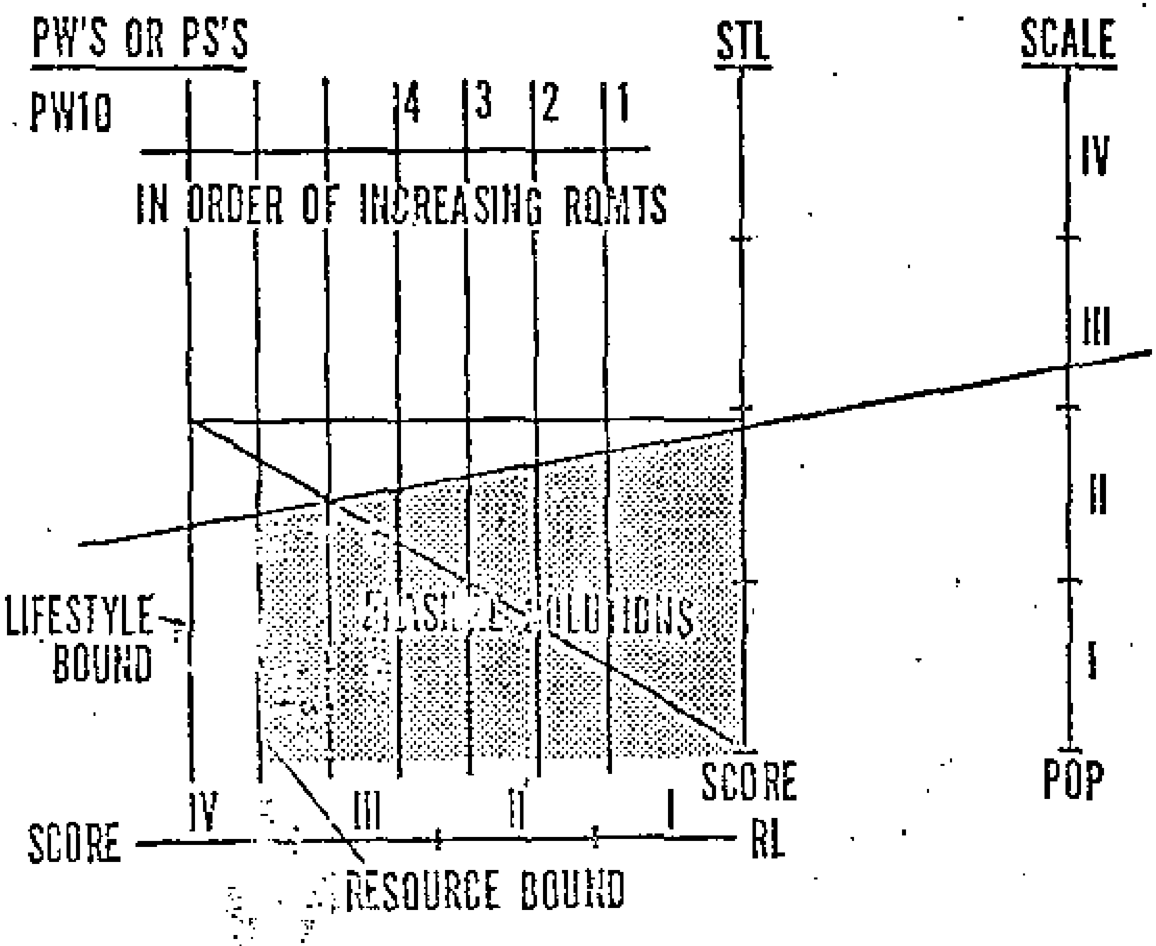
STEP THREE

Use population, goals, and available processes to find suitable combination.

STEP FOUR

Arrive at manpower and costs from social technological level and scale.

PROCESS SELECTION



STEPS

A – IDENTIFY STL SCORE DRAW HORIZONTAL LINE TO 45° LINE TO SET PROCESS BOUND.

B – IDENTIFY R.S. SCORE DRAW VERTICAL LINE AS BOUND

C – LINE (ONE OF TWO) CLOSEST TO STL LINE DEFINES SOLUTION AREA, OR PROCESSES THAT HAVE BEEN SCREENED.

D – IDENTIFY SCALE, CONNECT TO FURTHER DEFINE AREA.

E – IDENTIFY WQS – RAW VS. GOAL

F – SELECT PW &/OR PS IN PROPER COMBINATION TO MEET WQS.

Session 1.4

Title: Client/Donor and Engineer/Donor Relationships

Objective: To explain the genus of this program - poorly used resources due to selection of inappropriate technology.

ABSTRACT

(excerpt from text, Chapter 1, p. 7) 2/

In studying the problem of technology transfer, the engineer/client relationship was seen to be of critical importance:

In the design of water supplies the choice of components, materials and dimensions is often governed by codes of practice or by professional conventions which engineers trained in the West too readily take for granted. And not only do these conventions tend to limit the adaptation of design to local needs, but like the WHO standards for water quality, they are suited to the needs of urban water supply in Europe rather than to village water supply in the tropics. Thus codes of practice may lead to the choice of unnecessarily expensive materials or equipment, or may discourage an engineer from improvising when the "correct" components are not available. Every village deserves the best possible engineering design for meeting all the immediate objectives, but given the kind of objectives which seem right for rural water supply, the "best possible" may not always look a good solution when measured against Western codes of practice.

Some engineers are conscious of this dilemma, but feel that if they chose an unorthodox solution to a specific problem and the equipment failed and led to an outbreak of disease, they would carry an undue burden of responsibility; but if they had followed the "correct" design conventions, they would not be blamed (21).

SESSION OUTLINE:

I. Introduction

A. Global Conference - WHO and OU, 1975

1. Objectives of Conference

a. to assess the state of the art in water and wastewater treatment
b. to establish priorities for various studies to be done
c. to discuss the development of international coordination of programs

B. Need for community water supply - nearly 1/3 of the world's population has no adequate water supply, and only 0.8% are served by sewage treatment facilities

C. Water supply and sanitation are an integral part of the development process (lessons of history)

1. Each country needs:

a. an overall national plan
b. to establish water resources planning aid
c. to establish relations between in-country universities, which in turn should communicate with out-of-country (developed country) universities, etc.

D. Program failures - due to several factors

1. Shortage of resources
2. Lack of governmental support within the LDC
3. Inadequate institutional structures
4. Lack of local acceptance or interest

E. While the need is greater among dispersed populations, the aid could be more effective if concentrated on nucleate units.

F. Other conclusions of the Global Conference

1. Groundwater should be given priority as a source of water supply
2. Slow sand filters have proven effective in developing countries
3. Lagoons have also proven effective in developing countries
4. Different standards apply to developing countries, than apply to developed countries. Don't confuse goals with standards.
5. Local professionals prefer to rely on foreign consultants
6. Importance of involvement of locals from start of project
7. The local public and decision-makers need to be familiar with the processes.

I. Selection of appropriate technology - using the predictive model as a tool

A. Inappropriate technology has led to ineffective and inefficient use of international investments.

1. Examples of inappropriate use of technology

B. Technology should be appropriate to in-country manpower, materials, and societal support

C. Encourage design of in-country operable and manageable processes

II. Engineer/Client Relationship

A. The engineer is working in an alien and often very complicated environment.

B. There are at least eight separate, frequently conflicting elements which the engineer must take into consideration (See figure 1.1)

V. AVCO/Reid Study

A. Results showed that 80% of the decision-makers wanted what everyone else was currently using; 15% wanted older, cheaper solutions; only 5% wanted innovative solutions

B. The engineer's interest is limited to the task of getting the plant built

C. Neither the decision-maker nor the engineer appeared to be interested in the ability of the plant to continue functioning (design & walk away)

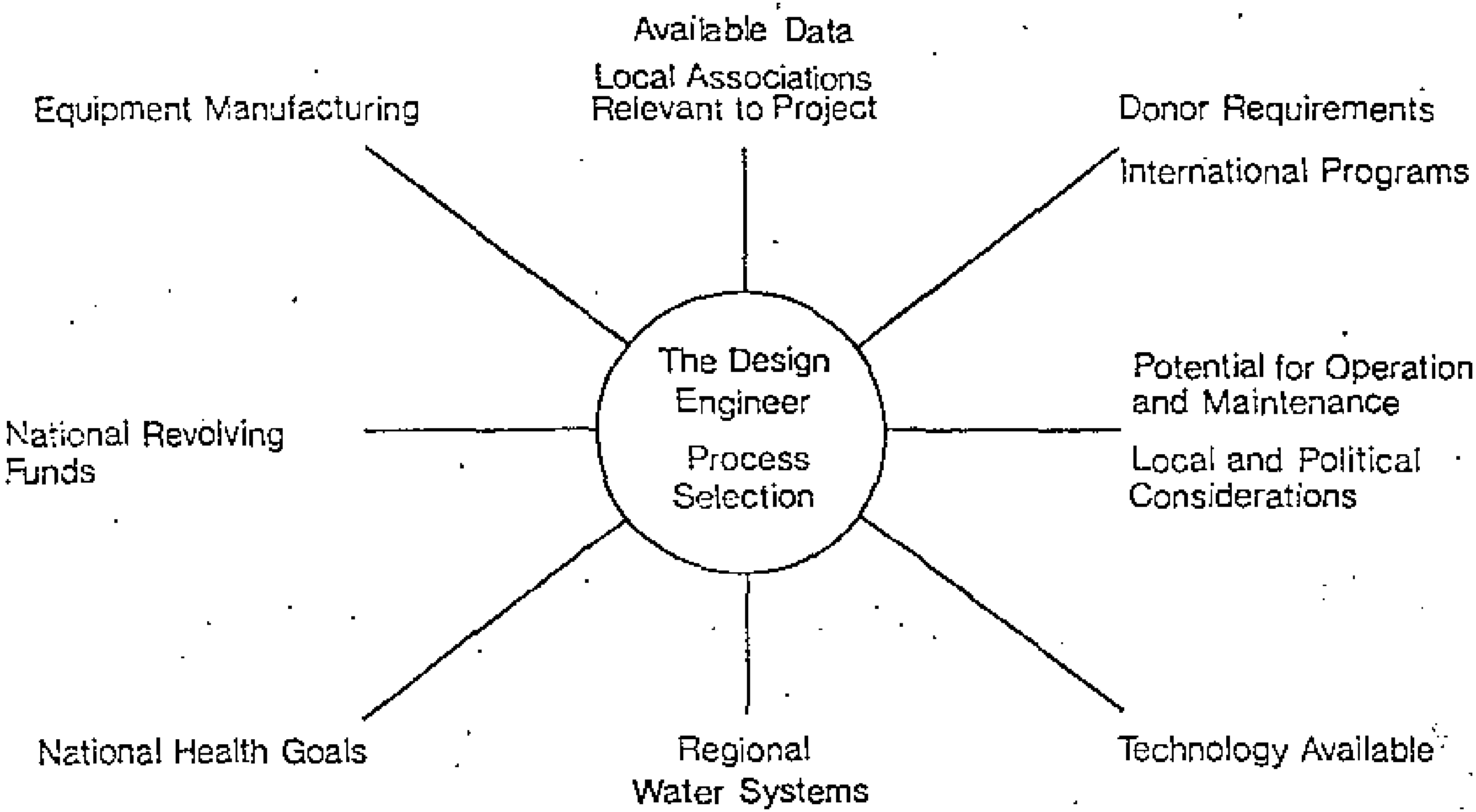

Available Data
Local Associations
Relevant to Project
Equipment Manufacturing
Donor Requirements
International Programs
The Design
Engineer
Process
Selection
Potential for Operation
and Maintenance
Local and Political
Considerations
National Revolving
Funds
National Health Goals
Regional
Water Systems
Technology Available

Figure I.1

. Expatriate Advisors

A. Often, in-country engineers preferred to transfer responsibility of plant design to an "out-of-country" expert

B. Nine specific problems are associated with use of expatriate advisors

1. The Promoter
2. The Biased
3. The Vacationers
4. The Impossible
5. The Irrelevant
6. The Confusion
7. The Out-of-Place
8. The Sophisticates
9. The Old-Timers

I. Communication Linkages - need for improvement in communication between the developing country's areas of need and the technology sources in developed and developing countries.

A. Gate keeper concept

B. Publications

C. Special courses and workshops

D. On-hand observation

II. Education - it is necessary to build up scientific competence within the developing country

A. Emphasis of system approach in education

B. Incorporation of concepts of appropriate technology

VIII. Relationships of nucleated sites to rural and community supplies

A. Nucleated sites are considered to be those with a population of less than 300.

B. Communities are broken down into two categories

1. Rural - population less than 800

2. Urban - population of greater than 800

IX. Relationship to other needs

A. Health

B. Education

C. Transportation

Session 2.1 80

Title: The Local Scene 81

Objective: Each workshop will relate to the local socio-economic and resources problem, the purpose herein is for a resident expert to explain the in-country situation as it pertains to water and wastewater treatment. In addition, there will be a discussion on collection of data at side level to operate the model.

SESSION OUTLINE:

I. Description of existing condition in terms of selection and prioritizing water and wastewater treatment construction

A. Demography

1. Distribution
2. Rates of growth

B. Economic

1. Sector activity level
2. Bi-lateral support

C. Institutional Arrangements

1. National agencies
2. Regional agencies
3. Local agencies
4. Educational institutions

II. Water, Sewage and Health Problems

A. Historical experiences

1. Governmental
2. Bi-lateral

B. Existing programs

1. Governmental
2. Bi-lateral

C. Future programs

1. Governmental
2 Bi-lateral

III. Amount and access to - necessary data for input into Predictive Model

A. Raw water quality - receiving stream quality

B. Drinking water standards - effluent standards

C. Socio-technological data

D. Demographic data

IV. Appropriate Technology Activities

A. In country successes and programs - historical perspective

B. Incorporation of imported concepts of appropriate technology

C. Educational programs in appropriate technology

D. Risk analysis of involvement in appropriate technology in the treatment of water and wastewater technology

V. Problem Areas

A. Dispersed rural communities

1. Significance of the problems
2. Present program
3. Possible solution

B. Small nucleated communities

1. Significance of the problem
2. Present program
3. Possible solution

C. Medium-sized communities

1. Significance of the problem
2. Present program
3. Possible solution

85

D. Large nucleated communities

   1. Significance of the problem
   2. Present program
   3. Possible solution

VI. Specific Problems of collecting (or availability of) necessary data

   A. Social technological Data

   B. Indigenous Resources Data

   C. Demographic Data. (Population)

   D. Water & Wastewater Quality Data

Session 2.2 87

Title: Prioritizing Model 87

Objective: Developing criteria for selecting which among the proposed projects should be executed, and of the order in which those selected should be implemented.

Methodology for Establishing Priorities among Water Supply Programs: A Case Study

(excerpt from CHAPTER V,* p. 167)

This chapter presents a methodology for setting priorities for water supply programs and represents a condensed form of material which has not been published previously. In this study analysis was made of the Indonesian Rural Water Supply Program. There were found to be three major constraints in executing that Program, namely, money, time, and manpower. The problem was to develop criteria for selecting which among the proposed projects should be executed first. Existing priorit models were deemed unsuitable for application in Indonesia at the present time because of the particular program strategies and conditions prevailing, and also because of the lack of well-trained engineering personnel, especially at the levels whe the selection of the project localities is made.

In this chapter a delineation is made of the relevant Indonesian administrative hierarchy, population characteristics, and the water and sanitation situation. In the study, the following ten prioritizing parameters were established: waterborne, diseases, difficulty in obtaining water, technological alternatives, population, village contribution, village potential, public places, excreta disposal, road conditions, and power supply. These are discussed in detail in this chapter.

Through the use of forms and questionnaires extensive data was obtained on particular localities in Indonesia. This da was subsequently processed, and some of the results are presented here to demonstrate utilization of the prioritizing model

* By Dr. Soetiman

92

SESSION OUTLINE:

I. Definition of a Prioritizing Model

In general it is a tool to assist in selecting which among proposed projects should be implemented first.

II. Why the need of a model to help select which communities and/or areas that water treatment/waste treatment improvements are to be made

A. Limited amount of funds to build water and/or waste treatment systems.

B. Competition among villages and communities within a country.

III. General Considerations for Priority Models

A. Strategies

1. Best first
2. Worst first
3. Economics of scale
4. Financial viability
5. Income redistribution
6. Large populations (serve most people)

7. Political

8. Social

IV. Literature Review - Existing Model (Page 188)

A. World Bank Paper - Based Upon Three Things

1. Village needs

a. Village interest
b. Adequacy of existing supply in terms of quantity
c. Convenience
d. Reliability during drought
e. Quality considerations
f. Prevalence of waterborne disease

2. Village potential

a. Growth of the community
b. Growth of institutions
1.) Economic activities
2.) Health
3.) Educational center
c. Non-domestic water uses
1.) Agricultural
2.) Cottage industries
3.) Produce preparation

3. System cost

a. Population distribution
b. Nature of the water source
c. Accessability of supply

B. Economics and Policy - Saunders & Warford

1. Economics of large scale production

a. Leads to the conclusion, the project serving the greatest number should be implemented first
b. Rank according to population

2. Service quality

a. Transmission costs
b. Source works - public hydrant versus house connections

3. Growth point strategies

a. Create centers which will hold populations and hold economic activities
1.) Educational facilities
2.) Roads
3.) Market places
4.) Water and wastewater

4. Income redistribution - "worst case strategy"
Rural investment results in high to low income redistribution

5. Financial viability and community enthusiasm

a. Not consistent with worst case strategy
b. Consistent with a growth point strategy
c. If community does not perceive a need for the project, usage rate will be low.

C. Criteria adopted by countries for assigning priorities

1. Population, size, density (30)

2. Scarcity (23)

3. Development (23)

4. Health (21)

5. Social reasons (18)

6. Community demand (18)

7. Cost (9)

V. Priority Models

A. Linear programs - PSA group of WHO in 1973 for Rural Water Supply Program in Indonesia

Maximize functions

1. Population

2. Water demand

3. Budget - expected

4. Probability of foreign investment

5. Level of foreign investment

6. Probability of domestic investment

7. Level of domestic investment

8. Expected technology costs

VI. Different Priority Models

A. Linear Programming Model - WHO - PSA Group

B. Pragmatic Approach - WHO - PSA Group

C. Priority Index Formula - PAHO

D. Reid and Discenza Model - AT/LDC Model

E. Priority Index - OU/Soetiman (Indonesian)

VII. Linear Programming Model

A. Developed in 1973 by the PSA Group of WHO experts for assigning priority for the Rural Water Supply Program in West Java Providence, Indonesia

B. Formula R in text on page 194

C. Disadvantages

1. Very sophisticated

2. Every constraint requires a separate analysis

3. Requires that personnel involved have a background in economics, mathematical statistics, demography, and engineering

VIII. Pragmatic Approach

A. There is no basic formula for ranking every variable

B. It requires practical experience and to some extent personal judgement

C. Developed by PSA Group as alternative model for the linear programming approach.

D. Basic characteristic of the method is a systematical integration of hydrological, hydrogeological, technological, demographic, health and socio-economic information

E. The quantification of most of the above variables follows an integrative process consisting of 12 steps (page 195)

IX. The PAHO Priority Index Formula

A. Developed in Mexico by the Pan American Health Organization

B. The Formula is

$$I = 100 \frac{P}{C-A} rk$$

$\frac{P}{C-A}$ = Inverse of cost per capita of the system

r = Index or physical availability

k = Index of concentration of houses

C. The priority index formula is much simpler and more realistic than the previous two

D. All variables easy to quantify

E. It fits the strategies

1. Economics of scale

2. Financial viability

F. It reflects the "best first" strategy

G. Model implies communities with

1. Larger population

2. Higher village contribution

3. Higher house density

4. Abundance of water sources

H. In General a Larger Population indicates better economic development, better educational levels and better sanitation conditions in the community. In other words this type of community does not need very much help.

X. Reid-Discenza Model

A. Was not suitable for the Rural Water Supply Program in Indonesia

B. Mainly because inputs were not available

The inputs were

1. Socio-technological factors

2. Indigenous resources

C. The method of development and utilization is the same as for the Priority Model

XI. Model Development

A. The objective of the study was to develop a model which would establish priorities for the Indonesian Rural Water Supply Program - taking into consideration the strategy established by the country

B. Also had to consider the qualifications of the personnel that would use the model

C. The model developed is a very simple one and is a matrix system in mathematical terms is expressed as

$$PI_j = \sum_{i=1}^{10} W_i \cdot S_{ij}$$

PI = Priority Index

W = Weight of each parameter

S = Score of each parameter

i = A subscript denoting the i^{th} parameter

j = A subscript denoting the j^{th} village

where:

villages represent matrix rows

parameters represent matrix columns

D. The entries consist of the product of weight times score of each parameter -- $W_i S_{ij}$

E. The 10 elements that make up the variables of the model are

1. Waterborne diseases
2. Difficulty in obtaining water
3. Technological alternatives
4. Population
5. Village contribution
6. Village potential
7. Public places
8. Excreta disposal
9. Road conditions
10. Power supply

F. Why the above 10 variables among many which could be selected

1. They fit the strategy of the Indonesian Rural Water Supply Program.

2. They were relevant to the program.

3. They were suitable to the Indonesian rural conditions and characteristics.

4. They were feasible because they could be obtained with the data which was available.

G. Six of the above are the same as the criteria adopted by countries for assigning priority in providing new community water supplies.

H. A discussion of the relevance of each parameter can be found starting on page 201 of the large text.

1. Waterborne diseases

   This variable could be given the highest weight because water plays an important role in transmitting diseases.

2. Difficulty in obtaining water

   For rural water supply - distance is very important. Also change in elevation (climb or descend) is important.

3. Technológical alternatives

   Type of water treatment technology to be installed will be based on the availability of water sources and the capability of the community to operate and maintain the system. Choose the simplest and most economical systems.

4. Population

   This parameter is associated with the economy of the project. More important in this respect is whether the population is nucleated or dispersed -- population receives a high weight.

5. Village contributions

This parameter reflects village interest and involvement in the program. Village contributions, income, money, labor and local materials.

6. Village potential

This parameter includes the elements of economic growth potential and manpower. Maybe best way to express is income per family. In Indonesian study this variable was expressed as the Village Economic Growth Potential measured as type of 1) land use 2) mineral resources 3) industrial development and number of infrastructures and utilities.

7. Public places

Public places play an important role in spreading or controlling waterborne diseases.

8. Excreta disposal method

This parameter is expressed in terms of the percentage of houses in each village using sanitary excreta disposal methods such as septic tanks, latrines, fish pond.

9. Road conditions

Important because of transporting equipment and materials during construction and later maintenance. Accessible road will reduce the construction cost and save time.

10. Power supply

Availability of electric power will be very helpful because it will reduce the costs of operation and maintenance -- electric pump is easier to operate and maintain than a diesel pump.

I. Weighting Process

The Delphi Method was used as the weighting process
need: A panel of experts
kept apart
asked to rank each variable

The average weight of the ten (10) parameters can be found on page 207.

J. Scoring Process

The scoring process consisted of the categorization of the data and score assignment of each data category.
Efforts were made in categorization to quantify as many of the parameters as possible.
The score values ranged from 0 to 15.

K. Test of the Model

See page 219 - 229

L. Discussion of Results

A. Five of the ten variables could not be used because the data was not available.

B. Two of the five remaining variables used (waterborne diseases and village contributions) did not affect the PI values because most of the villages within the same group had the same scores. -no variation-

C. In future surveys data collected should be conducted by well-trained staff to insure reliability of data.

D. In developing models of this type one has to use inputs and variables which can reasonably be obtained.

E. Also the variables have to have variation - otherwise the model will not work.

TABLE V.22
PI VALUES FOR VILLAGES IN THE IBU KECAMATAN

No.	Village	$W_i.S_{ij}$					PI
		Waterborne Diseases	Difficulty in Obtaining Water	Technological Alternatives	Population	Village Contributions	
1.	Podal	0	14	111	35	161	321
2.	Tengwango	0	86	97	23	161	367
3.	Togowo	0	86	97	23	161	367
4.	Duno	0	86	42	35	161	324
5.	Tokowoko	0	14	111	12	161	298
6.	Goin	0	14	42	23	161	240
7.	Sangaji Nyeku	0.	14	42	23	161	240
8.	Sangaji Adu	0	14	42	12	161	229
9.	Toguis	0	115	42	12	161	330
10.	Togoreba Sungi	0	14	42	23	161	240
11.	Borona	0	14	42	23	161	240
12.	Todake	0	29	42	23	161	255
13.	Sirimahu	0	86	111	23	161	381
14.	Pasalulu	0	14	42	35	161	252
15.	Togoreba	0	115	111	35	161	422
16.	Tobaol	0	14	111	35	161	321
17.	Tongutette	0	14	139	46	81	280
18.	Gam Lamo	0	14	42	35	81	172
19.	Gam Ici	0	14	139	46	81	280
20.	Tongute Sungi	0	58	42	46	81	227
21.	Akesibu	0	14	42	35	81	172
22.	Tongute Goin	0	14	42	35	81	172
23.	Maritango	0	14	42	23	81	160
24.	Kie Ici	0	144	42	35	81	302
25.	Naga	0	86	42	23	81	232
26.	Tosoa Togower	0	115	97	23	81	316
27.	Tababal	0	14	111	23	81	229
28.	Baru	0	14	111	58	81	264
29.	Aduu	0	58	111	23	81	273
30.	Ngawet Nanas Jere	0	58	111	35	.81	285

Session 2.3

105

107

Title: Consumer Acceptance; Lessons of History

SESSION OUTLINE:

I. Introduction

   A. Basic problem - "if one has a better mouse trap, how does one get others to use it?"

II. Theories of Perception - how does one perceive what one is explaining?

   A. Concepts of perception, reinforcement

      1. 3 tier brain (Skinner)
      2. 5 tier linkages (Schumacher)

   B. Who makes the decision

   C. What is the decision based on, cognitive learning of personality

III. Benefit Analysis

   A. Who benefits - group, individual, community, donor

   B. From what phase (groups and individuals)

      1. Design
      2. Construction
      3. Financing
      4. Operation (jobs)

   C. Community

      1. Industrial development
      2. Better lifestyle
      3. Better health
      4. Employment

   D. Possible consequences of appropriate and inappropriate technology

IV. Penetration

A. Demonstration projects

B. Recap advantages

C. Short courses, workshops

D. Publications, health education activities

E. Information directed to leaders (rotary clubs)

F. Information through industry itself

G. Gatekeeper (someone with a "foot in each camp")

V. Marketing Concepts

A. There are two distinct parts to the problem of marketing the contents of the workshops

1. Dissemination of the concepts of the workshop
2. Dissemination of the model for conceptual design of appropriate technology systems

B. Assumptions

1. Awareness - acceptance of concepts
2. Capability - demonstration and use

C. Concept - the user community is divided into two groups: customers for treatment systems and suppliers of those systems

1. Both groups are somewhat victimized by technological fads. (Current technology may be considered fashionable, but it is not necessarily appropriate)
2. Customers aremore or less at the mercy of the suppliers who tend to offer a limited menu
3. Suppliers of treatment systems should be included as part of the target audience for appropriate technology awareness training

D. Customer acceptance appears to rest with at least five interdependent groups

1. Decision-makers, in-country, local, and central
2. Technical staff, in-country, local, and central
3. Political staff, in-country, central
4. Consultant and advisory staff, in-country, local, and central
5. Foreign sponsor agency staff, technical and programmatic

E. Supplier acceptance appears to rest with at least four additional groups

1. Foreign architectural and engineering firms
2. Foreign equipment suppliers
3. Foreign financiers
4. Foreign government agencies promoting international trade or sponsoring development of markets for their country's goods.

F. Long-term acceptance of the concepts of appropriate technology will depend on the education of the user community

G. Development of key communicators (gatekeepers) inside and outside of the U.S. may be more valuable in the long run

H. Dissemination of the model

1. The decision model for concept design of appropriate system appears to be a good demonstration of the utility of the concepts of appropriate technology
2. The model itself does not appear to be a marketable item, however, the concept of the model is
3. Use of the model illustrates the type of information required by in-country decision-makers. Immediate value can be derived from manipulation of the model if such information can be identified and action initiated for its collection
4. There is little reason to believe that funding agencies will promote or require the use of this type model for decision making
5. It would be very helpful if a high prestige, internationally active American consulting firm could be influenced to use this type of model to assist LDC decision-makers

I. The concept of appropriate technology is several times more valuable than the application model at this time.

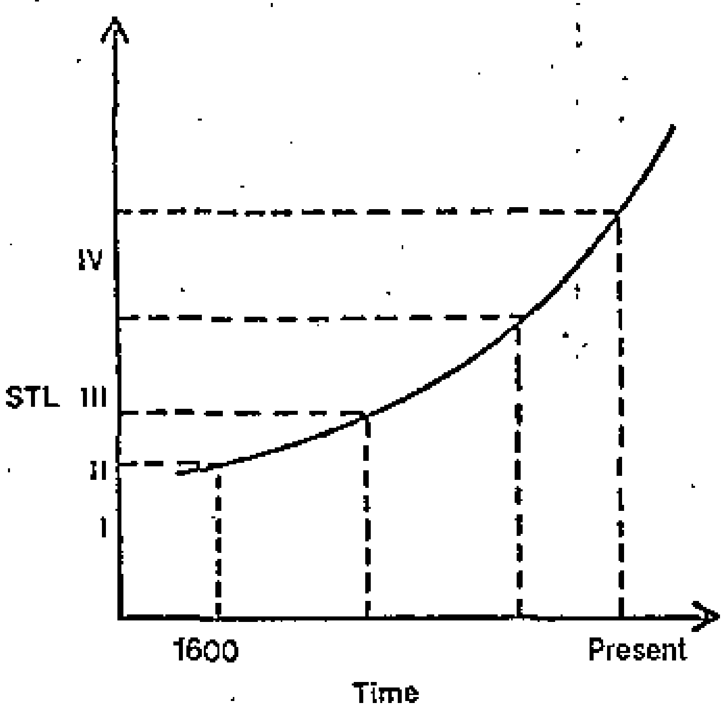
1. The concept is broad enough to be transferred to other social/ engineering applications, such as energy.

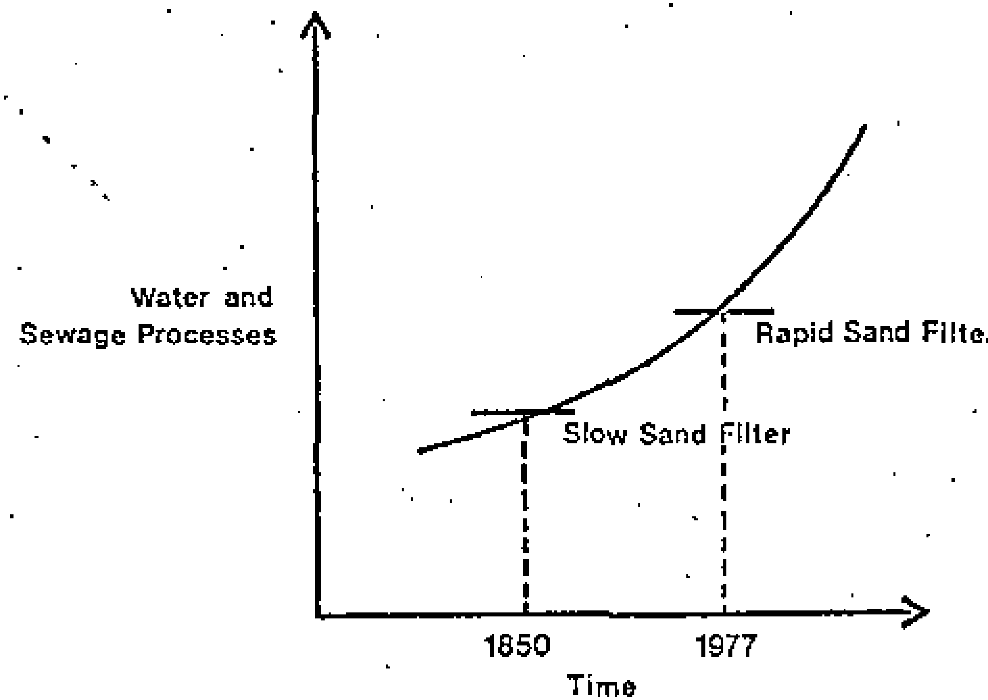
VI. Lessons of History (see text, Chapter VI, pp. 231-322)

A. Concepts of consumer acceptance

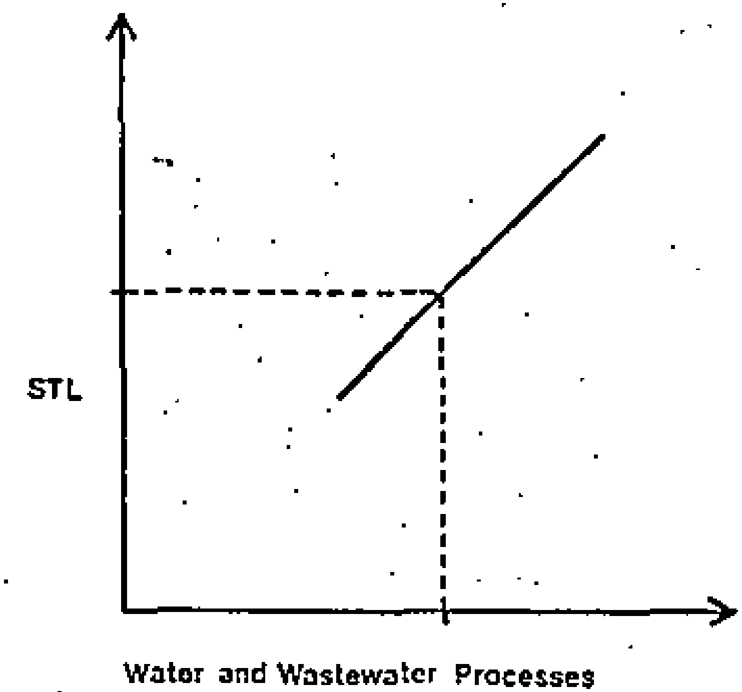
B. Concepts of retrogressive technology

C. Studies of history should lead to a schedule of sequential array of technology (time vs. technology and STL vs. time)





D. With this information, one can plot the following:



Consequently, site (STL) identification should lead to historically acceptable processes by people, e.g. consumers.

VII. Failures

A. More than twenty countries of Africa, Asia, and Latin America have reported system failures

1. Mosquito breeding
2. Inadequate maintenance
3. Heavy rainfall
4. Odor and excessive amounts of organic matter in lagoon's effluent

B. Communities in rural Africa reported numerous operational failures

1. Lack of laboratory equipment
2. Manpower leaks
3. Imported chemicals were too expensive

C. A survey of 10 treatment plants in India showed 80% improper operation

D. Other problems

1. Sedimentation tanks became breeding grounds for mollusks and sponges
2. Chlorine dosing equipment often out of order
3. Treated water was recontaminated during transport to the consumer (Brazil)
4. Physical or political failures (Kenya and Nigeria)

VIII. Successes

A. Most LDC's report stabilization ponds to be both very economical and practical

B. In India, treatment methods which require very little or no skilled supervision for operation are advocated. They are simple to construct and have a minimum amount of mechanization

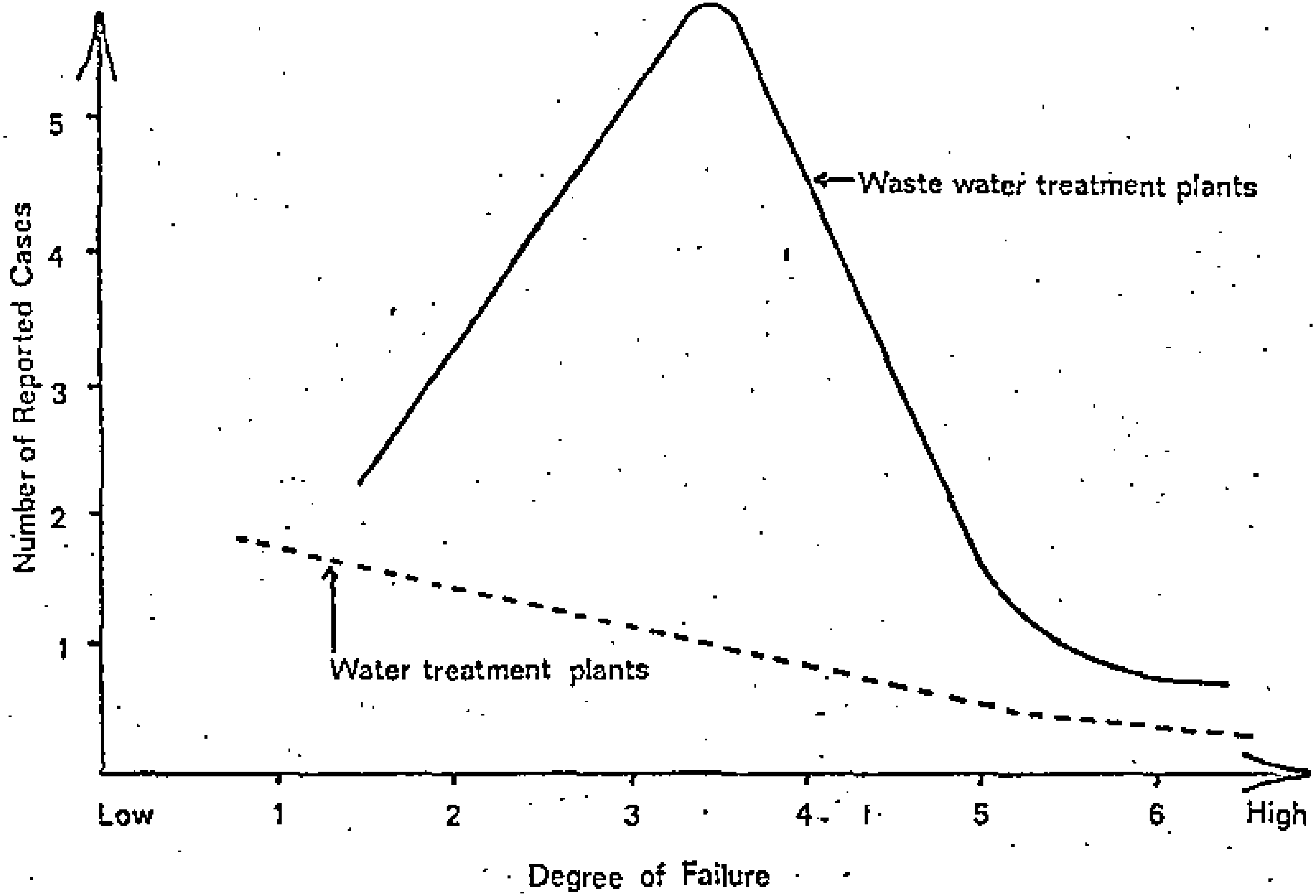
C. Land treatment for waste disposal

D. Earthenware chlorination pot (India)

E. Kenya

F. Nigeria and (hand dug wells)

Successes and Failures



Title: Model Applications, Management Implications, and Limitations

Objectives: To demonstrate some economic and management concerns with their relationship to the model.

SESSION OUTLINE:

I. Some Economic/Management Concerns and the Model.

   A. Demand for Water

   B. Cost and Delays - aggregate projects

   C. Cost and K/OM ratio

      1. Counter intuitive of capital intensive.

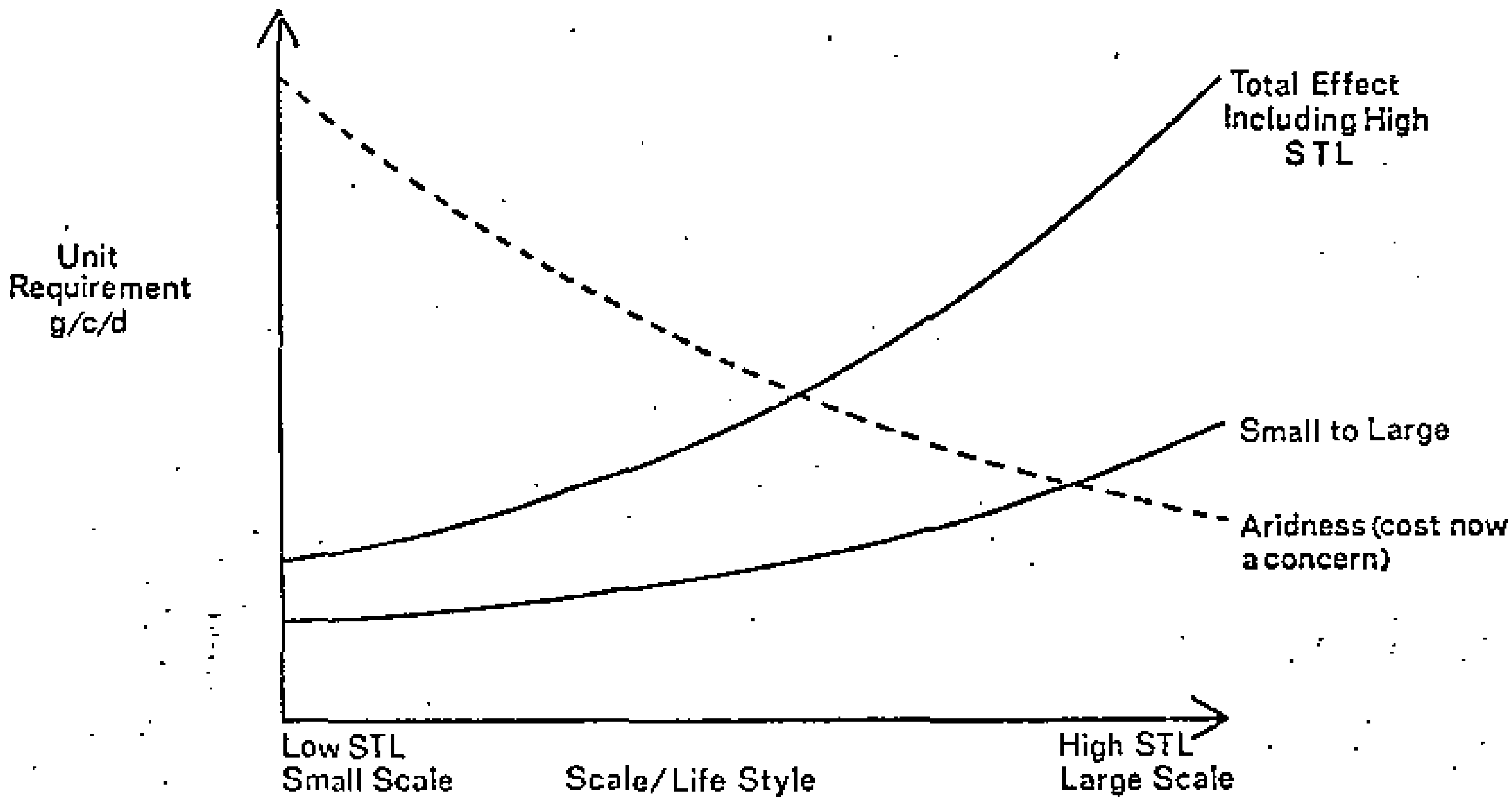
   D. Unit cost and scale

      1. Volunteerism

   E. Total Cost

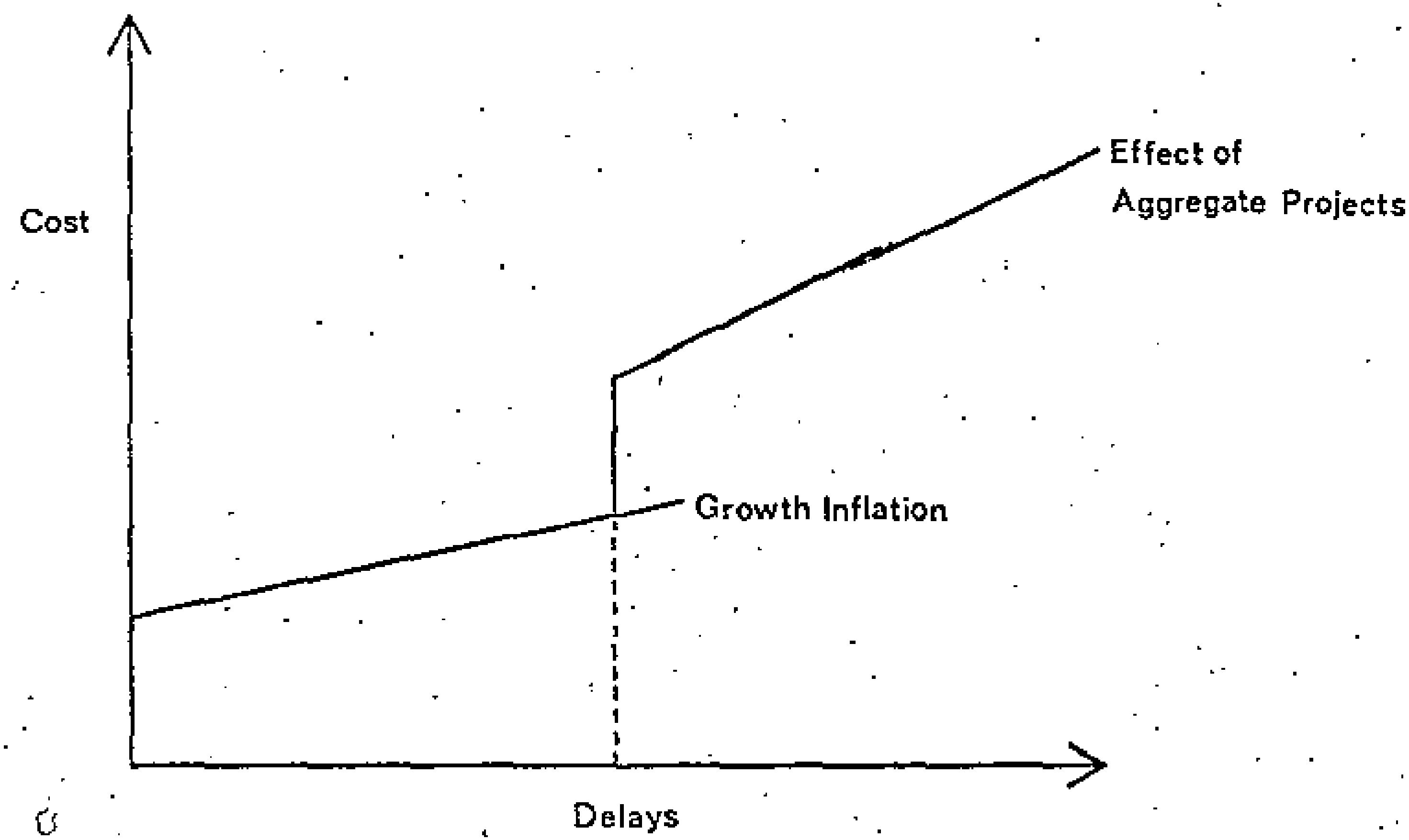
   F. Size and scale

      1. Charts 2.4a-f



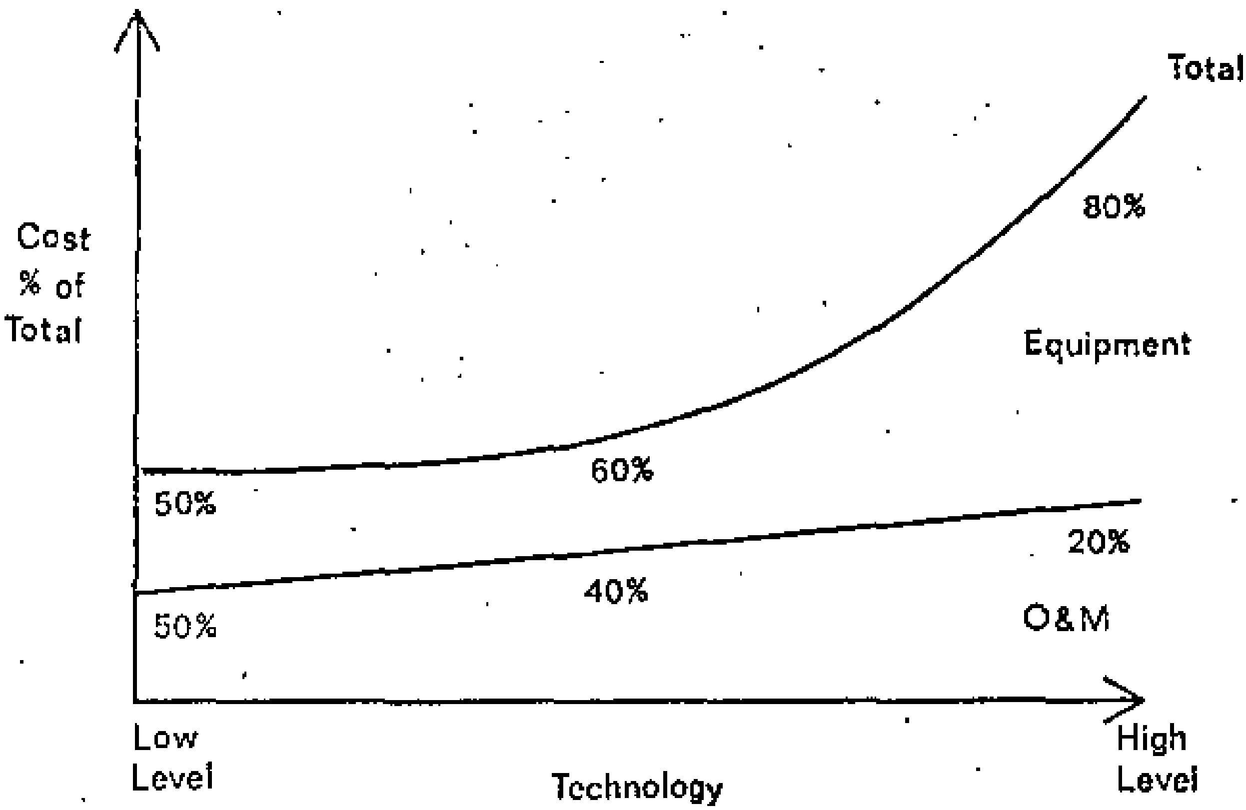
DEMAND FOR WATER, RELATED SCALE, AND LIFE STYLE

FIGURE 2.4.a



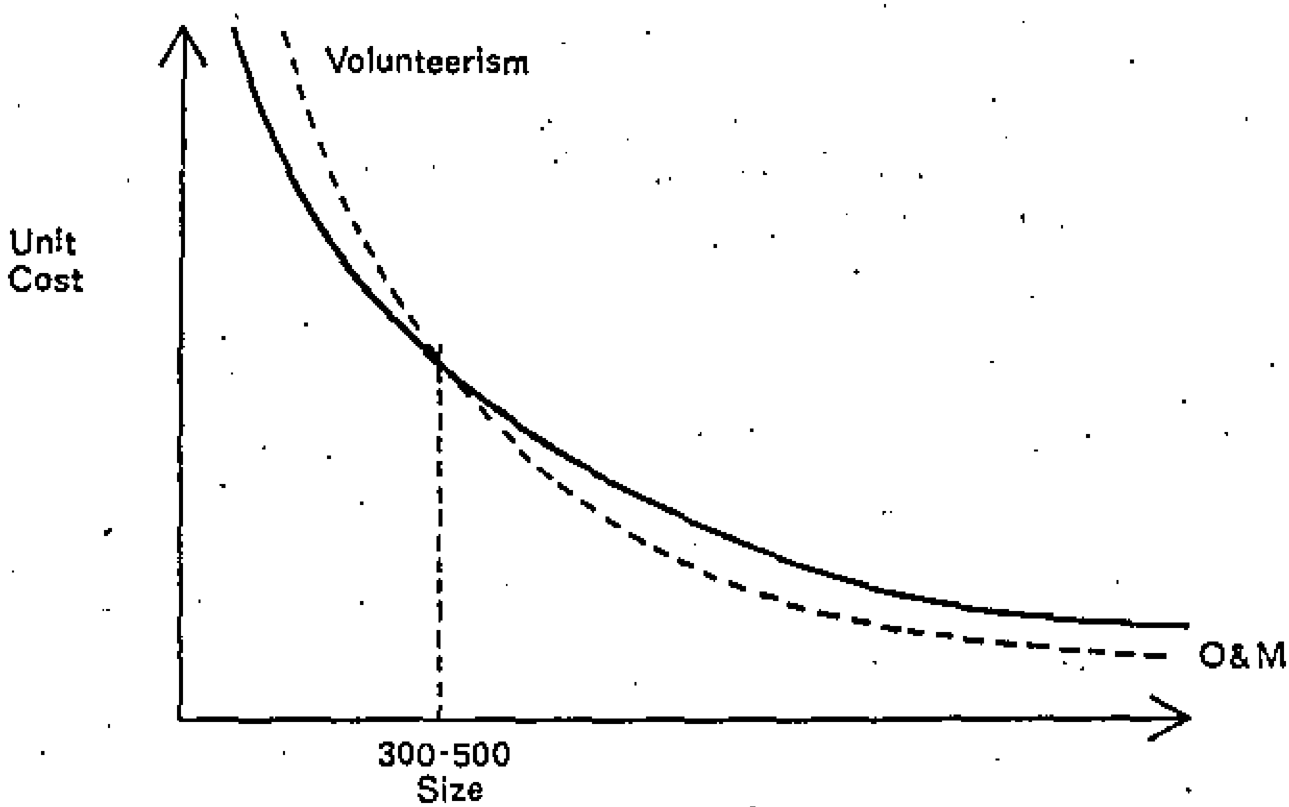
COST & DELAYS

FIGURE 2.4.b



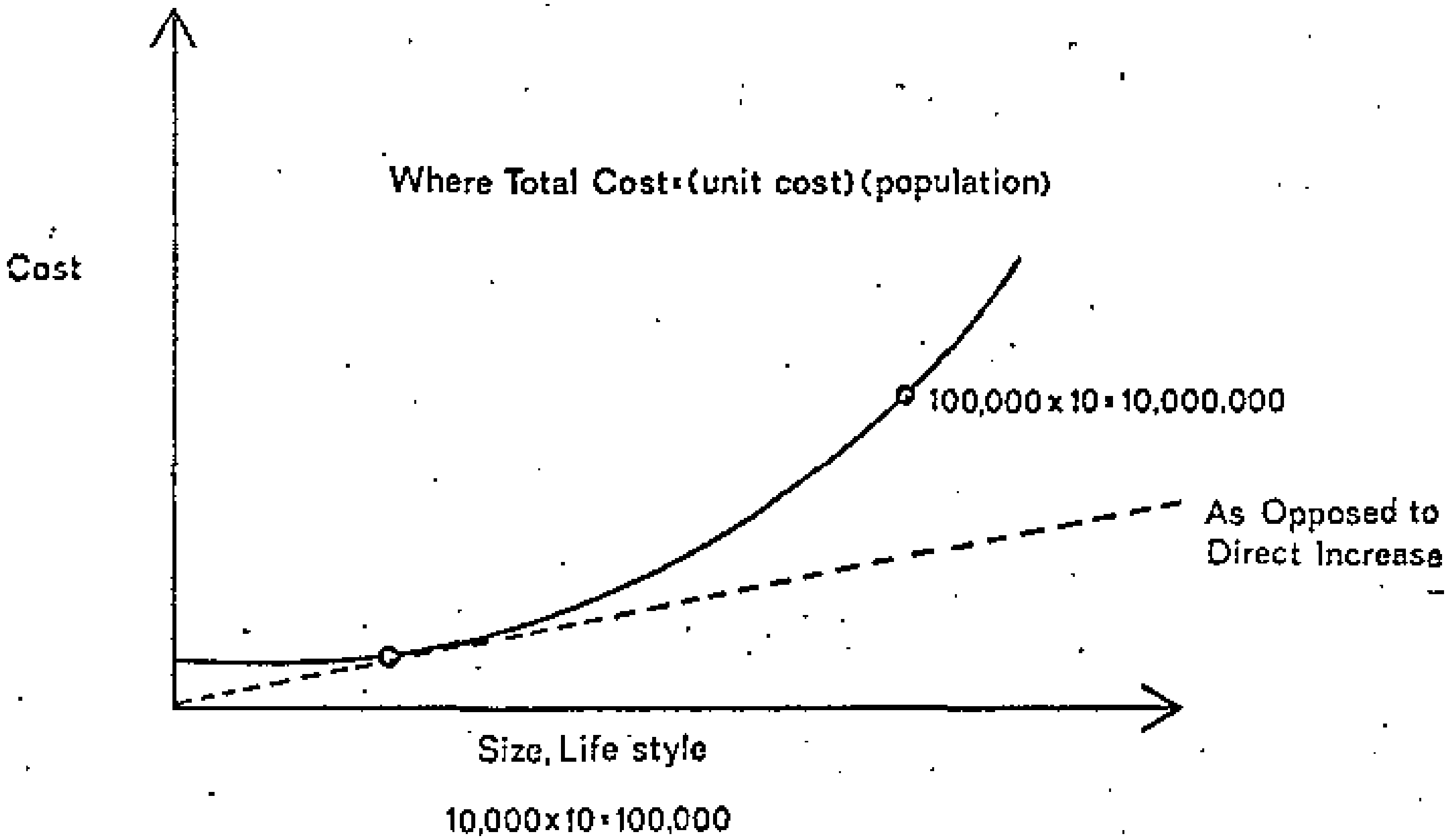
COST & K/OM AND RELATIONSHIP TO TECHNOLOGY LEVEL

FIGURE 2.4.c



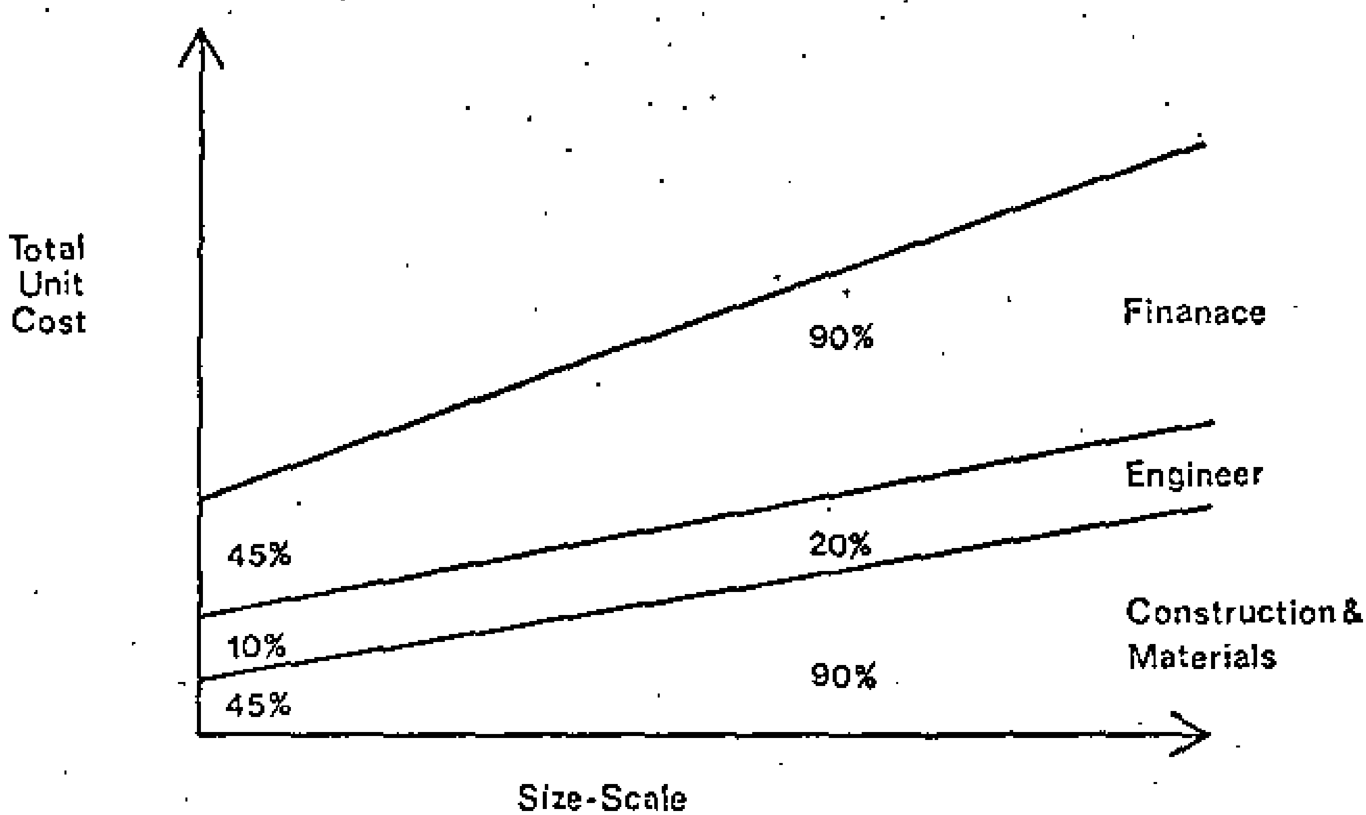
UNIT COST-SCALE SHOWING BREAKPOINT ON VOLUNTEERISM

FIGURE 2.4.d



TOTAL COST BY SIZE & LIFESTYLE

FIGURE 2.4.e



RELATIVE COSTS BY SCALE
FINANCE, CONSTRUCTION, ENGINEER

FIGURE 2.4.f

II. Sensitivity Analysis

A. Goals - Elements

1. Levels [See Workbook Figure #2.4.g]

a. Coliform, BOD., TDS., etc.
[1 → 10 → 30, etc.]

III. System Reliability (computers)

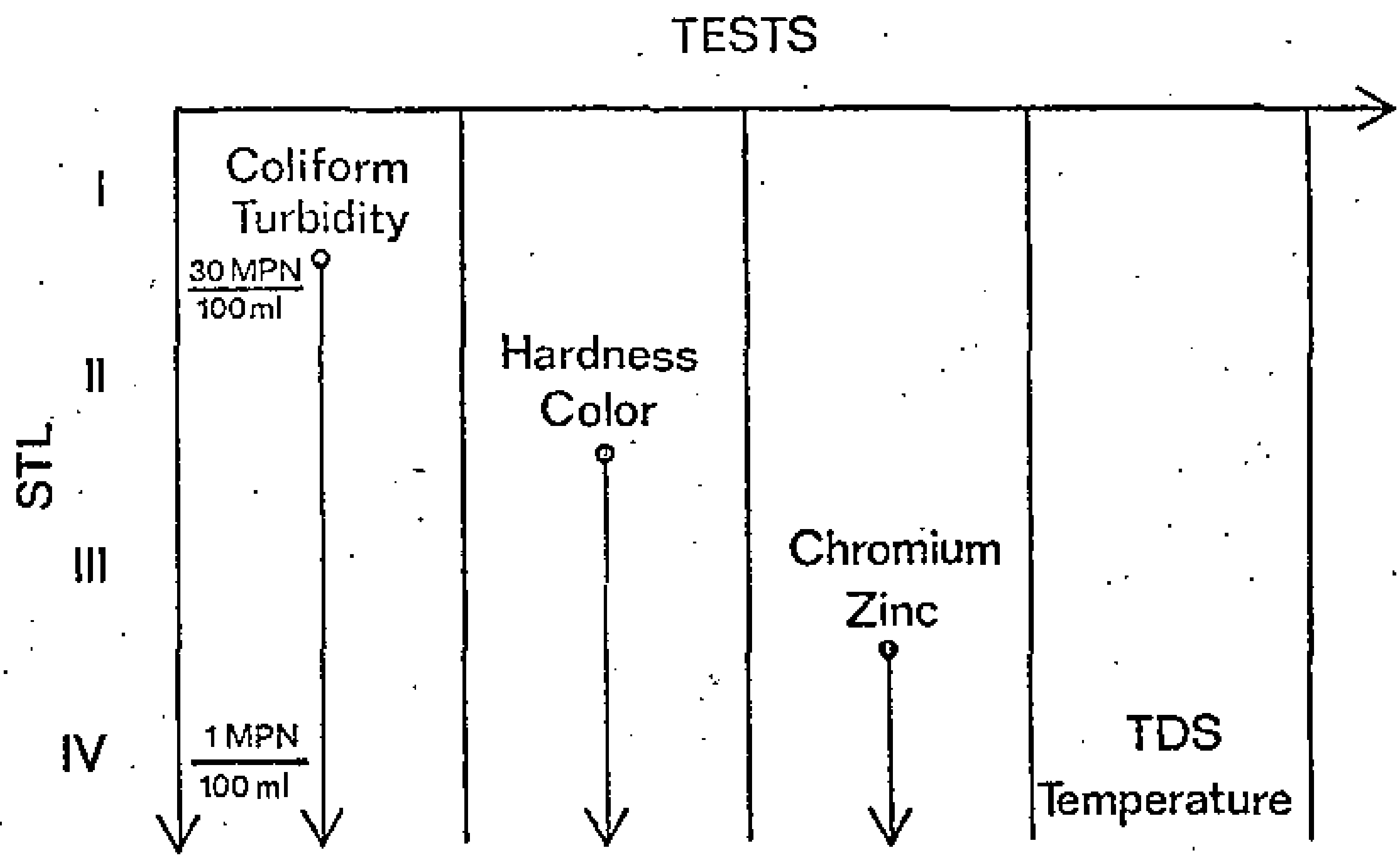
A. Modified goals

B. Resulting goals

C. STL.

1. Jumps in levels

2. Cost difference between each level jump



RELATIONSHIP OF STL TO TEST PARAMETERS

FIGURE 2.4.g

	TESTS / PROCESSES	Acidity	Alkalinity	Carbon Dioxide	Chlorine Residual	Coliform Bacteria	Dissolved Oxygen	Iron	Hardness	Odor	pH	Relative Stability	Suspended Solids	Taste	Temperature	Total Dissolved Solids	Turbidity
	<u>WATER TREATMENT</u>																
LDC	No Treatment					X											X
↓	Sedimentation					X					X		X				X
	Disinfection				X	X				X	X			X			
	Slow Sand Filter					*							*				*
	Rapid Sand Filter					X					X		X				X
	Activated Carbon					X				X			X	X			
	Aeration	X		X		X	X	X		X	X		X	X		X	
DC	Softening	X	X	X		X			*		X					X	
	<u>WASTE WATER TREATMENT</u>																
LDC	Dilution					X						X	X				
↓	Oxidation Pond					*	*					*	*		*		
	Sedimentation					X						X	X				
	Trickling Filter					X						X	X		X		
	Activated Sludge					X						X	X		X		
DC	Disinfection				X	X					X						

* Method of choice in developing countries.

IV. Interrelationship of the Entire Delivery System.

  A. Expanded telling what each block is made up of. [See Workbook Figure #2.4.h]

V. Priority

  A. Providing background list of key points

VI. Interacting Relationship

  A. Points for consideration

    1. Water and Health Care

    2. Water and Education

    3. Water and transportation

VII. Cost/Benefit Analysis

  A. Cost of effectiveness analysis

VIII. Management Points and Programming

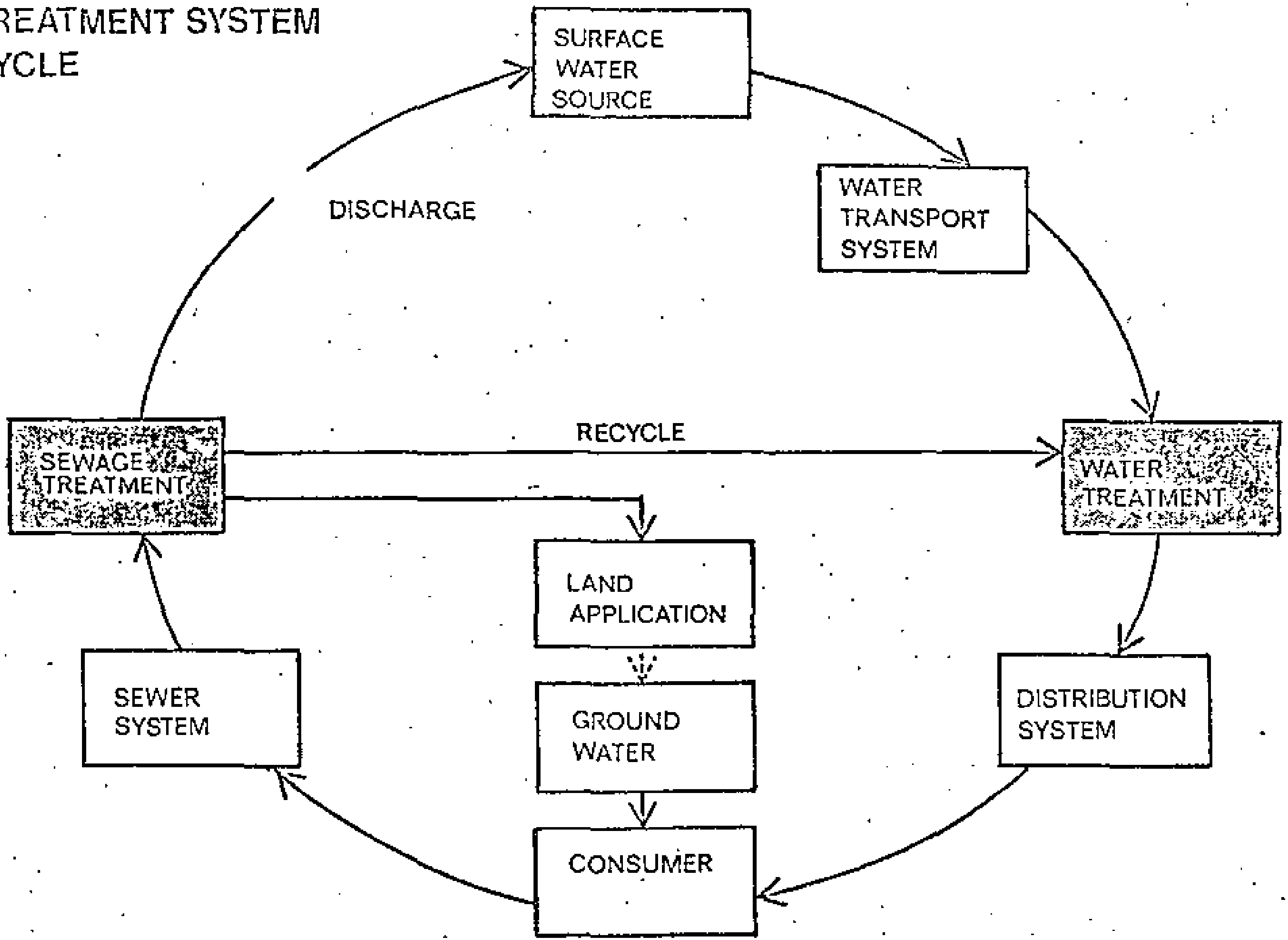
  A. Use of simulator tools

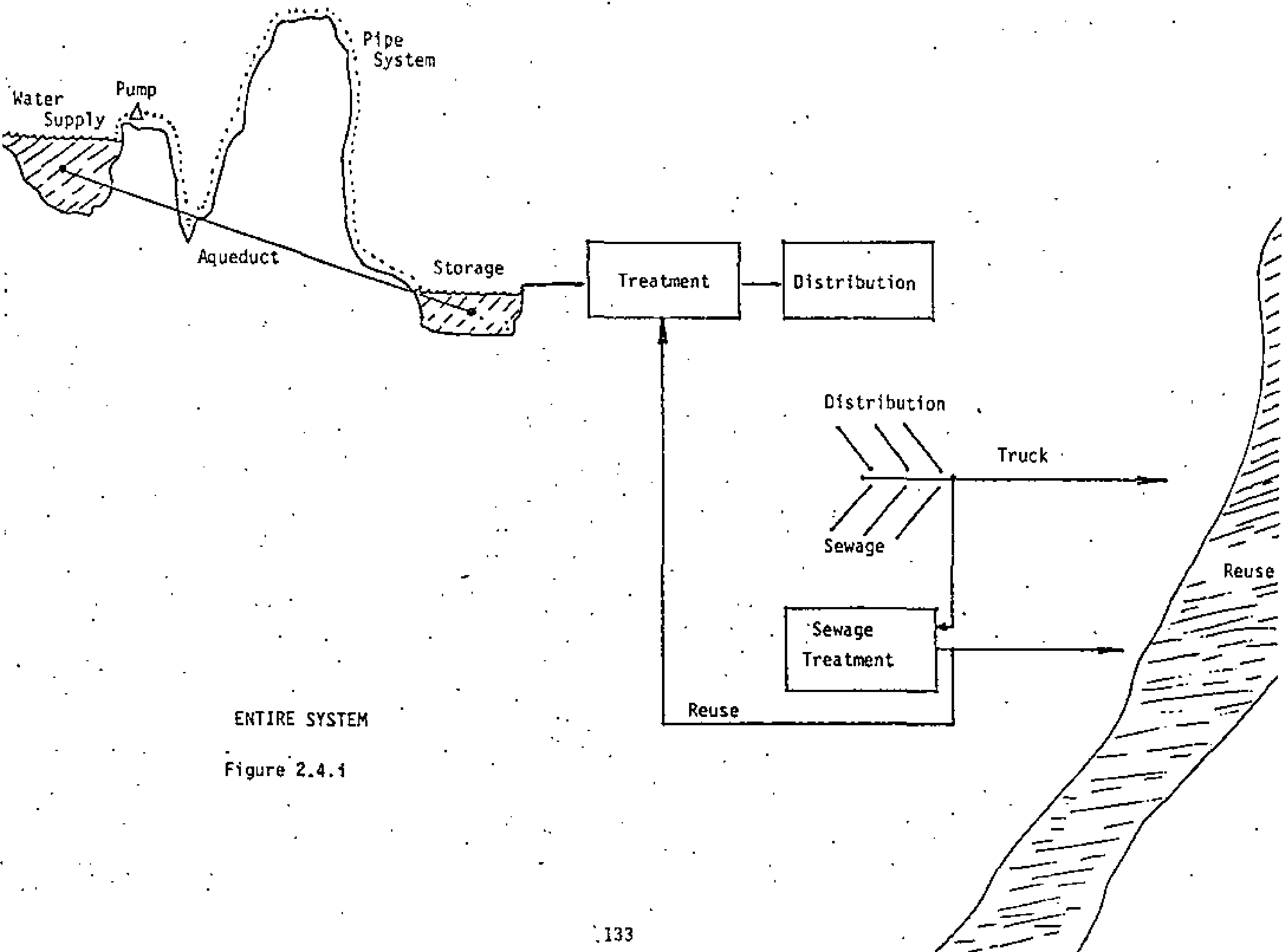
    1. Reactive model

    2. Proactive model

FIGURE 2.4.h

TREATMENT SYSTEM CYCLE





ENTIRE SYSTEM

Figure 2.4.1

INTAKE: infiltration galley; river bed intakes

PIPELINE: aqueduct vs. pipe and pump, vs. various materials

DISTRIBUTION: fire protection; pvc, cd, etc.; valveless

SEWERAGE: pressure system; separate grey water

DISCHARGE: alternative discharge - recycle
- land application

Sessions
3.1 & 3.2

Title: Water Treatment - Goals and Processes

Objective: To present the goals of water supply and treatment, and to discuss various processes and systems.

Water Supply and Treatment

(excerpt from CHAPTER VII, p. 323)

In LDC's it is not always possible to provide the population with drinking water that satisfies DC standards. The first concern may be to make adequate amounts of water easily available. With regard to water quality, resources and capabilities must be weighed in order to derive standards suitable to a particular situation, with pathogenic purity being an important consideration. The determination of standards for potable water and water treatment relates to economic feasibility and to in-country ability to provide operational skills necessary for water analysis. When more sophisticated treatment processes are used, the need increases for better analytical support. In general, in an LDC situation, costly and complicated equiment should be avoided.

As an LDC develops or changes with respect to its industries or type of life-style, additional measurements (attributes) of the quality of drinking water will be required, and the acceptable level for each attribute will also be subject to change. At least, in DC's the pattern of change has been toward more restrictive standards, moving for example, from limits on simple turbidity and coliform bacteria to the identification of organic chemicals, toxic metals, or viruses. It is of interest to note that although in the United States great reliance has been placed upon chlorine for the removal of pathogens, the presence of chlorine has been implicated in the production of detrimental health effects, and dechlorination has been advocated.

In the first section of this chapter, emphasis is placed on "Water Supplies in Rural Areas of Developing Countries"; however, application can be made to nearly all but the largest settlements. Examination is made of some of the possible causes for failures in the area of potable water supply in LDC's. Information is provided on water consumption, sources, treatment, and transport and distribution. To furnish this article complementary material was included from two original publications which were greatly reduced and rewritten for adaptation to the limits of this text.

The second section of this chapter provides a study of a sand filter in Thailand. Details are given related to its design and operation. The original publication was condensed and rewritted for inclusion in this text.

The third section in this chapter is an article which was prepared especially for publication in this volume. It presents certain advantages, disadvantages, and design criteria for small wells, and slow and rapid sand filtration with particular application to developing areas. When feasible, recovery of groundwater is suggested as the most desirable source for domestic supplies, since any pathogenic organisms will generally have had sufficient time to die away, and the result will be a hygienically safe water. Slow sand filters present a choice method of treatment in LDC's since they are uncomplicated in management and maintenance, utilize unskilled labor, and have a tremendous purifying capacity. Although slow sand filters have great advantages for developing countries, the advantages of rapid sand filters are that they show greater adaptability to more turbid waters and have smaller land requirements.

PROCESS SUMMARY DESCRIPTION (TABLE 9.1)

WATER

PW 1 -- No-Treatment: Use of existing ground water or catchment control with no treatment before use.

PW 2 -- Pre-Treatment: Control of turbidity and algae through use of sand filters, thermocline control and chemicals.

PW 3 -- Slow Sand Filtration: Separation of water and suspended matter through the use of a relatively large bed of unstratified sand resting on a gravel bed.

PW 4 -- Rapid Sand Filter - Conventional: Separation of water and suspended matter through the use of a stratified sand bed using conventional, surface agitation, dual media, and upflow methods.

PW 5 -- Rapid Sand Filter - Advanced: The use of multimedia, plate or tube settling, or polyelectrolytes with the rapid sand filter process.

PW 6 -- Softening: The use of lime soda and zeolites to remove excess ions of calcium and magnesium.

PW 7 -- Disinfection: The use of chlorine, iodine, ozone, ultra violet, lime, and heat to kill pathogenic organisms.

PW 8 -- Taste, Odor, Fe, Mn: The use of aeration, zeolite, chlorine or absorbents to remove taste, odor, Fe, Mn, from a water supply system.

PW 9 -- Desalting - Saltwater: The use of pressure, multiple effect evaporation or the freezing process to reduce a salt concentration of 35,000 mg/L to less than 1000 mg/L.

PW 10 -- Desalting - Brackish water: The use of electrodialysis, reverse osmosis and chemicals to reduce a salt concentration of 100 mg/L - 35000 mg/L to less than 1000 mg/L.

PW 11 -- Containment Filters: Dunbar; coconut fiber/charred rice husks; asbestos/charred pine needle

PW 12 -- Disinfection Filter:

TABLE 9.2

WATER TREATMENT PROCESS/CODE IDENTIFIERS

CODE	PROCESS
PW 1	No-Treatment
PW 2	Pre-Treatment
PW 3	Slow Sand Filtration
PW 4	Rapid Sand Filter-Conventional
PW 5	Rapid Sand Filter-Advanced
PW 6	Softening
PW 7	Disinfection
PW 8	Taste-Odor - Fe, Mn
PW 9	Desalting - Saltwater
PW 10	Desalting - Brackish
PW 11	Containment Filters

TABLE

WATER PROCESSES VS. MANPOWER REQUIREMENTS FOR POPULATION LEVELS

Manpower Requirements/Process	Level	Unskilled	Skilled	Professional
PW 1	1	1		
	2	2		
	3	4		
	4	8		
PW 2	1	1	1	
	2	1	1	
	3	3	2	
	4	5	4	
PW 3	1	1		
	2	2		
	3	5		
	4	8		
PW 4	1	1	1	
	2	1	1	1
	3	8	2	1
	4	10	3	1
PW 5	1	1	1	1
	2	1	1	1
	3	6	2	2
	4	10	5	2
PW 6	1	1	1	1
	2	1	1	1
	3	6	2	2
	4	10	5	2
PW 7	1	1		
	2	1	1	
	3	2	1	1
	4	4	1	1
PW 8	1	1	1	1
	2	1	1	1
	3	6	5	2
	4	1	1	1
PW 9	1	1	1	1
	2	6	2	2
	3	10	5	2
	4	1	1	1
PW 10	1	1	1	1
	2	1	1	1
	3	6	2	2
	4	10	5	2

PROCESS CONSTRAINTS

WATER TREATMENT PROCESSES WITH ESSENTIAL MANPOWER & RESOURCES REQUIRED FOR OPERATION

TREATMENT METHODS	PROCESS NUMBER	PROCESS REQUIREMENTS						
		MANPOWER			RESOURCES REQUIRED			
		UNSKILLED	SKILLED	PRO-FESSIONAL	OPERATION EQUIPMENT	PROCESS MATERIALS	MAINT SUPPLIES	CHEMICAL SUPPLIES
NO TREATMENT	PW1*	X			X	X	X	
PRE-TREATMENT	PW2	X			X		X	
SLOW SAND FILTRATION	PW3	X				X	X	
RAPID SAND FILTER (Conv.)	PW4	X	X	X	X	X	X	X
RAPID SAND FILTER (Adv.)	PW5	X	X	X	X	X	X	X
SOFTENING	PW6	X	X	X	X	X	X	X
DISINFECTION	PW7	X	X		X	X	X	X
TASTE, ODOR-Fe, Mn	PW8	X	X		X	X	X	X
DESALTING-SALT	PW9	X	X	X	X	X	X	X
DESALTING-BRACKISH	PW10	X	X	X	X	X	X	X
CONTAINMENT FILTER	PW11[a]	X				X	X	
DISINFECTANT FILTER	PW12	X						X

* Water Source (Groundwater Availability)

[a] Listed for completeness only, not actually available as a model output at this time.

WATER TREATMENT

ACCEPTABLE COMBINATIONS OF TREATMENT PROCESSES, ACCORDING TO RAW WATER QUALITY OR DEGREE OF DILUTION AVAILABLE TO WASTE FLOWS

CODE FOR PROCESS COMBINATIONS	PROCESS COMBINATIONS	CRITERIA LEVELS		
		RAW WATER CONCENTRATION		
		COLIFORM BACTERIA (MPN/100 ml)	SOLIDS	
			TURBIDITY (JTU)	OTHER (mg/l)
W1	PW1	1-2 [a]	10	
W2	PW3	200	100	
W3	PW11	300	800	
W4	PW1 + PW7	500	10	
W5	Pw2 + PW3	1,000	800	
W6	PW2 + PW12	3,000	800	
W7	PW3 + PW7	5,000	100	
W8	PW2 + PW3 + PW7	10,000	1,000	
W9	PW4 + PW7	10,000	100	
W10	PW2 + PW4 + PW7	10,000	1,000	
W11	PW5 + PW7	10,000	100	
W12	PW2 + PW5 + PW7	10,000	1,000	
W13	(any one of W1 to W12)+PW6			300 hardness
W14	(any one of W1 to W12)+PW8			1-3 Fe & Mn
W15	(any one of W1 to W12)+PW9			3000 TDS[a]
W16	(any one of W1 to W12)+PW10			2000 TDS[a]

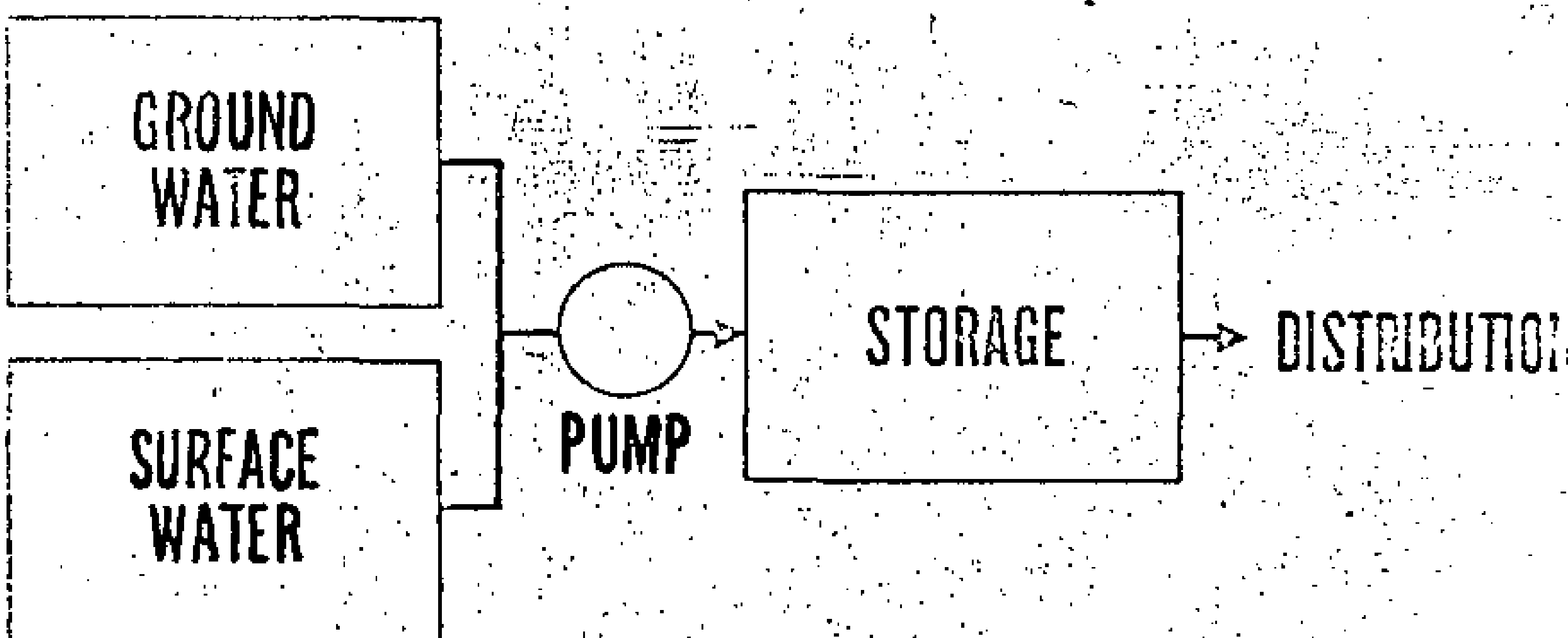
[a] This represents standards for developed countries; different standards may be more appropriate for developed countries.

FEASIBLE PROCESS COMBINATION	TOTAL COST RATIO 20 YEAR	MANPOWER REQUIRED UNSKIL	SKIL	PROF
S3	76.99	2	0	0
S4	339.19	2	1	0
S9	282.68	3	1	0
S10	475.44	4	2	0
S14	228	3	1	0
S15	490	3	2	0

THE LOWEST TOTAL COST RATIO IS
S3 AT A 20 YEAR SUM OF 76.99

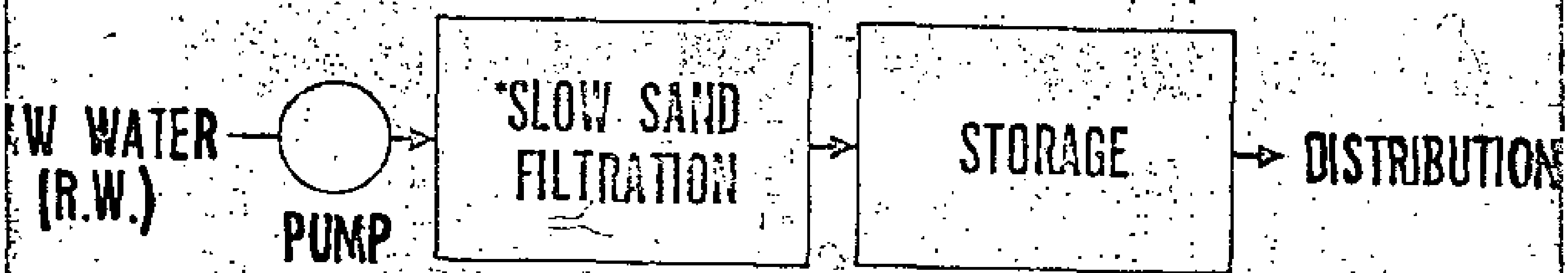
ENTER 5 WHEN YOU WISH TO CONTINUE
?

WI – NO TREATMENT (PW 1)



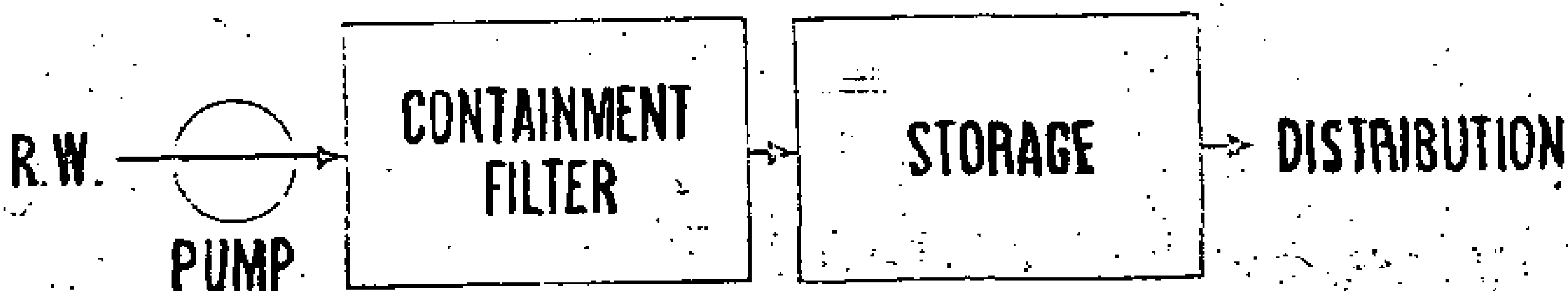
= (PW1) = UN, OE, PM, and OMS

W2 – SLOW SAND FILTRATION (PW3)



echanism of S.S.F. – straining + sedimentation + flocculation + biological act

W3 – CONTAINMENT FILTER (PW11)

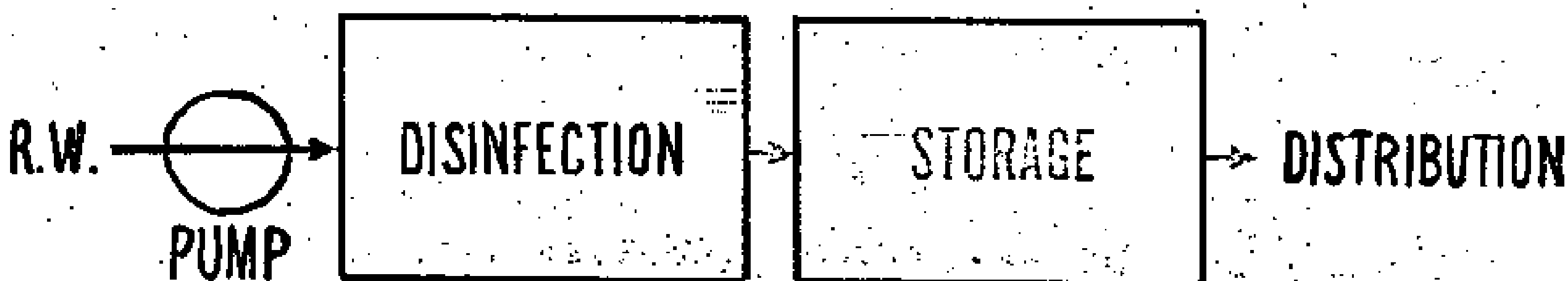


113

W3 = (PW11) = UN, PM, and OMS

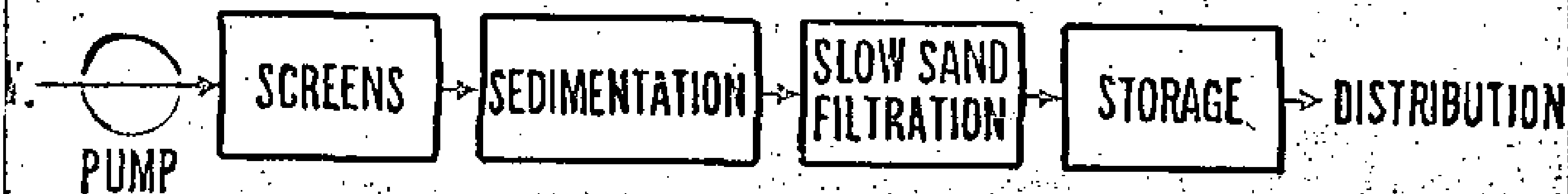
= (PW7) = UN, SK, OE, FR, CHS, and CS

W4 – NO TREATMENT + DISINFECTION (PW1+PW7)



114

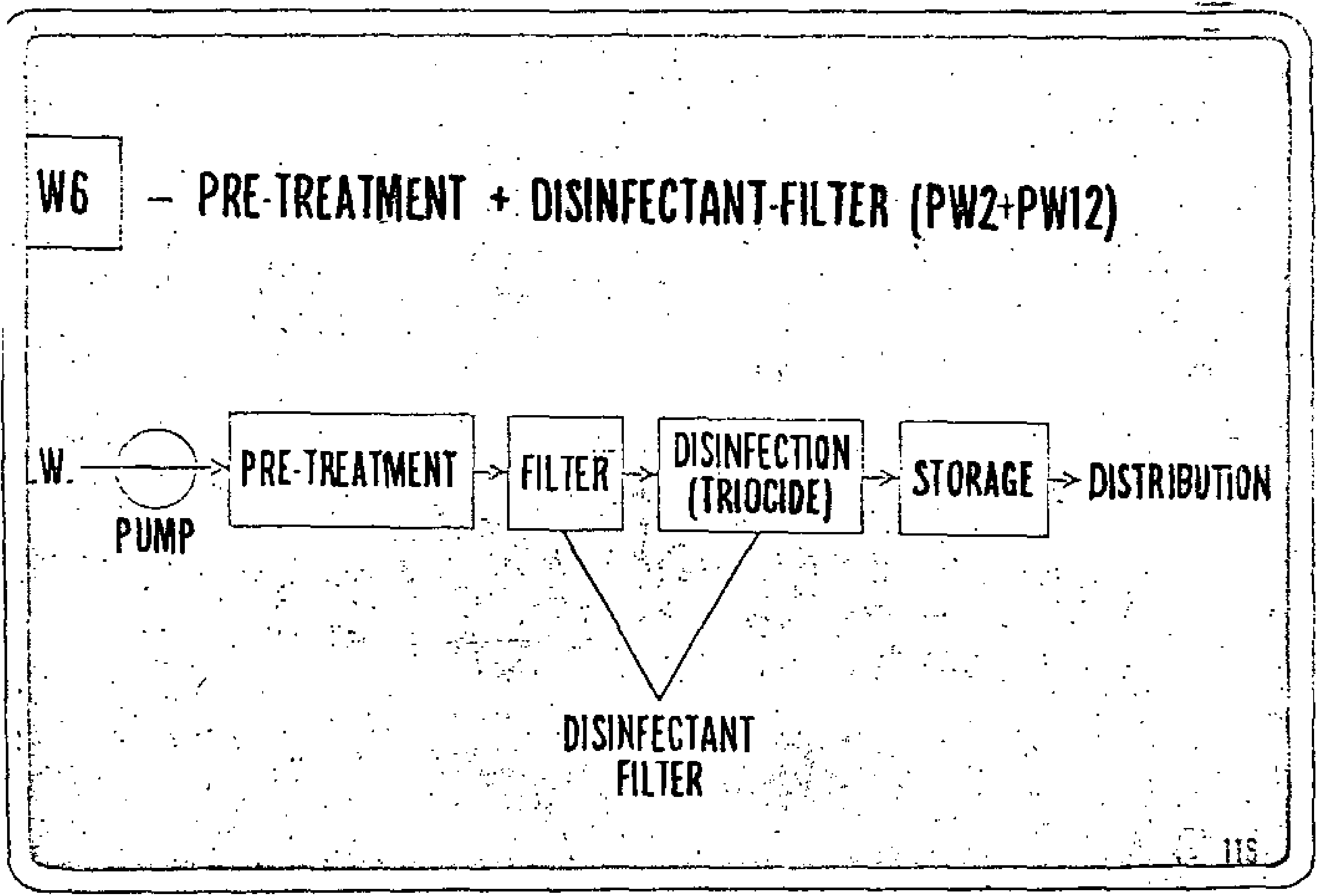
W5 — PRE-TREATMENT + SLOW SAND FILTRATION (PW2+PW3)



115

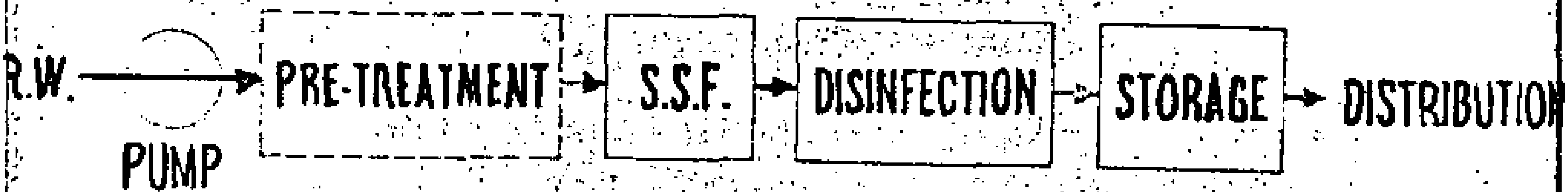
W5 = (PW2 + PW3) = UN, OE, PM, and OMS

- (PW2 + PW12) = UN, OE, PM, OMS and CS



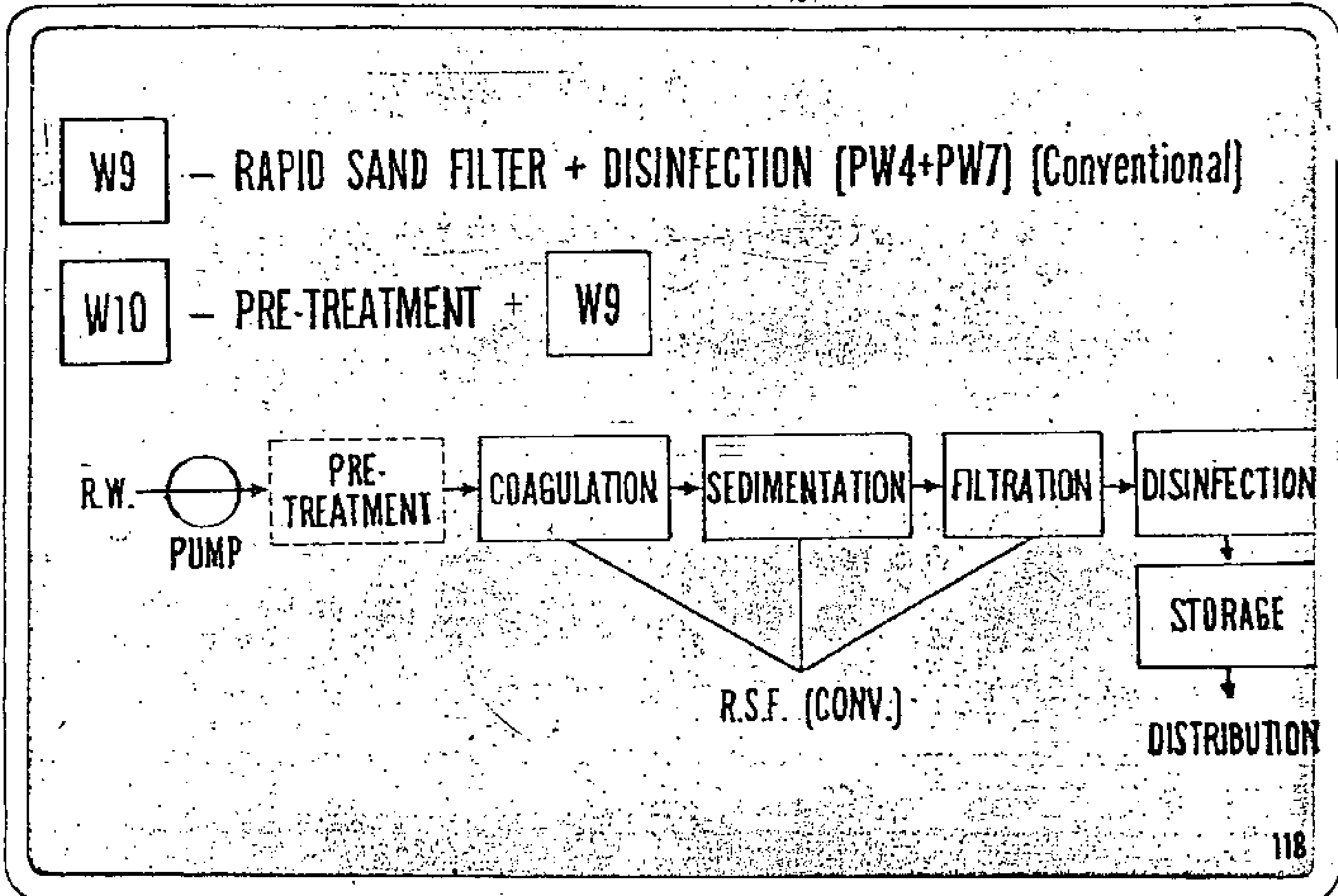
W7 – SLOW SAND FILTRATION (S.S.F.) + DISINFECTION (PW3+PW7)

W8 – PRE-TREATMENT + **W7**



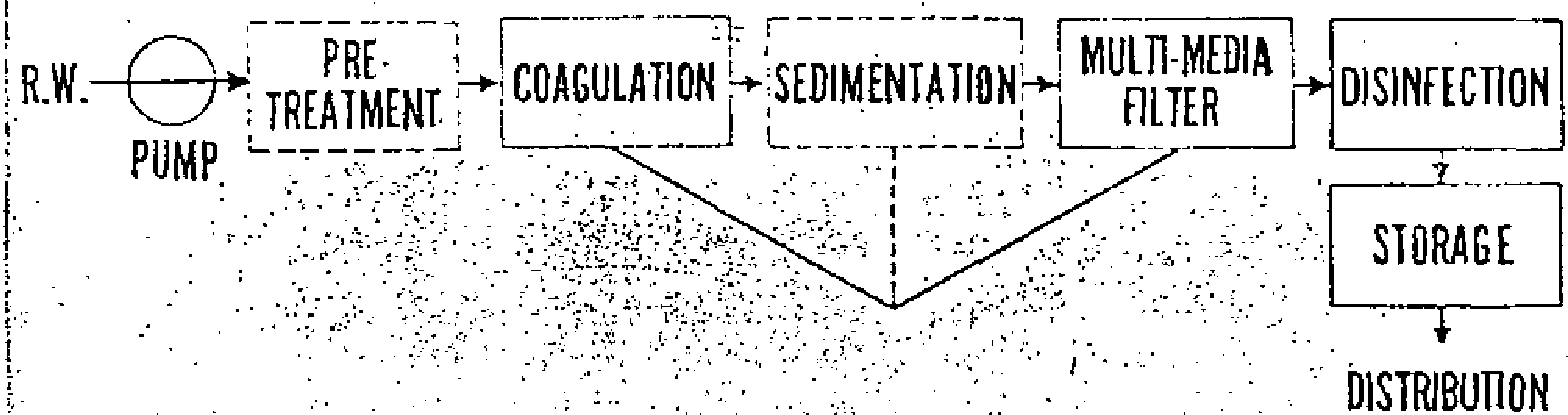
W7 = (PW3 + PW7)
= (PW2 + PW3 + PW7) = UN, SK, OE, PM, OMS, ar :S

W9 = (PW4 + PW7)
0 = (PW2 + PW4 + PW7) = UN, SK, PF, OE, PM, OMS and CS



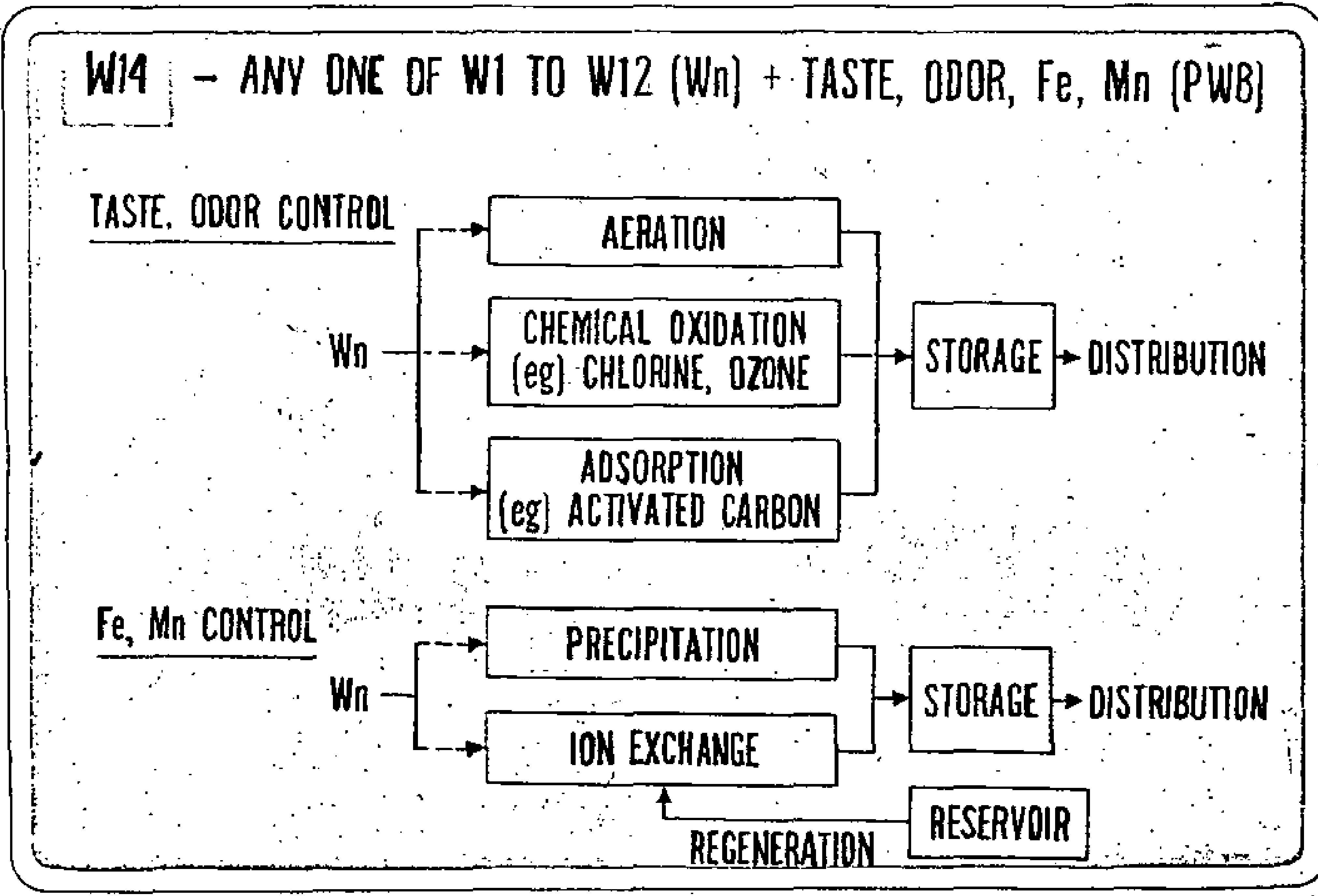
W11 – RAPID SAND FILTER + DISINFECTION (PW5+PW7) (Advanced)

W12 – PRE-TREATMENT + **W11**



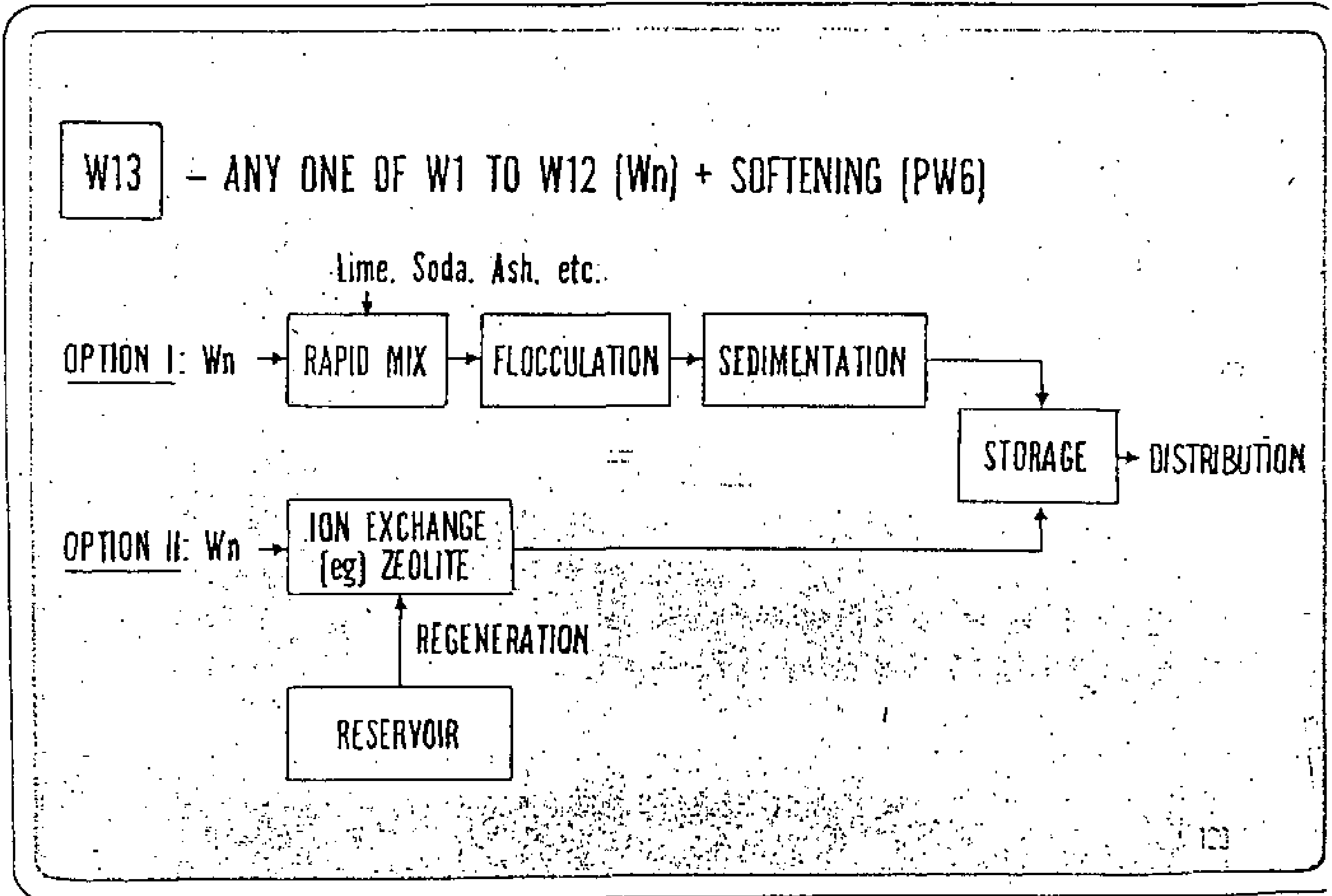
119

W11 = (PW5 + PW7)
2 = (PW2 + PW5 + PW7) = UN, SK, PF, OE, PM



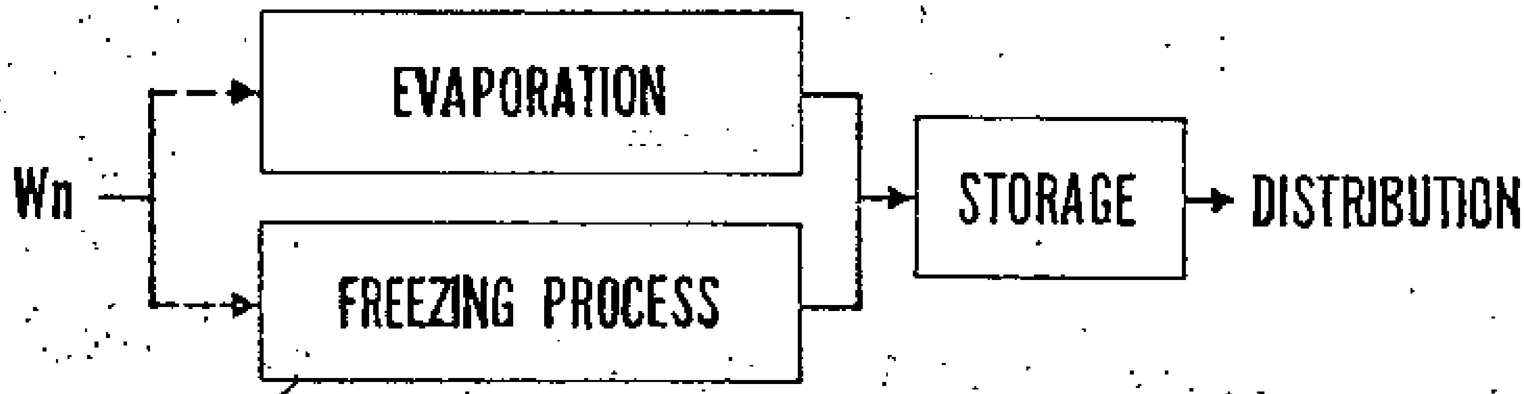
W14 = (anyone of (W1 to W12) + PW8) = UN, SK, PF DE, PM, OMS, and CS

.3 = (anyone of (W1 to W12) + PW6) = UN, S[illegible], [illegible]OE, PM, OMS, and CS

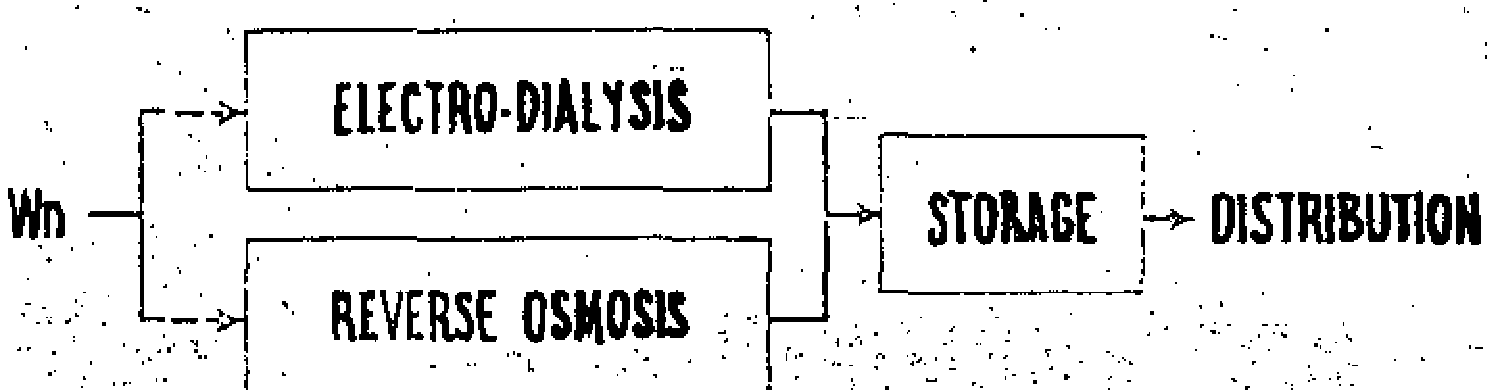


W15 = (anyone of (W1 to W12) + PW9) = UN, SK, PE, OE, PM, OMS, and CS

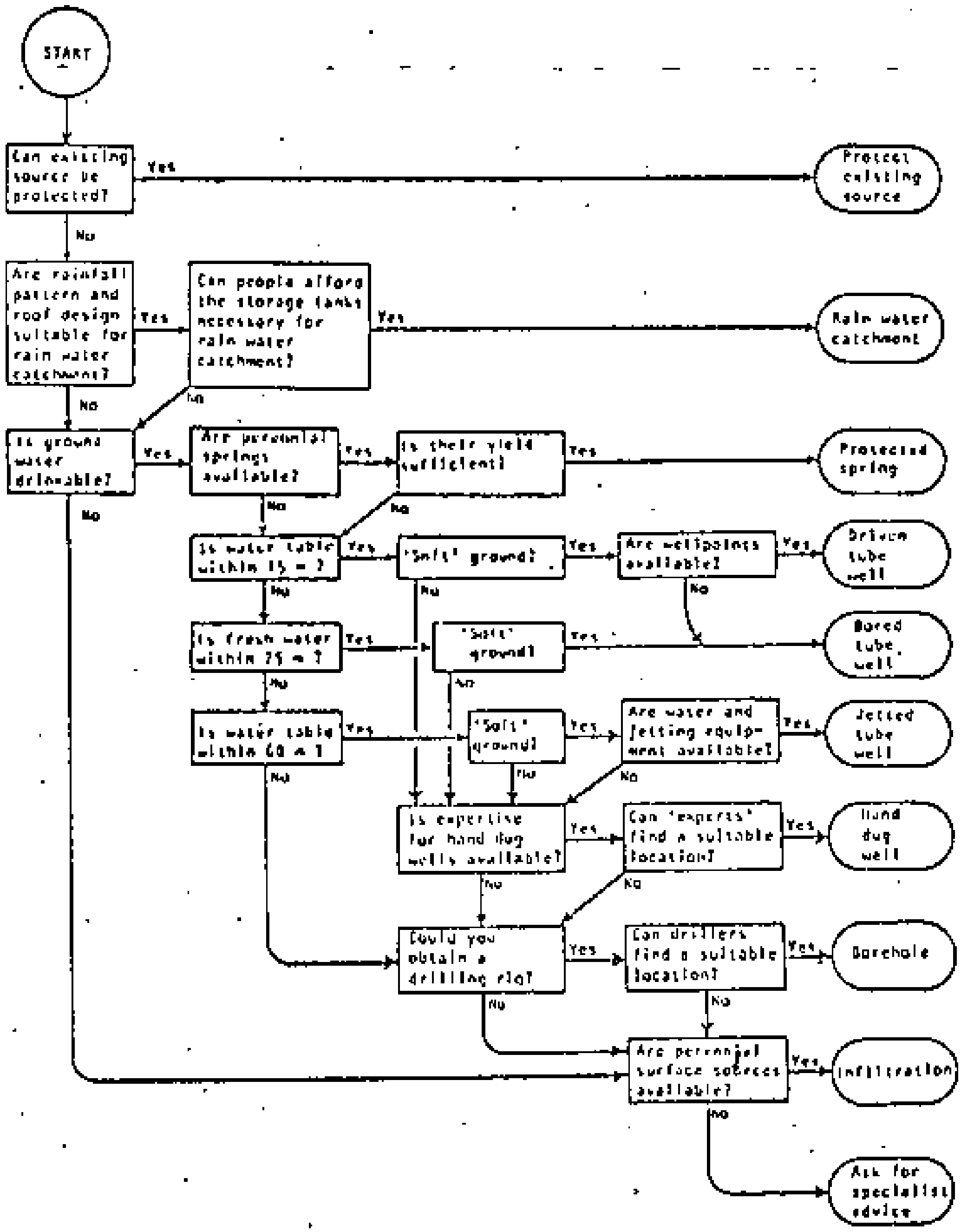
W15 – ANY OF W1 TO W12 (Wn) + DESALTING –SALT (PW9)



W16 – ANY OF W1 TO W12 (Wn) + DESALTING–BRACKISH (PW10)

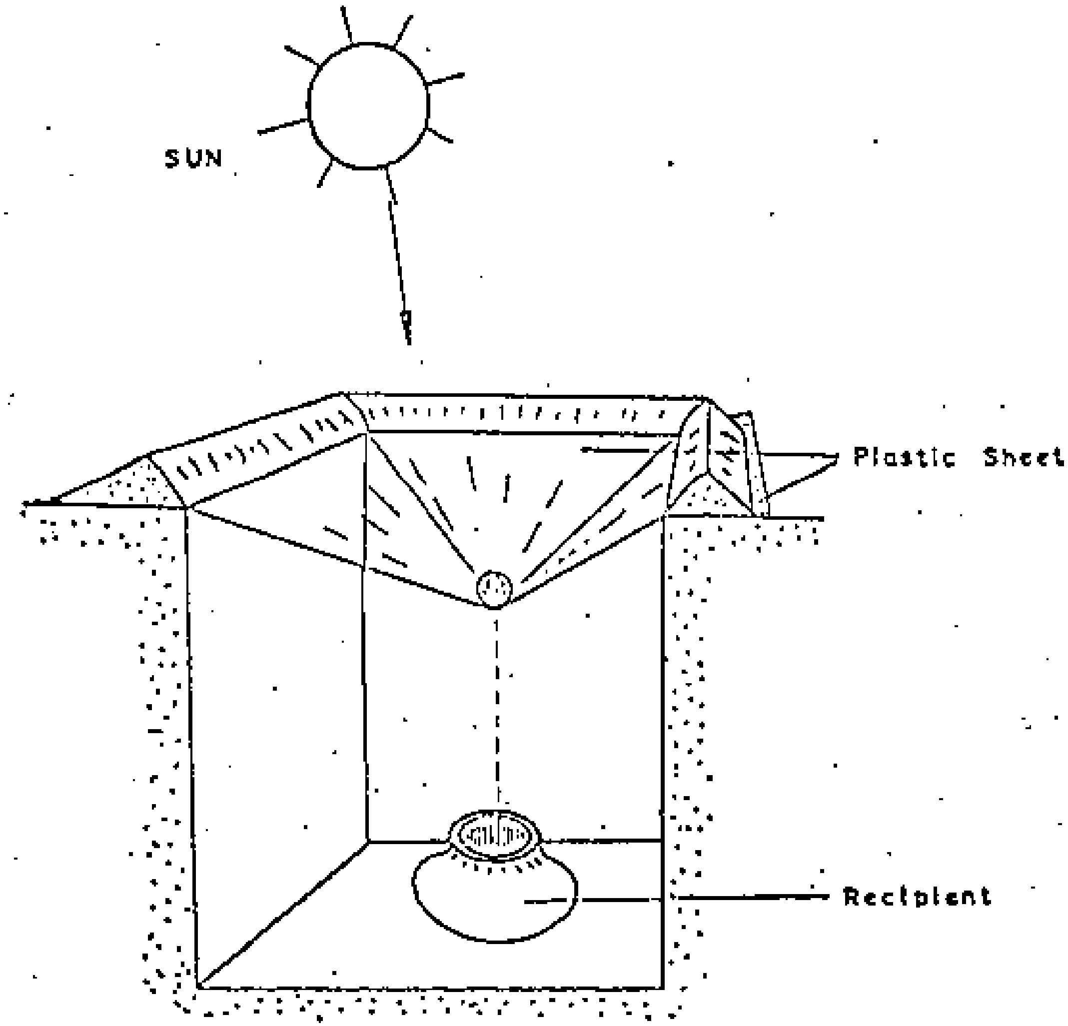


W16 = (anyone of (W1 to 12) +PW10) = UN, SK, PF, PE, PM, OMS, and CS

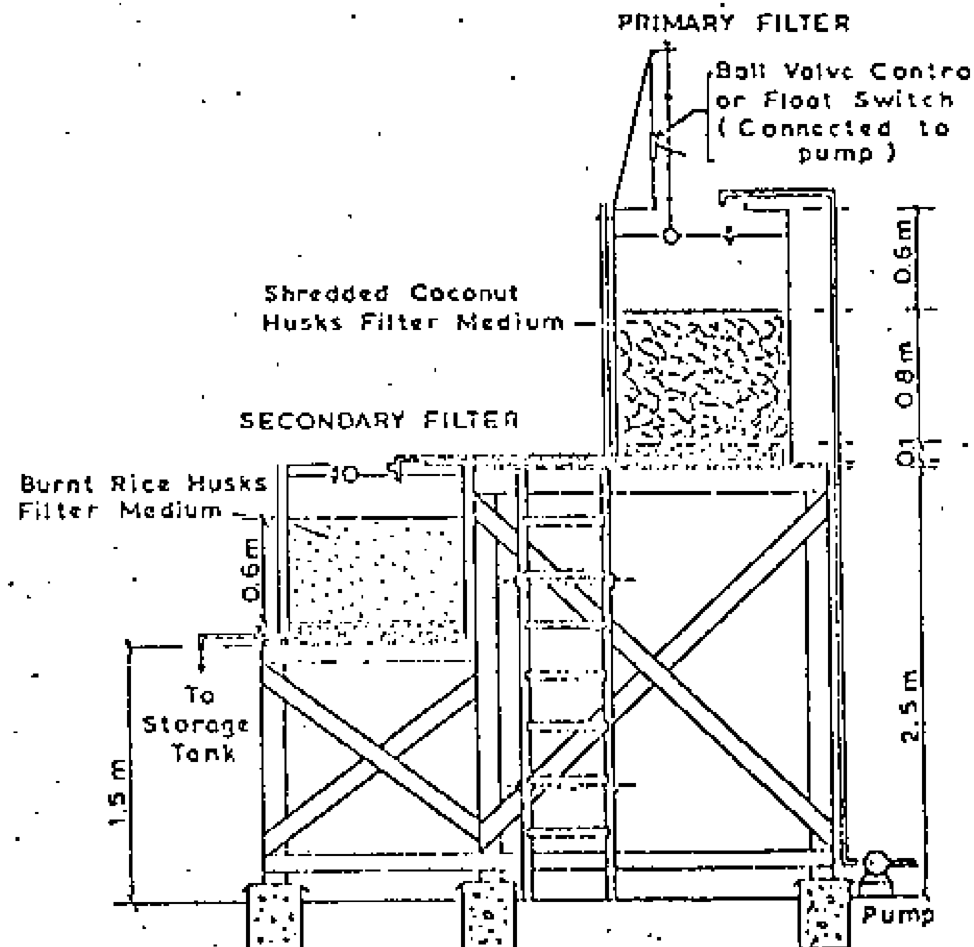


Choosing a source of water. Follow the arrow corresponding to your answer to the question in each box.

/6/

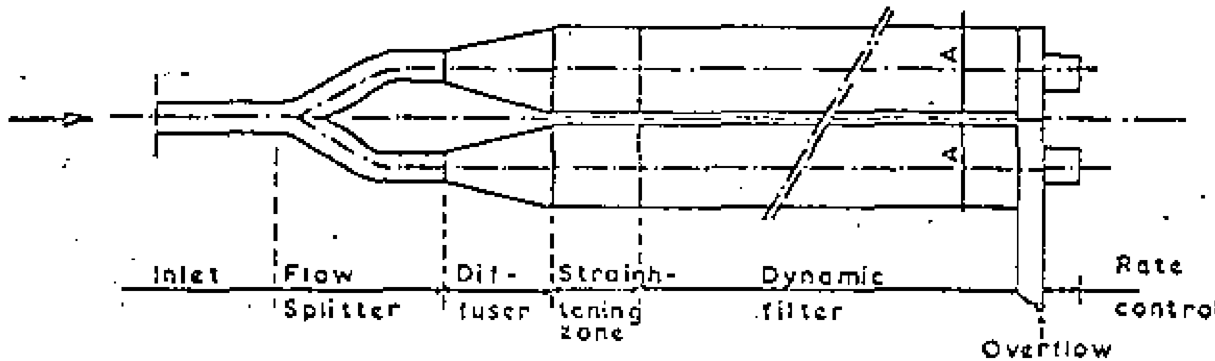


EVAPORATION / COLLECTION
OF SUBSURFACE WATER, ALGERIA

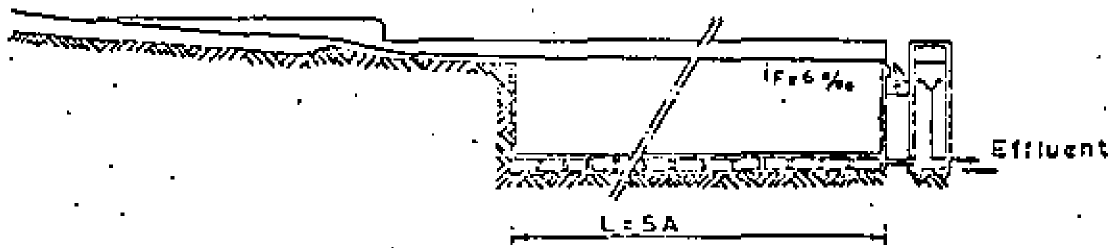


TWO-STAGE FILTRATION UNIT
THAILAND

DYNAMIC FILTER ARGENTINIA

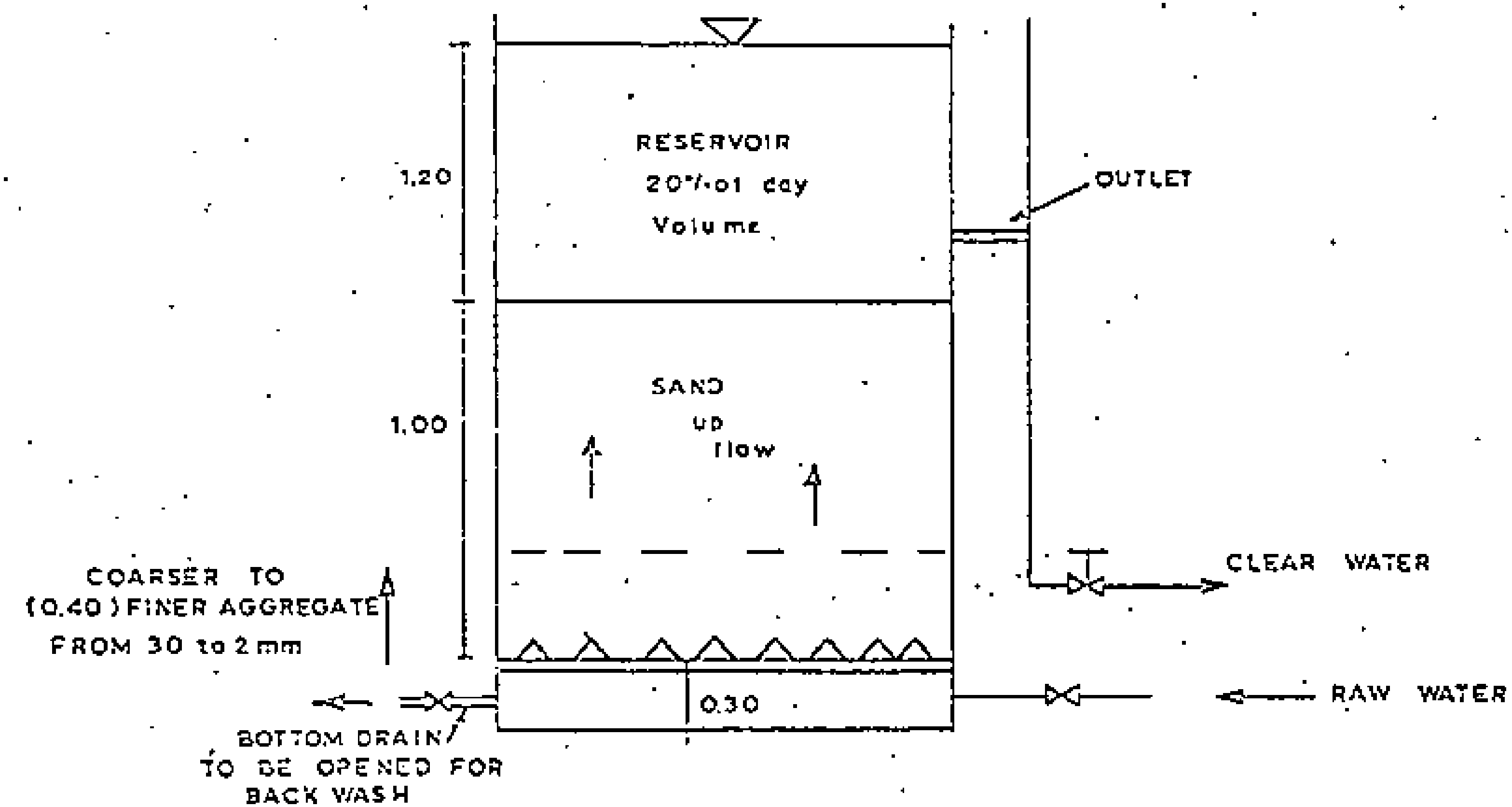


PLANT

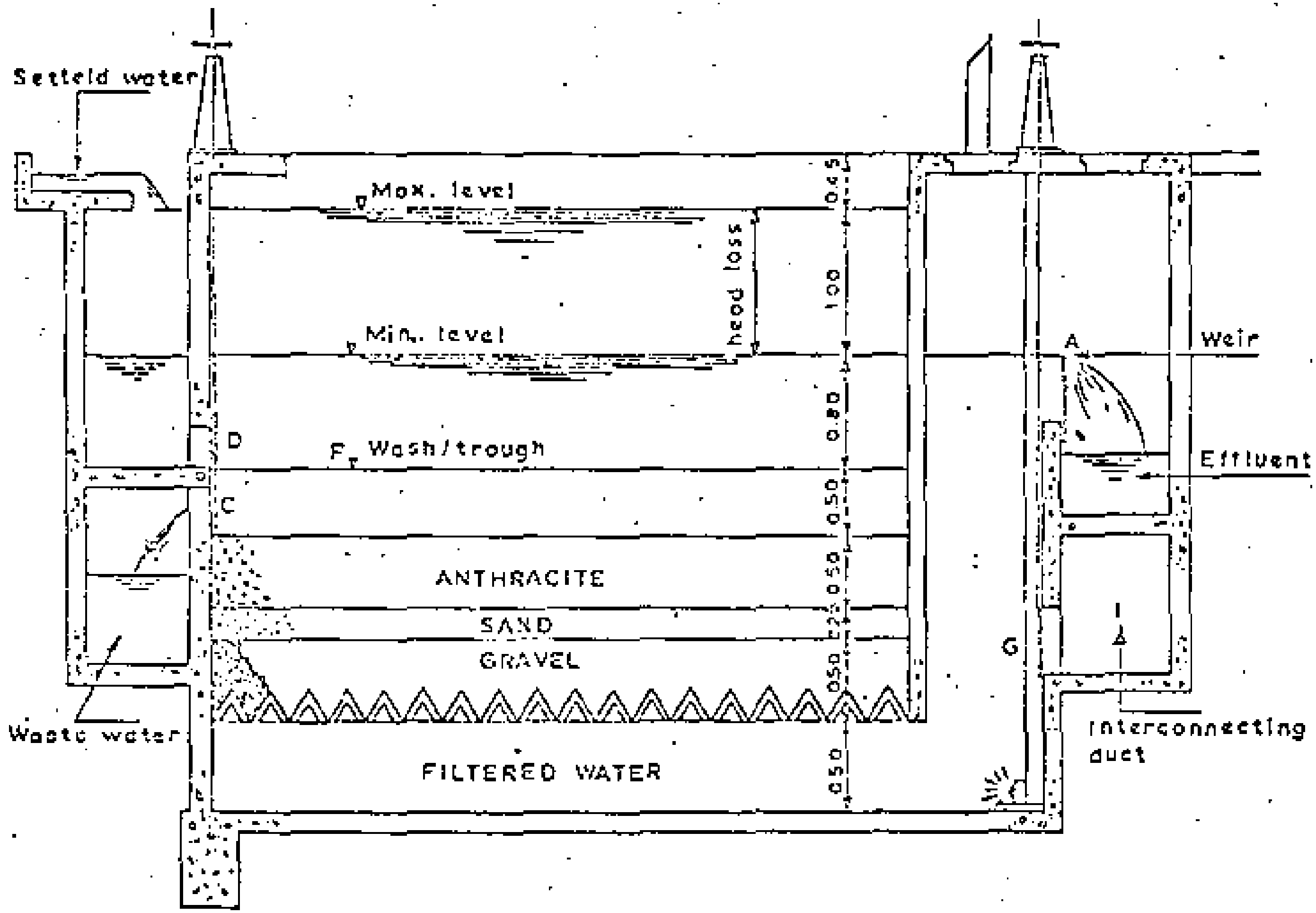


LONGITUDINAL SECTION

LOW RATE UPFLOW FILTER
AND WATER TANK

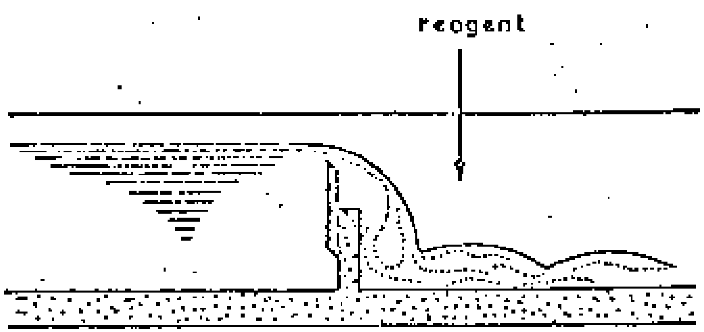


CAPACITY: 3 - 10 $m^3/m^2/d$ COSTA RICA



RISING HEAD FILTER , PERU

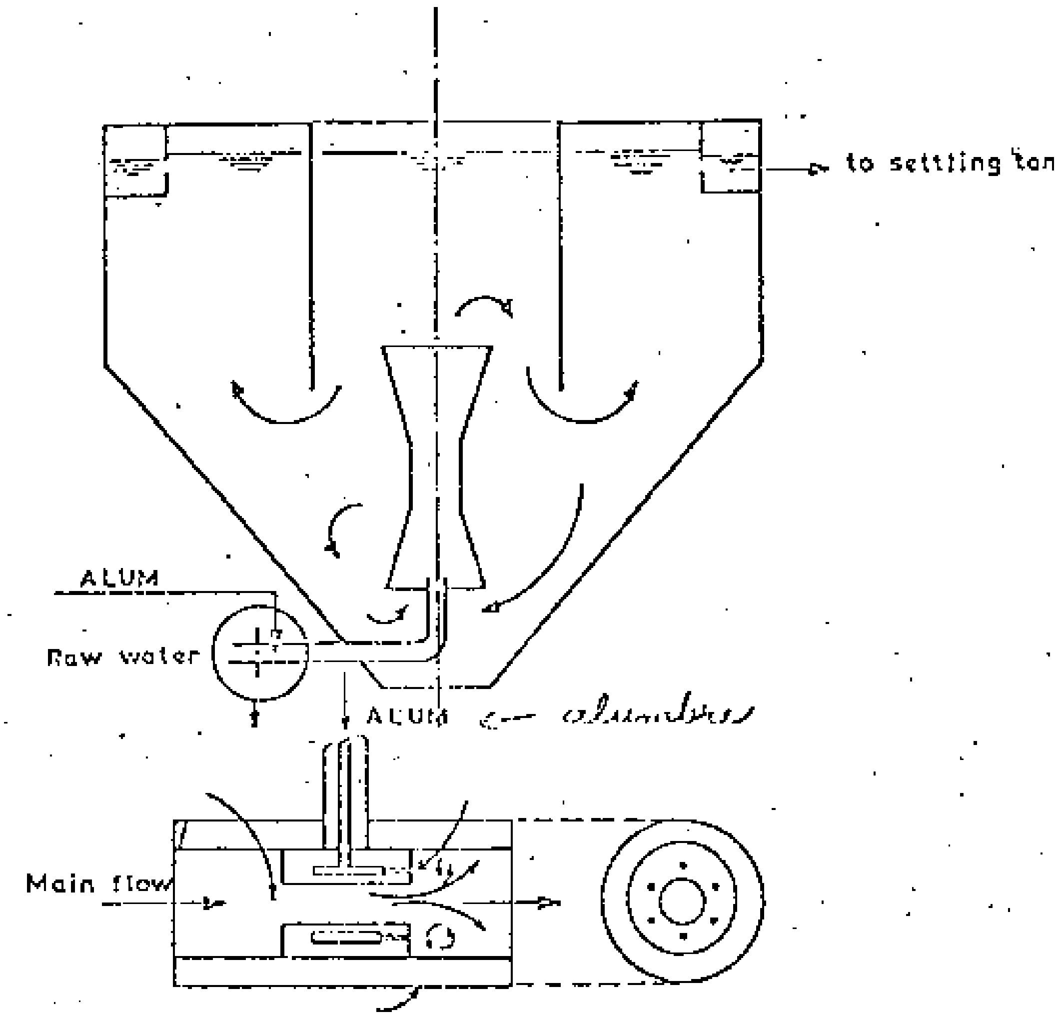
MIXING



measuring weir

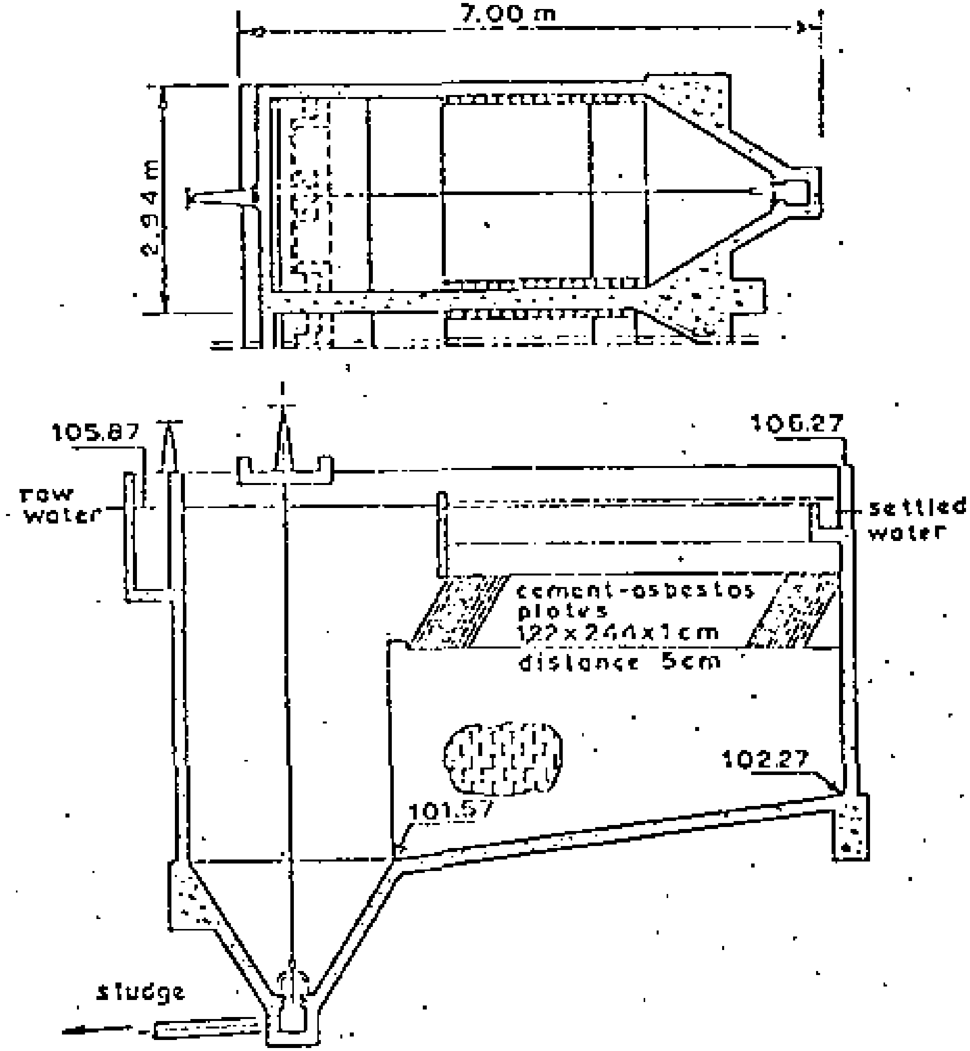
DESCRIPTION : Combined with metering

DISPERSION OF CHEMICAL

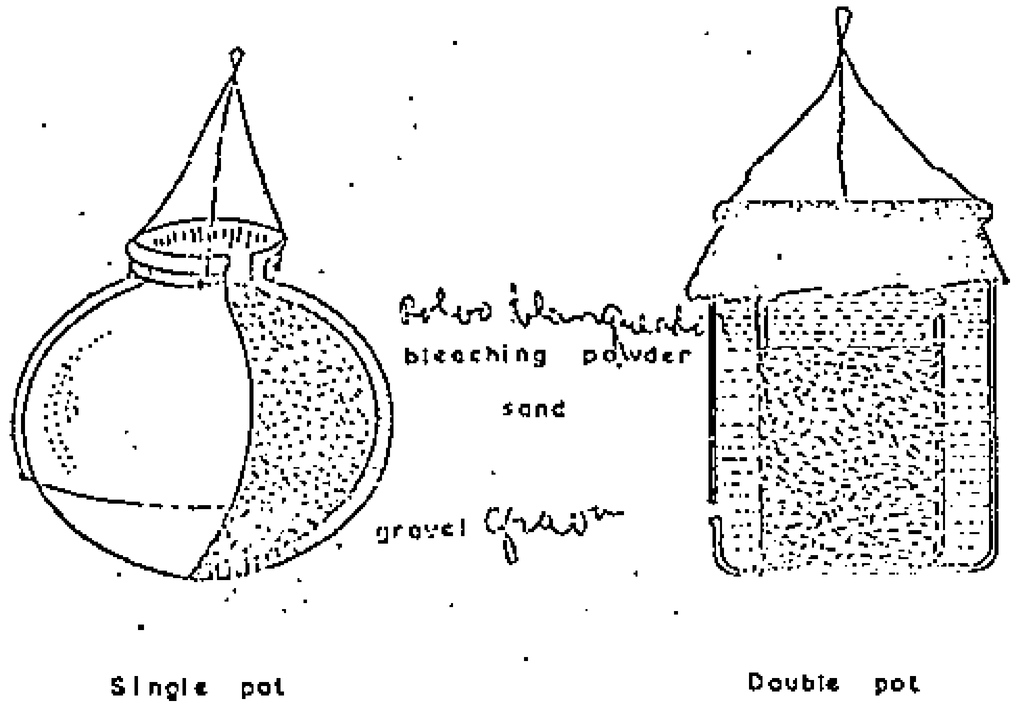


FLOCCULATOR WITH ORIFICE MIXER

CHEMICAL FEEDING



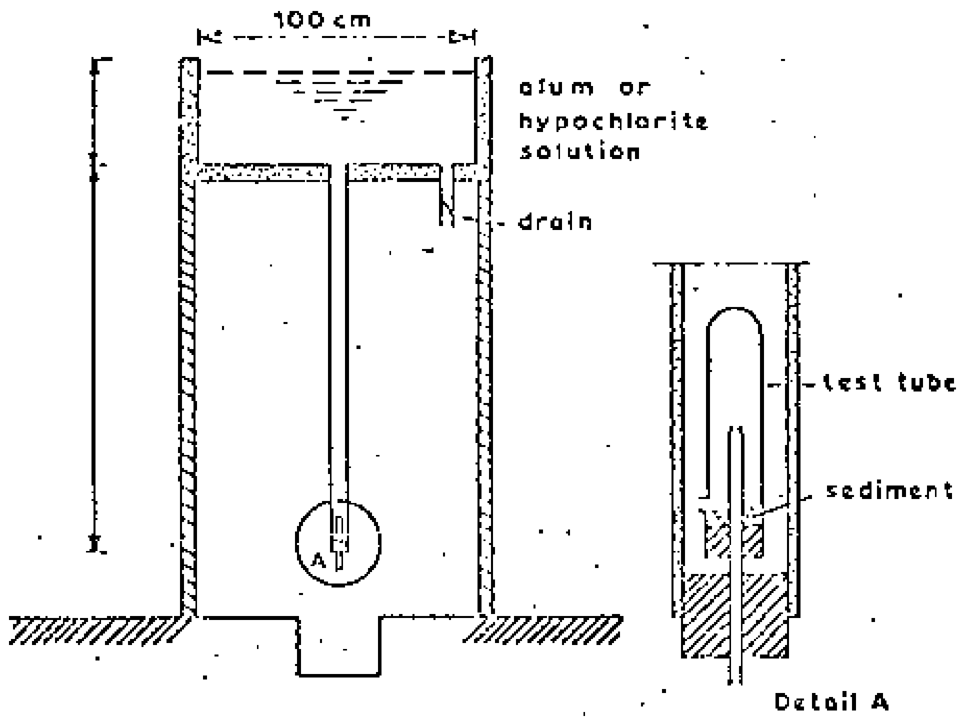
HIGH RATE SETTLER, PERU



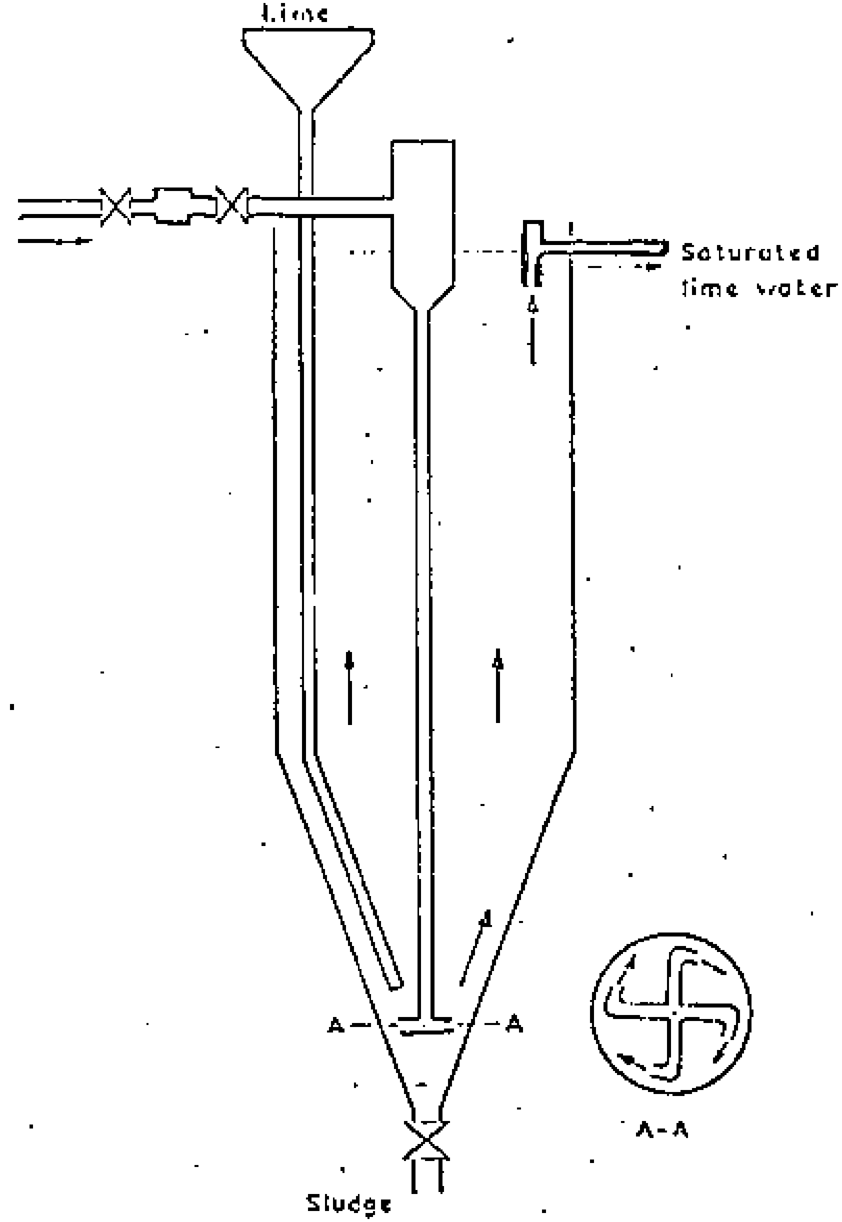
DESCRIPTION : For well chlorination
SOURCE : CPHERI

CHLORINATION POT, INDIA

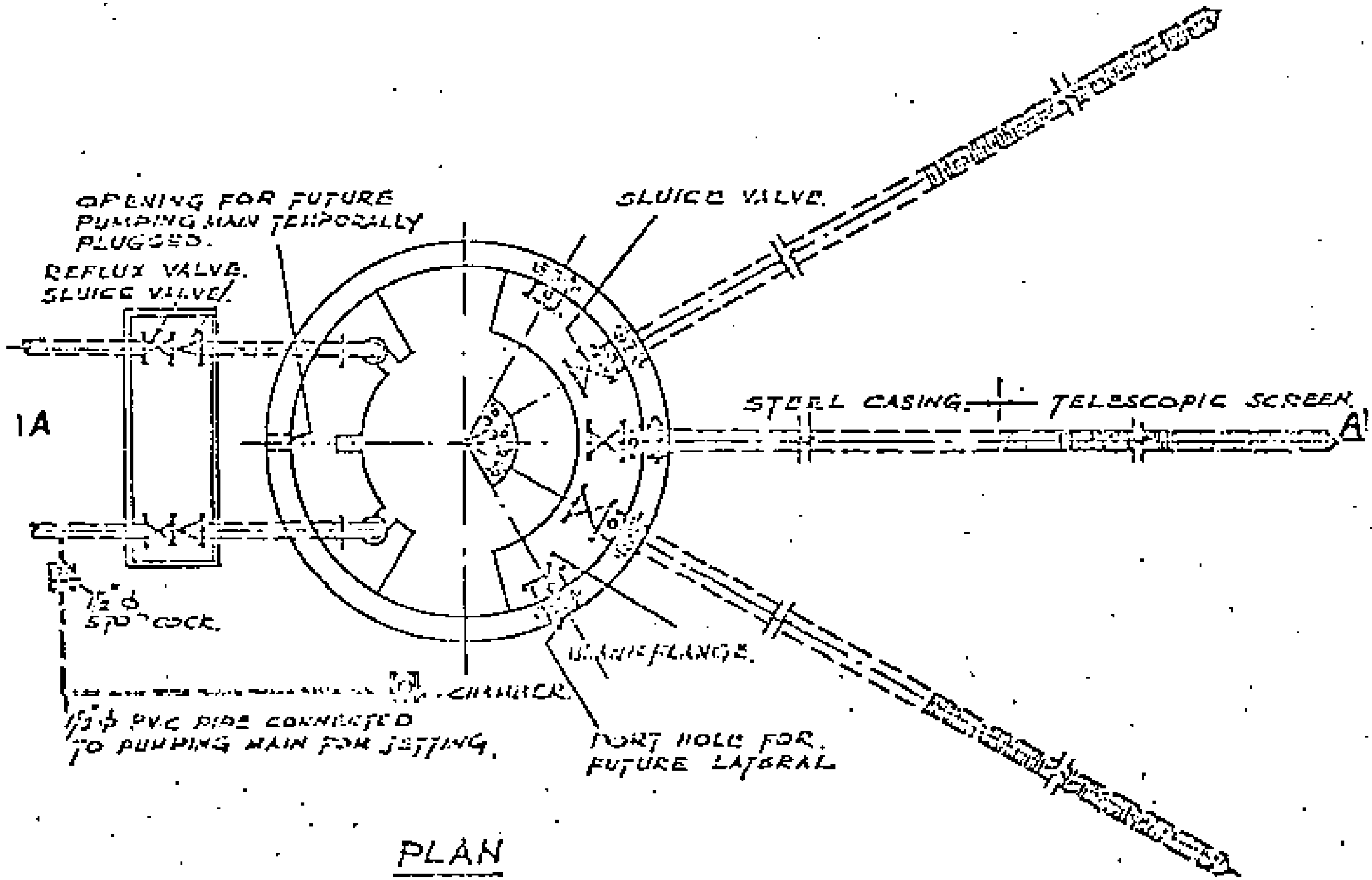
CHEMICAL FEEDING



TUBE FEEDER (HISTORIC)

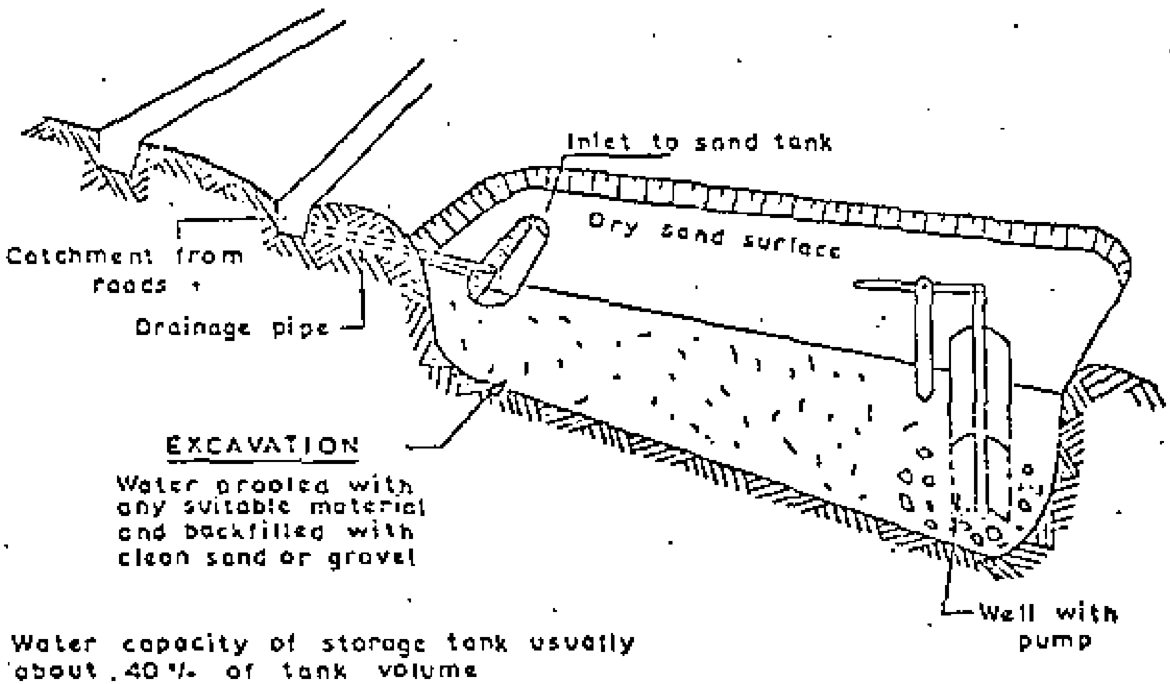


LIME SATURATOR, INDONESIA

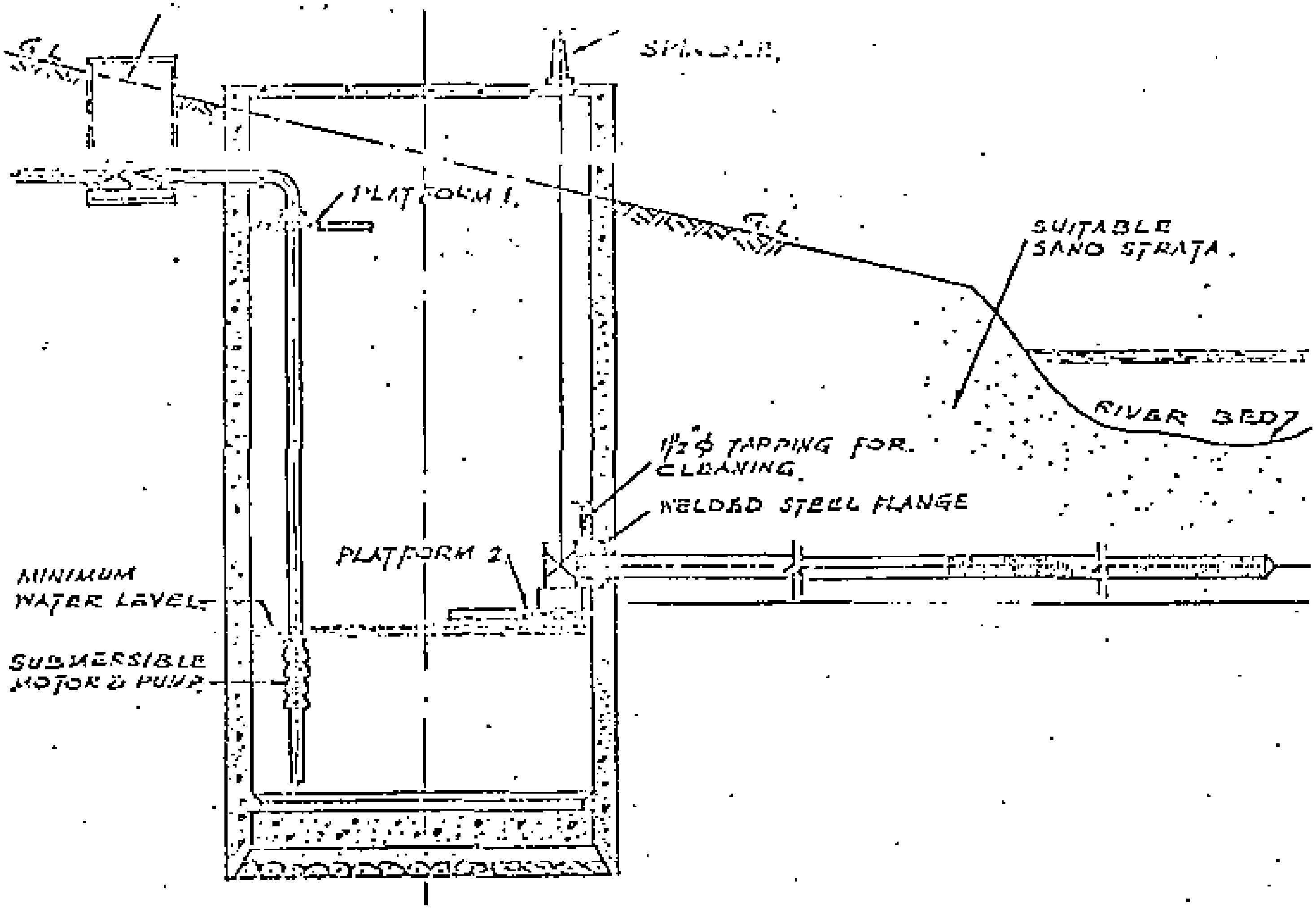


PLAN

INFILTRATION GALLERIES FOR RIVER BANK FILTRATION



SAND FILLED STORAGE TANK
FOR RAINWATER CATCHMENT ITDG


G.L.
PLATFORM 1.
G.L.
SUITABLE SAND STRATA.
RIVER BED
1½"φ TAPPING FOR. CLEANING.
WELDED STEEL FLANGE
PLATFORM 2
MINIMUM WATER LEVEL
SUBMERSIBLE MOTOR & PUMP

SECTION A-A

Session 3.3

Title: Data Questionnaire and Sample Manual Calculation

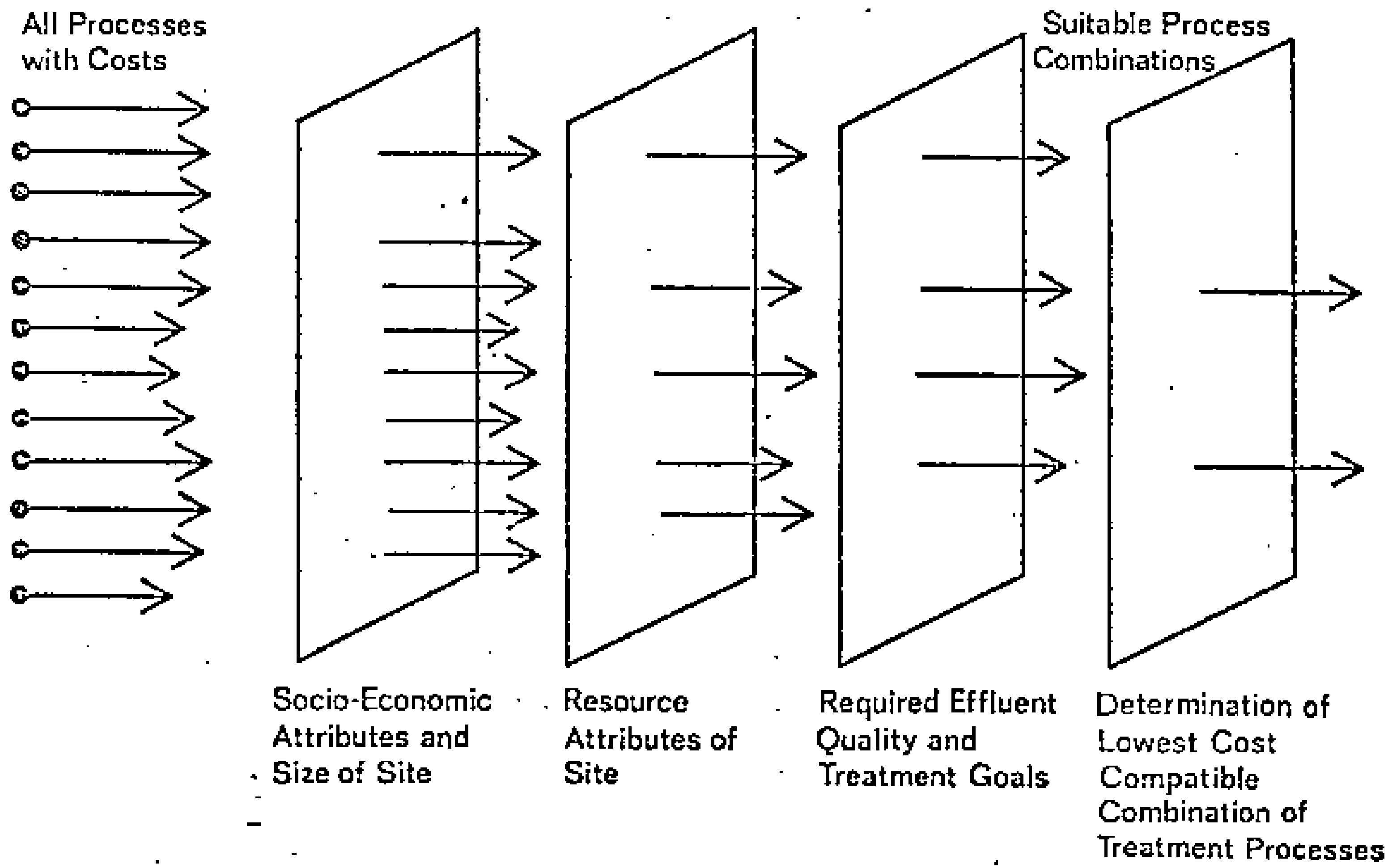
Objective: The purpose of this lecture is to use a set of test data to demonstrate "pen and paper" application of the model. The goals of the lecture include:

(a) an increase in the workshop participant's understanding of the water/wastewater treatment selection model;

(b) to demonstrate the internal operation of the model; and

(c) to indicate the limitations, and flexibility, of the model.

TYPES OF SCREENING INVOLVED IN THE SELECTION OF A COMPATIBLE LOWEST COST COMBINATION OF TREATMENT PROCESSES



Predictive Model Questionnaire - Part I "General Information"

CALCULATIONS

1) Location of community

City *Smallville,*

State *Kansas*

Country *U.S.A.*

2) Planning group or agency: ____________

Predictive Model Questionnaire - Part II "Demographic Data"

If local or site data is not available, use a national estimate.
Answer either Part A or Part B.

(A) 1) Present population (this figure or estimate of the present population should reflect the number of inhabitants that the proposed water or wastewater treatment facility is going to serve).

Actual population *10161*

If unknown, estimate the following:

500-2,500 people ______
2,500-15,000 ______
15,000-50,000 ______
50,000-100,000 ______
Source ______

2) Annual population growth rate *1.7%* or estimate in the following:

1%-1.5% ______
1.5%-2.0% ______
2.0%-2.5% ______
2.5%-3.0% ______
3.0%-3. ______
3.5%-4.0% ______

(B) Population estimate at last census ______
Date of census *1970*
Source of census ______
Annual growth rate at date of last census or present annual growth rate ______

Population estimate at last census ______
Date of census ______
Source of census ______
Annual growth rate at date of last census or present annual growth rate ______

Year of project design: 1980

Terminal year of desig[n] 2010

Predictive Model Questionnaire - Part III "Socio-technological Data"

		Weighting Factor	CALCULATIONS (sum of weighting facto
(1) Average level of education obtained by inhabitants living in the community.	Level / None / Primary / High School / Technical Institute / College 1 / 95% / 4% / 1% / 0% / 0% 2 / 70% / 19% / 7% / 3% / 1% 3 / 55% / 22% / 14% / 6% / 3% 4 / 9% / 34% / 42% / 8% / 7%	0 5 10 15	10
(2) Average distribution of labor force in the community.	Level / Unskilled / Semi-skilled / Professional 1 / 97% / 2% / 1% 2 / 80% / 16% / 4% 3 / 61% / 27% / 12% 4 / 45% / 30% / 25%	0 5 10 15	15
(3) Annual average income per family in local currency: Amount_____ Unit_____ Check approximate U.S. dollars equivalent of this amount:	Less than $100 $100-$500 ✓$500-$1,000 $1,000-$3,000 Greater than $3,000	0 4 8 12 15	23
(4) Among highly skilled and technical workers, what percentage of these are non-local or non-native people?	Less than 10% 10%-25% 25%-50% 50%-75% 75%-100%	4 3 2 1 0	25
(5) Are there any primary and secondary schools operated by voluntary or missionary organizations rather than the government itself?	Yes No	0 5	30
(6) What is the highest grade offered by local schools on a regular basis?	None 1 2 3 4 5 6 7 8 9 10 11 12 12+	0 2 4 7 10	40

		Weighting Factor	CALCULATIONS	
(7) If the grade selected in question #6 is less than 12, how far away is the nearest high school offering the 12th grade?	Less than 10 miles (16 km) 10-30 miles (16-48 km) 30-50 miles (48-80 km) More than 50 miles (80 km)	3 2 1 0	40	Not answered
(8) Are there any technical or vocational schools in the community?	**Yes** No	**5** 0	45	
(9) Has the community achieved compulsory primary education of at least 6 years?	Yes **No**	5 **0**	45	
(10) Are there any formal in-service training programs by either the government or local industry for their employees?	**Yes** No	**5** 0	50	
(11) Is there a college of university in the local community?	**Yes** No	**10** 0	60	
(12) Does the university have a chemistry department or lab?	Yes **No**	3 **0**	60	
(13) How do you rate the ability of the community to finance a water & sewage treatment project?	a) Unable to repay; the project is a gift because the beneficiaries are poor. b) Limited ability to repay; however, the benefits exceed the costs. c) Repayment prospects are good; the beneficiaries have relatively high income	Informational only	60	

		Weighting Factor		[illegible]
(14) Is unemployment widespread?	(Yes) No	(0) 5	60	
(15) Are advisory services widely available to farmers for community development or for other programs designed to upgrade the skills and enlist the participation of the inhabitants?	Yes (No)	3 (0)	60	
(16) Do most college or university students of the community receive their education in neighboring communities or countries or other foreign countries	(Yes) No	(0) 3	60	
(17) The level of technology available can generally be classified as:	Hand tools only ✓Mechanical tools (i.e., gasoline powered equipment) Chemical products (fertilizers, chlorine) Electronic technology	0 (5) 10 15	65	
(18) Does the government dominate the labor market?	Yes (No)	0 (5)	70	
(19) Are public employment services readily available?	(Yes) No	(5) 0	75	

The Total Weighted Socio-technological level (TWSTL) is equal to the sum of the weighting factors of Questions #1-19, not including Question #13.

TWSTL ____75____

STL ____III____ (refer to following charts)

Socio-technological Level (STL)	Range for TWSTL	Manpower Availability		
		Unskilled	Skilled	Professional
I	1-23	X		
II	24-51	X	X	
III (pop. < 50,000)	52-93	X	X	
III (pop. > 50,000)		X	X	X
IV	93+	X	X	X

The manpower availability for an STL of III and a population of 12,050 is:

Type of Manpower	Availability	Score (Yes = 1; No = 0)
Unskilled (UN)	Yes	1
Skilled (SK)	Yes	1
Professional (PF)	No	0

Predictive Model Questionnaire - Part IV "Indigenous Resources Data"

Category	Check If Not Available	Calculations	CALCULATIONS
(20) Operation Equipment (OE)		Critical Level* for Operation Equipment >3.	
·Meters; water, gas, recording devices, such as thermostats, water meters	______	Sum of Items Not Available 2	
·Sheet metal fabrication, etc.	______	Availability of Operation Equipment 1 (Yes = 1, No = 0)	
·Gauges; vacuum, flow, etc.	______		
·Laboratory equipment such as test tubes, etc. as found in high school chemistry labs, medical offices, and hospitals	✓		
·Portable power plants such as gasoline powered electric generators	______		
·Motors such as 1-3 horsepower electric motors	______		
·Pumps, fans, etc.	✓		
(21) Process Materials (PE)		Critical Level for Process Materials >3.	
·Pipe (clay, asbestos, cement, plastic)	______	Sum of Items Not Available 3	
·Pipe (cast iron, steel, copper)	______	Availability of Process Materials 1 (Yes = 1, No = 0)	
·Concrete, cement	______		
·Valves, pipe fittings	✓		
·Tanks	✓		
·Structural Steel	______		
·Heat exchangers	✓		

*Critical Level (CL) beyond which this resource is not available: For example, if 3 or more of the items in Question #20 not generally available, then the entire category, operation equipment, is not considered available.

Category	Check if not available	Calculations	Calculations
(22) Operation and Maintenance Supplies (OMS)		Critical Level for Operation and Maintenance Supplies >2	
·Silica sand and gravel	✓		
·Paint		Sum of Items Not Available 1	
·Water sealing compound, epoxy		Availability of Operation and Maintenance Supplies 1 (Yes = 1, No = 0)	
·Petroleum			
·Electricity			
(23) Chemical Supplies (CS)		Critical Level for Chemical Supplies > 1	
·$Al_2(SO_4)_3$ (aluminum sulfate), $FeCl_3$ (ferric chloridge), polyelectrolytes	✓	Sum of Items Not Available 2	
·NA_2CO_3 (soda ash), activated charcoal, CaO (lime)		Availability of Chemical Supplies 0 (Yes = 1, No = 0)	
·Cl_2 (Chlorine), O_3 (ozone), chlorindioxide, bromine HTH, $CuSO_4$	✓		

Note: Questions 20-23 can be replaced with water and waste equipment versus process matrix from the international equipment document, pages 29 & 30.

Summary of the Results for Parts III & IV (Manpower and Indigenous Resources)

UN	SK	PF	OE	PM	OMS	CS	GW
1	1	0	1	1	1	0	1

(Available = 1; Not Available = 0)

PROCESS CONSTRAINTS

WATER TREATMENT PROCESSES WITH ESSENTIAL MANPOWER AND RESOURCES REQUIRED FOR OPERATION

Treatment Methods	Process Number	Process Requirements						
		Manpower			Resources Required			
		Unskilled	Skilled	Professional	Operation Equipment	Process Supplies	Maintenance Supplies	Chemical Supplies
No Treatment	PW 1*	X			X	X	X	
Pre-Treatment	PW 2	X			X		X	
Slow Sand Filtration	PW 3	X				X	X	
Rapid Sand Filter (Conv.)	PW 4	X	X	X	X	X	X	X
Rapid Sand Filter (Adv.)	PW 5	X	X	X	X	X	X	X
Softening	PW 6	X	X	X	X	X	X	X
Disinfection	PW 7	X	X		X	X	X	X
Taste, Odor - Fe, Mn	PW 8	X	X		X	X	X	X
Desalting - Salt	PW 9	X	X	X	X	X	X	X
Desalting - Brackish	PW 10	X	X	X	X	X	X	X
Containment Filter	PW 11[a]	X				X	X	
Disinfectant - Filter	PW 12	X						X
		UN	SK	PF	OE	PM	OMS	CS

*Water Source (Groundwater Availability)

[a]Listed for completeness only; not actually available as a model output at this time.

List of Possible Water Treatment Processes:

PW 1

PW 2

PW 3

CODE FOR PROCESS COMBINATIONS	CODE FOR PROCESS COMBINATIONS
W1	PW1
W2	PW3
W3	PW11
W4	PW1 + PW7
W5	PW2 + PW3
W6	PW2 + PW12
W7	PW3 + PW7
W8	PW2 + PW3 + PW7
W9	PW4 + PW7
W10	PW2 + PW4 + PW7
W11	PW5 + PW7
W12	PW2 + PW5 + PW7
W13	(any one of W1 to W12) + PW6
W14	(any one of W1 to W12) + PW8
W15	(any one of W1 to W12) + PW9
W16	(any one of W1 to W12) + PW10

List of Possible Water Process Combinations,
Based on the Resource and Manpower Screen:

W1 = PW1

W2 = PW3

W5 = PW2 + PW3

Predictive Model Questionnaire - Part V "Water Quality"

A) Raw Water Quality			Notes/Comments
Number of coliform bacteria	50	(MPN/100 ml)	
Turbidity	50	(JTu)	
Hardness	150	(mg/l)	
Total Dissolved Solids (TDS)	1,500	(mg/l)	
Iron and Manganese	.5	(mg/l)	
*BOD		(mg/l)	
*pH		(0-14)	
*Dissolved oxygen		(mg/l)	
*Temperature		(oc)	
*Chloride		(mg/l)	
(*At this point, these tests are informational only, and not actually part of the model).			
B) Wastewater Quality (prior to treatment)			
Dilution		(CFS receiving water flow/1000 PE)	
Dilution	15	(Receiving water volume/waste volume)	
BOD		(mg/l; may be needed to ascertain figure for PE in dilution ratio)	

ACCEPTABLE COMBINATIONS OF TREATMENT PROCESSES, ACCORDING TO RAW WATER QUALITY OR DEGREE OF DILUTION AVAILABLE TO WASTE FLOWS

CODE FOR PROCESS COMBINATIONS	CODE FOR PROCESS COMBINATIONS	CRITERIA LEVELS RAW WATER CONCENTRATION COLIFORM BACTERIA (MPN/100 ml)	SOLIDS Turbidity (JTU)	SOLIDS Other (mg/l)
W1	PW1	1-2 *	10	
→ W2	PW3	200	100	
W3	PW11	300	800	
W4	PW1 + PW7	500	10	
→ W5	PW2 + PW3	1,000	800	
W6	PW2 + PW12	3,000	800	
W7	PW3 + PW7	5,000	100	
W8	PW2 + PW3 + PW7	10,000	1,000	
W9	PW4 + PW7	10,000	100	
W10	PW2 + PW4 + PW7	10,000	1,000	
W11	PW5 + PW7	10,000	100	
W12	PW2 + PW5 + PW7	10,000	1,000	
W13	(any one of W1 to W12) + PW6			300 hardness
W14	(any one of W1 to W12) + PW8			1-3 Fe & Mn
W15	(any one of W1 to W12) + PW9			3000 TDS[a]
W16	(any one of W1 to W12) + PW10			2000 TDS[a]

Acceptable water combinations, based on the raw water quality:

W 2
W 5

* These are standards for developed countries; different standards may be more appropriate for developing countries.

To select a combination based on cost, then the following procedure would be used:

1. Calculate the design year population scale.

Design year	1980
Actual population year	1970
Actual population value	10,181
Population growth rate	1.7%

Design year population value = (Actual Population) $(1 + \text{Population growth rate})^n$

where n represents the difference between the design year and the actual population year.

Design year population = $(10{,}181)\,(1 + .017)^{10} = 12{,}050$

Population Ranges and Scale Values

Estimated Population	Population Scale
500 - 2,499	I
2,500 - 14,999	II
15,000 - 49,999	III
50,000 - 100,000	IV

The design year population scale equals II.

2. Find the appropriate cost ratios.

By referring to Table 4.2 (Population Scale II), the following cost ratios are indicated:

Combination	Construction Cost Ratio	Operation & Maintenance Cost Ratio
W 2 = PW 3	14.66	6.05
W 5 = PW 2 + PW 3	3.00 + 14.66 = 17.66	7.67 + 6.05 = 13.72

TABLE 4.′

POPULATION SCAL I (2,500 - 14,999)
PER CAP[illegible]A [illegible]ST RATIOS
CONSTRUCTION/OPERATION AND MAINTENANCE

Process			Social-Technological Levels (STL) I	II	III	IV
(No Treatment)	PW1	Construction	2.70	2.43	1.48	1.37
		Operation and Maintenance	1.75	2.01	3.01	3.53
(Pre-Treatment)	PW2	Construction	2.20	2.50	3.00	3.25
		Operation and Maintenance	6.74	7.17	7.67	8.15
(Slow S.F.)	PW3	Construction	11.29	13.48	14.66	15.00
		Operation and Maintenance	2.94	5.71	6.05	6.45
(R.S.F. - Conv.)	PW4	Construction	22.00	19.89	14.45	11.00
		Operation and Maintenance	4.90	8.27	9.93	10.45
(R.S.F. - Adv.)	PW5	Construction	70.94	59.57	50.00	40.88
		Operation and Maintenance	43.13	41.68	40.22	38.77
(Softening)	PW6	Construction	115.86	90.49	65.12	39.75
		Operation and Maintenance	38.48	37.52	36.57	35.61
(Disinfection)	PW7	Construction	3.81	3.57	2.94	2.80
		Operation and Maintenance	18.47	15.65	12.54	11.42
(Odor, Taste, Fe, Mn)	PW8	Construction	91.34	80.44	70.53	59.63
		Operation and Maintenance	51.00	49.28	47.56	45.84
(Desalting - Salt)	PW9	Construction	146.94	129.63	117.31	95.00
		Operation and Maintenance	24.77	25.17	23.92	22.26
(Desalting - Brackish)	PW10	Construction	120.04	105.53	91.01	77.50
		Operation and Maintenance	37.87	36.59	35.31	34.03
(Disinfectant Filter)	PW12	Construction	30.25	28.55	26.74	24.12
		Operation and Maintenance	27.78	25.45	23.25	20.64

Note: Complete cost ratio tables may be found under Lecture 3.4, "Manpower, Costs, and Equipment"

3. Calculate the total cost ratios.

$$\text{Total cost ratio} = \text{Construction Cost Ratio} + \text{Operation \& Maintenance Cost Ratio} \left[\frac{1-(1+r)^{-n}}{r}\right]$$

where r is the discount rate

n is the discount period

If we assume r = 7.25% and n = 20, the discount multiplier is

$$\text{discount multiplier} = \frac{1 - (1 + r)^{-n}}{r}$$

$$= \frac{1 - (1 + .0725)^{-20}}{.0725}$$

$$= 10.39$$

For total cost ratios

Combinations	Construction Cost Ratio	+	Operation & Maintenance Cost Ratio	=	Total Cost Ratio
W 2 = PW 3	14.66	+	(6.05) (10.39)	=	77.53
W 5 = PW 2 + PW 3	17.66	+	(13.72) (10.39)	=	160.23

⟶ Based on the total cost ratios, combination W 2 would be selected at least costly.

Selection of Sewage Treatment System

Summary of the manpower and indigenous resource data:

UN	SK	PF	OE	PM	OMS	CS
1	1	0	1	1	1	0

(Available = 1; Not Available = 0)

PROCESS CONSTRAINTS

SEWAGE TREATMENT PROCESSES WITH ESSENTIAL MANPOWER AND RESOURCES REQUIRED FOR OPERATION

Treatment Methods	Process Number	Process Requirements						
		Manpower			Resources Required			
		Unskilled	Skilled	Professional	Operation Equipment	Process Materials	Maintenance Supplies	Chemical Supplies
Primary (Conv.)	PS1	X			X	X	X	
Primary - Stabilization Pond	PS2	X				X	X	
Sludge (Conv.)	PS3	X	X		X	X	X	
Sludge (Adv.)	PS4	X	X	X	X	X	X	X
Sludge (Combined (Imhoff)	PS5	X			X	X	X	
Secondary - Standard Filter	PS6	X	X		X	X	X	
Secondary - High Rate Filter	PS7	X	X		X	X	X	X
Secondary - Activated Sludge	PS8	X	X	X	X	X	X	
Extended Aeration	PS9	X	X		X	X	X	
Rotating Biol. Contactor	PS10	X	X		X	X	X	
Disinfection	PS11		X		X	X	X	X
Land Application	PS12	X	X		X	X	X	
Aqua Culture	PS13[a]	X						
Individual	PS14[a]	X						
Individual (Adv.)	PS15[a]		X		X		X	
		UN	SK	PF	OE	PM	OMS	CS

[a]Listed for completeness only; not available as a model output at this time.

List of possible waste treatment processes: 197

PS 1

PS 2

PS 3

PS 5

PS 6

PS 9

PS 10

PS 12

List of the possible waste combinations: 198

Code for Process Combinations	Process Combinations
S 1	PS5
S 2	PS1 + PS3
S 3	PS2
S 4	PS9
S 5	S2 + PS10
S 6	S2 + PS6
S 7	S2 + PS7
S 8	S2 + PS8
S 9	PS1 + PS12
S 10	S4 + PS12
S 11	PS2 + PS13
S 12	S1 + PS11
S 13	S2 + PS12
S 14	S3 + PS13
S 15	S4 + PS14
S 16	S5 + PS15
S 17	S6 + PS16
S 18	S7 + PS17
S 19	S8 + PS18

199

Based on the resource and manpower screen the possible water combinations are: <u>Possible Combinations</u>

S1 = PS5
S2 = PS1 + PS3
S3 = PS2
S4 = PS9
S5 = S2 + PS10
S6 = S2 + PS6
S9 = PS1 + PS12
S10 = S4 + PS12

200

Wastewater Quality Data

1. Dilution ________ (CFS receiving water flow/1000 PE)

or

Dilution __15__ (Receiving water volume/waste volume)

SEWAGE TREATMENT

ACCEPTABLE COMBINATIONS OF TREATMENT PROCESSES, ACCORDING TO RAW WATER QUALITY OR DEGREE OF DILUTION AVAILABLE TO WASTE FLOWS

CODE FOR PROCESS COMBINATIONS	PROCESS COMBINATIONS	RECEIVING WATER VOLUME (7-day low flow level)/WASTE VOLUME	
		BASED ON BOD	BASED ON COLIFORM
S1	PS5	20	160
S2	PS1 + PS3	20	160
→ S3	PS2	10	16
→ S4	PS9	3	16
S5	S2 + PS10	5	32
S6	S2 + PS6	6	32
→ S9	PS1 + PS12	0	0
→ S10	S4 + PS12	0	0

Based on the dilution ratio screen the acceptable waste combinations are:

Acceptable Combinations
S 3
S 4
S 9
S 10

(The cost calculations for the waste combinations are similar to the calculations for water systems.)

Session 3.4

205

Title: Manpower, Costs, and Equipment

Objective:

I. Determination of Equipment needs, by process

II. Determination of Skill needs, by equipment

Methodology for Predication of Water and Wastewater Volumes and Treatment Costs

(Excerpt from Chapter IV)

To obtain LDC cost or volume figures for selected water and wastewater treatment processes, three methods may be used in order of increasing accuracy, they are the following: an empirical analysis of U.S. data, regional or national multip regression data, and in-country or local data. In this chapter a cost-demand model is presented in which modelling techniques have been used to develop equations for Africa, Asia, and Latin America to predict water demand quantities and wastewater amounts, as well as construction and operation and maintenance costs for slow sand filters, rapid sand filters stabilization lagoons, aerated lagoons, activated sludge systems, and trickling filters. The basic technique used in thi study was step-wise multiple regression using available cost data from Africa, Asia, and Latin America gathered through t use of questionnaires and a review of the literature.

The material contained in this chapter is a shortened and revised version of the original publication. Numerous tabl have been included which present the results for mean water demand, waste disposal, and costs of water and wastewater treatment systems for selected socioeconomic and technological conditions of LDC's. Two sample problems illustrate the u of this predictive mathematical model.

SESSION OUTLINE:

I. Numerous Studies for Forecasting Water and Sewage Treatment Costs

A. Developers of forecasting tools .

1. Schoeffer
2. Wolman
3. Smith
4. Assenzo
5. Black and Veatch
6. AVCO/ES
7. Kanti Shah
8. Reid

B. Development of models for water demands and water costs in terms of populations

1. Tools devised are those sophisticated regression models

a. Such as: from $WD_t = (Pop_t)(gcd)$

to $WD_t = (Pop_t)(gcd) + (\sum_{i}^{n} Ind\ Pop_t)(gcd)$ etc.

to $WD_t = C_0 + C_1\ Pop^{n1} + C_2\ PPCT^{n2} + C_3\ INC^{n3}$ etc.

II. Similarly other tools have been developed for cost analysis

A. Generally two routes exist

1. The aggregate model
2. Detailed summation of component parts. The Composite Model.

III. Recognizing the problems with USA cost forecasts, and the shortage of LDC data

A. Development of DC aggregate forecasting models adapted to the amount of LDC data available

1. Figure 12.1

PER CAPITA COST PARAMETERS ($U.S.) AND
OPERATION AND MAINTENANCE MANPOWER REQUIREMENTS
PROCESS:: SLOW SAND FILTER (PW3)

Population Scale		Social-Technological Levels I	II	III	IV	Manpower Required (Number of Workers) Unskilled	Skilled	Professional
1	Construction	12.65	16.50	16.00	20.00			
(500 - 2,499)	Operation and Maintenance	1.33	2.00	2.33	5.00	1		
2	Construction	9.03	11.72	11.85	14.28			
(2,500 - 14,999)	Operation and Maintenance	0.60	0.90	1.05	2.25	2		
3	Construction	6.33	7.18	7.68	10.01			
(15,000 - 49,999)	Operation and Maintenance	0.33	0.58	0.73	1.25	5		
4	Construction	3.95	6.98	5.21	6.25			
(50,000 - 100,000)	Operation and Maintenance	0.20	0.35	0.44	0.75	8		

IV. After Field Demonstrations

A. Costs were expressed in terms of ratio's for the sake of comparison, and to eliminate the Effects of Scale

B. Some additional influences were also felt effecting cost

1. Cheaper land in LDC
2. Volunteerism becoming a factor in smaller LDC sites

C. The output is cost ratios

1. Ratio's representing capital and O + M values for possible successful candidate processes
2. Speculation can now be done as to whether

a. Initial expenditure or continuing costs are better
b. The use of comparison of an annualized or capitalized cost

V. The procedure to establish a common base for analysis of total cost is listed as follows

A. Estimation of the construction cost and O + M cost based on the cost of process and the effects of population scale and STL's.

(Calculations on following page)

TABLE 4.1 POPULATION SCALE I (500 - 2,499)

TABLE 4.3

POPULATION SCALE III (15,000 - 19,999)
PER CAPITA COST RATIOS
CONSTRUCTION/OPERATION AND MAINTENANCE

		Process	Social-Technological Levels (STL) I	II	III	IV
(No Treatment)	PW1	Construction	1.64	1.47	1.51	1.14
		Operation and Maintenance	1.42	1.95	2.50	2.75
(Pre-Treatment)	PW2	Construction	2.50	2.75	3.01	3.50
		Operation and Maintenance	6.83	7.33	7.83	8.33
(Slow S.F.)	PW3	Construction	9.59	11.45	13.31	14.17
		Operation and Maintenance	3.05	6.01	7.86	10.42
(R.S.F. - Conv.)	PW4	Construction	16.42	16.00	9.20	7.58
		Operation and Maintenance	6.58	9.25	11.91	14.58
(R.S.F. - Adv.)	PW5	Construction	49.15	43.37	37.60	33.82
		Operation and Maintenance	62.50	59.95	56.95	54.14
(Softening)	PW6	Construction	60.79	52.01	48.23	25.45
		Operation and Maintenance	44.50	42.67	40.83	39.00
(Disinfection)	PW7	Construction	3.48	3.04	2.71	2.57
		Operation and Maintenance	18.08	14.91	12.35	10.58
(Odor, Taste, Fe, Mn)	PW8	Construction	75.59	66.71	57.82	48.94
		Operation and Maintenance	87.50	84.22	80.95	77.67
(Desalting - Salt)	PW9	Construction	127.70	112.88	97.06	84.24
		Operation and Maintenance	32.67	31.22	29.78	28.33
(Desalting - Brackish)	PW10	Construction	106.50	95.42	81.31	69.21
		Operation and Maintenance	65.10	62.97	60.78	58.58
(Disinfectant Filter)	PW11	Construction	29.95	28.26	26.38	24.01
		Operation and Maintenance	27.13	25.17	22.89	20.19

TABLE 4.3 (cont.)

		Process	Social-Technological Levels (STL) I	II	III	IV	
(Prim. - Conv.)	PS1	Construction	9.07	9.94	10.70	11.00	(mech. equipment
		Operation and Maintenance	9.17	10.86	12.56	14.25	
(Primary Stabilization Pond)	PS2	Construction	1.50	1.70	2.22	3.35	
		Operation and Maintenance	2.10	3.17	5.33	7.50	
(Sludge - Conv.)	PS3	Construction	13.73	11.70	9.67	8.64	
		Operation and Maintenance	39.25	34.58	27.63	25.47	
(Sludge - Adv.)	PS4	Construction	23.78	22.50	18.22	14.94	
		Operation and Maintenance	30.67	36.28	40.95	47.50	
(Sludge - Imhoff)	PS5	Construction	28.11	21.28	20.04	18.80	
		Operation and Maintenance	38.58	41.80	42.03	42.25	
(Sec. - Std Filter)	PS6	Construction	27.99	29.50	30.90	31.00	
		Operation and Maintenance	5.33	8.53	11.72	14.92	
(Sec. High R. Filter)	PS7	Construction	27.11	23.51	19.90	17.68	
		Operation and Maintenance	14.20	16.44	21.14	25.83	
(Sec. - Act. Sludge)	PS8	Construction	30.30	29.00	23.22	18.00	
		Operation and Maintenance	13.90	17.67	21.43	24.83	
(Ext. Aeration	PS9	Construction	17.16	18.40	19.64	21.88	
		Operation and Maintenance	10.50	14.72	18.95	23.17	
(Rotating Biological Contactor)	PS10	Construction	37.93	35.70	28.71	20.48	
		Operation and Maintenance	25.24	20.31	16.20	13.37	
(Disinfection)	PS11	Construction	12.00	11.12	10.15	6.83	
		Operation and Maintenance	10.08	8.80	7.53	6.25	
(Land Application)	PS12	Construction	10.23	11.37	15.20	16.84	
		Operation and Maintenance	6.19	6.88	9.24	10.18	

TABLE 4.4

POPULATION SCALE IV (50,000 - 100,000)
PER CAPITA COST RATIOS
CONSTRUCTION/OPERATION AND MAINTENANCE

Process			Social-Technological Levels (STL)			
			I	II	III	IV
(No Treatment)	PW1	Construction	1.44	1.38	1.21	1.10
		Operation and Maintenance	1.00	1.78	1.95	2.43
(Pre-Treatment)	PW2	Construction	2.74	2.96	3.48	4.00
		Operation and Maintenance	6.93	7.63	7.93	8.53
(Slow S.F.)	PW3	Construction	7.90	9.43	10.97	12.50
		Operation and Maintenance	3.33	6.37	9.44	12.50
(R.S.F. - Conv.)	PW4	Construction	15.50	8.77	6.00	5.30 Note #1
		Operation and Maintenance	11.17	15.78	20.39	25.00 Note #1
(R.S.F. - Adv.)	PW5	Construction	31.20	27.53	23.87	20.20 Note #1
		Operation and Maintenance	82.50	79.72	76.95	74.17
(Softening)	PW6	Construction	47.90	30.87	27.83	22.80
		Operation and Maintenance	54.50	52.69	50.87	49.06
(Disinfection)	PW7	Construction	3.16	2.91	2.65	2.40
		Operation and Maintenance	16.50	12.33	12.17	10.00
(Odor, Taste, Fe, Mn)	PW8	Construction	61.76	54.57	47.39	40.20
		Operation and Maintenance	97.50	94.22	90.95	87.67
(Desalting - Salt)	PW9	Construction	83.52	73.95	65.37	57.80
		Operation and Maintenance	42.67	41.22	39.73	38.33
(Desalting - Brackish)	PW10	Construction	80.78	75.17	66.46	56.80
		Operation and Maintenance	66.33	70.72	65.11	59.50
(Disinfectant Filter)	PW11	Construction	29.32	28.10	26.23	23.75
		Operation and Maintenance	26.98	24.98	22.56	20.04

TABLE 4.4 (con't)

		Process	Social-Technological Levels (STL)				
			I	II	III	IV	
(Prim. - Conv.)	PS1	Construction	10.55	11.18	11.45	11.82	(mecn. equipment
		Operation and Maintenance	9.08	10.57	11.33	14.10	
(Primary Stabilization Pond)	PS2	Construction	2.00	2.50	3.50	4.00	
		Operation and Maintenance	1.00	2.83	4.67	6.50	
(Sludge - Conv.)	PS3	Construction	17.37	15.23	13.08	11.94	apparent revers economy of scal
		Operation and Maintenance	37.80	32.90	26.96	21.31	
(Sludge - Adv.)	PS4	Construction	19.29	17.03	15.78	12.52	
		Operation and Maintenance	28.60	33.83	39.07	44.30	
(Sludge - Imhoff)	PS5	Construction	30.38	27.28	24.17	21.07	
		Operation and Maintenance	18.70	24.60	26.50	31.40	
(Sec. - Std Filter)	PS6	Construction	23.32	24.27	25.21	26.16	
		Operation and Maintenance	5.10	8.13	11.17	14.20	
(Sec. High R. Filter)	PS7	Construction	20.11	18.86	17.62	16.37	
		Operation and Maintenance	11.75	16.07	17.93	19.80	
(Sec. - Act. Sludge)	PS8	Construction	23.31	21.82	18.34	15.85	
		Operation and Maintenance	13.67	17.39	21.11	24.20	
(Ext. Aeration)	PS9	Construction	17.23	19.57	20.90	23.24	apparent revers economy of scal
		Operation and Maintenance	8.40	10.30	14.27	15.20	
(Rotating Biological Contactor)	PS10	Construction	28.94	27.25	21.91	15.64	
		Operation and Maintenance	23.93	17.71	14.32	10.21	
(Disinfection)	PS11	Construction	16.84	13.50	10.17	9.18	
		Operation and Maintenance	5.80	5.07	5.33	3.60	
(Land Application)	PS12	Construction	8.25	9.19	12.23	13.58	
		Operation and Maintenance	4.95	5.52	7.34	8.15	

Sessions
4.1 & 4.2

Title: Wastewater Disposal and Treatment

Objective: To present the goals of wastewater disposal, and to discuss various processes and systems.

Wastewater Disposal and Treatment
(excerpt from CHAPTER VIII)

In this chapter are presented several wastewater treatment or disposal methods for application to sewered wastewaters. These particular methods were selected for inclusion because of their low cost and their suitability for developing countries. Stabilization ponds are among the processes associated with developing countries, and the first section of this chapter deals with this subject at length before giving brief descriptions of the use of fish ponds and oxidation ditches. This material represents a shortened version of the original publication. Stabilization pond systems are a treatment of choice in developing countries due to their generally low cost and because many developing countries are located in tropical areas which provide optimum climatic conditions for pond operation. Data are given on the performance and costs of ponds, and some comparisons are made with aerated lagoons and activated sludge systems.

In the second section in this chapter, information is given on the aerated lagoon, including process design considerations and power requirements for mixing. The cost of an aerated lagoon is generally more than that of a stabilization pond and less than that of an oxidation ditch. Among the advantages of aerated lagoons in comparison with stabilization ponds, are first, their ability to handle higher loadings with a shorter detention time in a reduced area. In addition, algae are not necessary to provide oxygen to an aerated lagoon; therefore, this type of unit can be used without regard to the amount of available sunlight.

In the third section of this chapter, an article on land application of wastewater presents a practice which was formerly used primarily for wastewater disposal but which more recently has often been used for wastewater treatment or reuse. Like the article on aerated lagoons this article was prepared especially for publication in this volume. Design criteria are given, and cost and health aspects are discussed. With this method wastewater is spread over the land.

After having been subjected to filtering and stabilization of the organic matter by topsoils and soil biota, the treated water may be collected by a drainage system for reuse or allowed to recharge natural aquifers. The requirements of this process are low in terms of energy and chemicals, and the water yielded from a properly maintained system will be of simi quality to the water provided by advanced tertiary treatment processes. A principal problem associated with land application is the possibility of pollution of groundwater or soils with harmful substances.

TABLE 13.1 231

WASTEWATER

PS1 -- Primary; Conventional: The removal of suspended solids and some BOD through the use of clarifiers and sedimentation basins.

PS2 -- Primary; Stabilization Pond: Removal of suspended solids in a quiescent settling pond using basically no constructed facilities.

PS3 -- Sludge; Conventional: The dewatering of sludge from the primary treatment stage by sludge drying beds, incineration or other heating processes.

PS4 -- Sludge; Advanced: The dewatering of sludge utilizing a wet oxidation process or land application.

PS5 -- Sludge Combined; Imhoff: A constructed two-story tank used for both sedimentation and digestion of solids.

PS6 -- Secondary; Standard Filter: The use of a standard trickling filter and bacterial action to remove colloidal and dissolved organic matter from the primary clarifier effluent.

PS7 -- Secondary; High Rate: The use of higher loading rates accomplished through a recirculation process.

PS8 -- Secondary; Activated Sludge: System in which the flocculated biological growths are continuously circulated and contacted with organic wastewater in the presence of oxygen.

PS9 -- Secondary; Extended Aeration: More time is provided in the aeration process to allow for oxidizing the biodegradable portion of the sludge.

PS10 -- Disinfection: Use of chlorine to kill pathogenic organisms.

PS11 -- Aqua-Culture: Utilization of waste effluent as a food source for fish and plant life in controlled ponds and lagoons.

PS12 -- Dilution: Reduction of waste levels by incorporation in large volumes of water.

PS13 -- Individual: Sewerless system used primarily for individual dwellings or on-site systems.

PS14 -- Individual; Advanced: Sewerless, individual system using chemical and thermal treatment of waste.

TABLE 13.2

WASTEWATER TREATMENT PROCESS/CODE IDENTIFIERS

CODE	PROCESS
PS1	Primary - Conventional
PS2	Primary Stabilization Pond
PS3	Sludge - Conventional
PS4	Sludge - Advanced
PS5	Sludge Combined - Imhoff
PS6	Secondary - Standard Filter
PS7	Secondary - High Rate Filter
PS8	Secondary - Activated Sludge
PS9	Secondary Extended Aeration (Oxidation Pond)
PS10	Disinfection - Chlorine
PS11	Aqua-Culture
PS12	Dilution
PS13	Individual
PS14	Individual (Advanced)

TABLE 13.3

WASTEWATER PROCESSES VS. MANPOWER REQUIREMENTS FOR POPULATION LEVELS

Process/ Manpower Requirements	Level	Unskilled	Skilled	Professional
PS1	1	1		
	2	1		
	3	2	1	
	4	4	2	
PS2	1	1		
	2	2		
	3	4		
	4	6		
PS3	1	1	1	
	2	1	1	
	3	2	1	
	4	4	2	1
PS4	1	1	1	
	2	1	1	
	3	2	1	
	4	4	2	1
PS5	1	1	1	
	2	1	1	
	3	2	1	
	4	4	1	
PS6	1	1		
	2	1	1	
	3	4	1	1
	4	6	2	1
PS7	1	1		
	2	2	1	
	3	4	1	1
	4	6	1	1
PS8	1	1	1	
	2	2	1	
	3	4	1	1
	4	8	2	2
PS9	1	1	1	
	2	2	1	
	3	4	1	1
	4	6	2	1
PS10	1	1		
	2	2		
	3	4	1	1
	4	6	1	1

PROCESS CONSTRAINTS

SEWAGE TREATMENT PROCESSES WITH ESSENTIAL MANPOWER

& RESOURCES REQUIRED FOR OPERATION

TREATMENT METHODS	PROCESS NUMBER	PROCESS REQUIREMENTS						
		MANPOWER			RESOURCES REQUIRED			
		UNSKILLED	SKILLED	PRO-FESSIONAL	OPERATION EQUIPMENT	PROCESS MATERIALS	MAINT SUPPLIES	CHEMICAL SUPPLIES
PRIMARY (Conv.)	PS1	X			X	X	X	
PRIMARY-Stabilization Pond	PS2	X				X	X	
SLUDGE (Conv.)	PS3	X	X		X	X	X	
SLUDGE (Adv.)	PS4	X	X	X	X	X	X	X
SLUDGE-Combined (Imhoff)	PS5	X			X	X	X	
SECONDARY-Standard Filter	PS6	X	X		X	X	X	
SECONDARY-High Rate Filter	PS7	X	X		X	X	X	X
SECONDARY-Activated Sludge	PS8	X	X	X	X	X	X	
EXTENDED AERATION	PS9	X	X		X	X	X	
ROTATING BIOL. CONTACTOR	PS10	X	X		X	X	X	
DISINFECTION	PS11		X		X	X	X	X
LAND APPLICATION	PS12	X	X		X	X	X	
AQUA CULTURE	PS13[a]	X						
INDIVIDUAL	PS14[a]	X						
INDIVIDUAL (Adv.)	PS15[a]		X		X		X	

[a]Listed for completeness only, not actually available as a model output at this time.

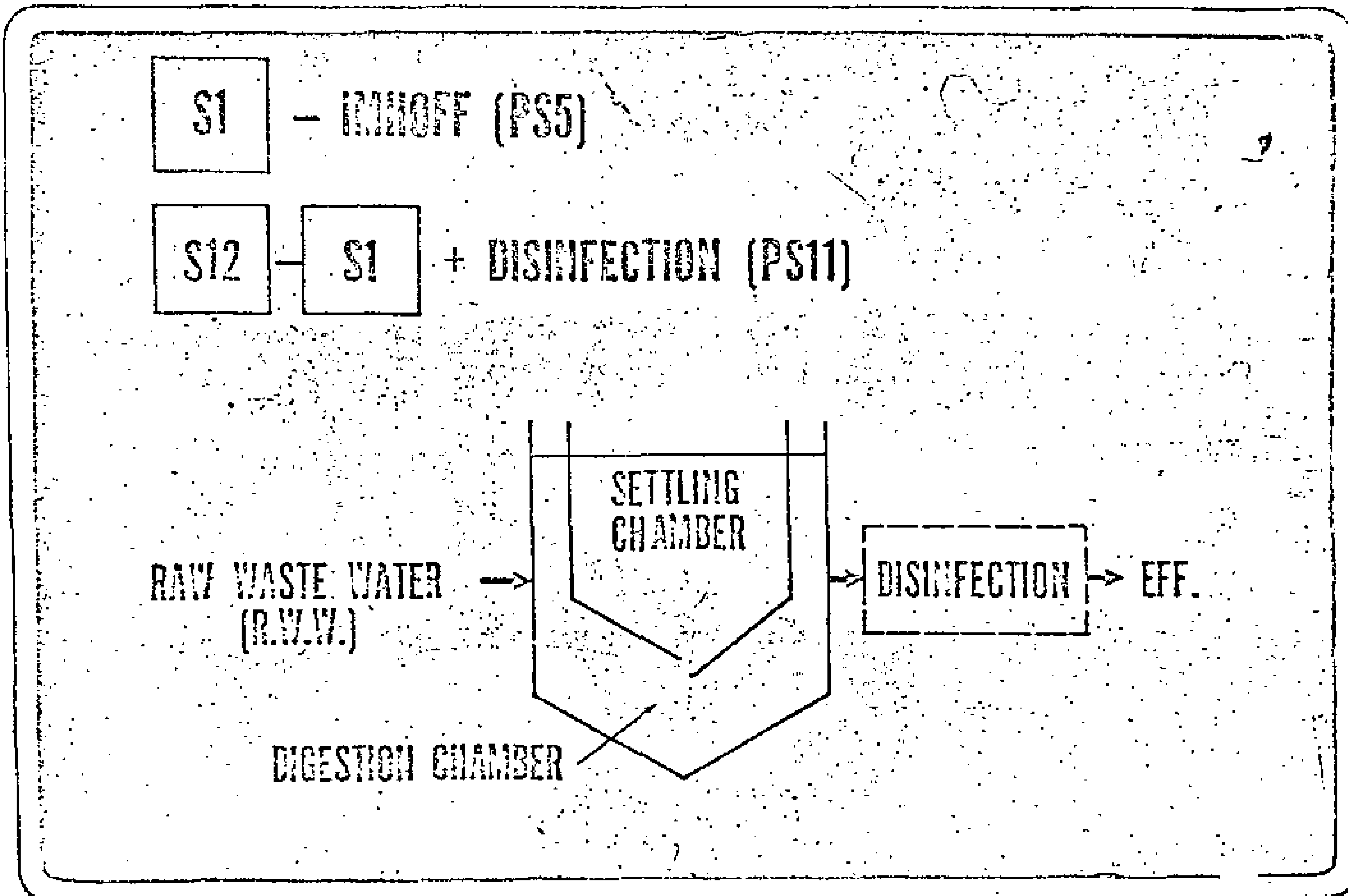
SEWAGE TREATMENT

ACCEPTABLE COMBINATIONS OF TREATMENT PROCESSES, ACCORDING TO RAW WATER QUALITY OR DEGREE OF DILUTION AVAILABLE TO WASTE FLOWS

CODE FOR PROCESS COMBINATIONS	PROCESS COMBINATIONS	RECEIVING WATER VOLUME (7-day low flow level)WASTE VOLUME	
		BASED ON BOD	BASED ON COLIFORM
S1	PS5	20	160
S2	PS1 + PS3	20	160
S3	PS2	10	16
S4	PS9	3	16
S5	S2 + PS10	5	32
S6	S2 + PS6	6	32
S7	S2 + PS7	5	32
S8	S2 + PS8	4	32
S9	PS1 + PS12	0	0
S10	S4 + PS12	0	0
S11	PS2 + PS13	5	16
S12	S1 + PS11	20	2
S13	S2 + PS11	20	2
S14	S3 + PS11	10	2
S15	S4 + PS11	3	2
S16	S5 + PS11	5	2
S17	S6 + PS11	6	2
S18	S7 + PS11	5	2
S19	S8 + PS11	4	2

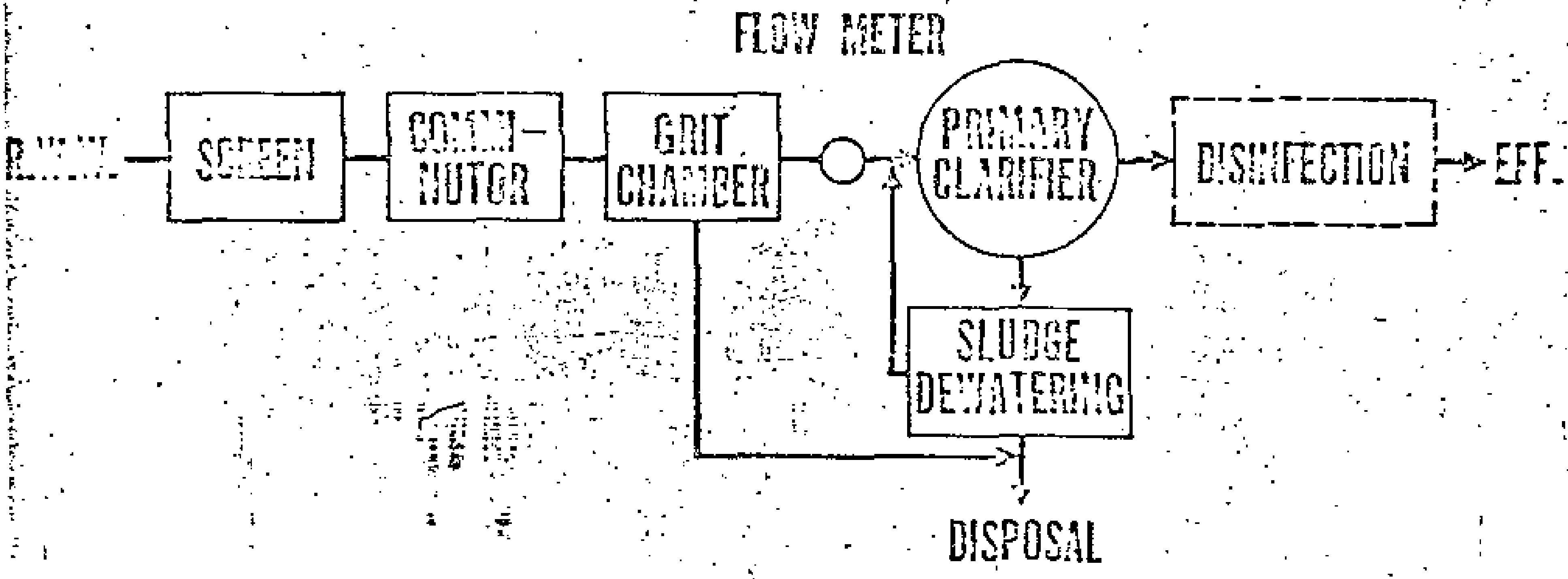
These represent standards for <u>developed</u> countries; different standards may be more appropriate for developing countries.

S1 = PS5
2= (S1 + PS11)
S12= (PS5 + PS11) = UN, SK, DE, PM, OMS, and CS



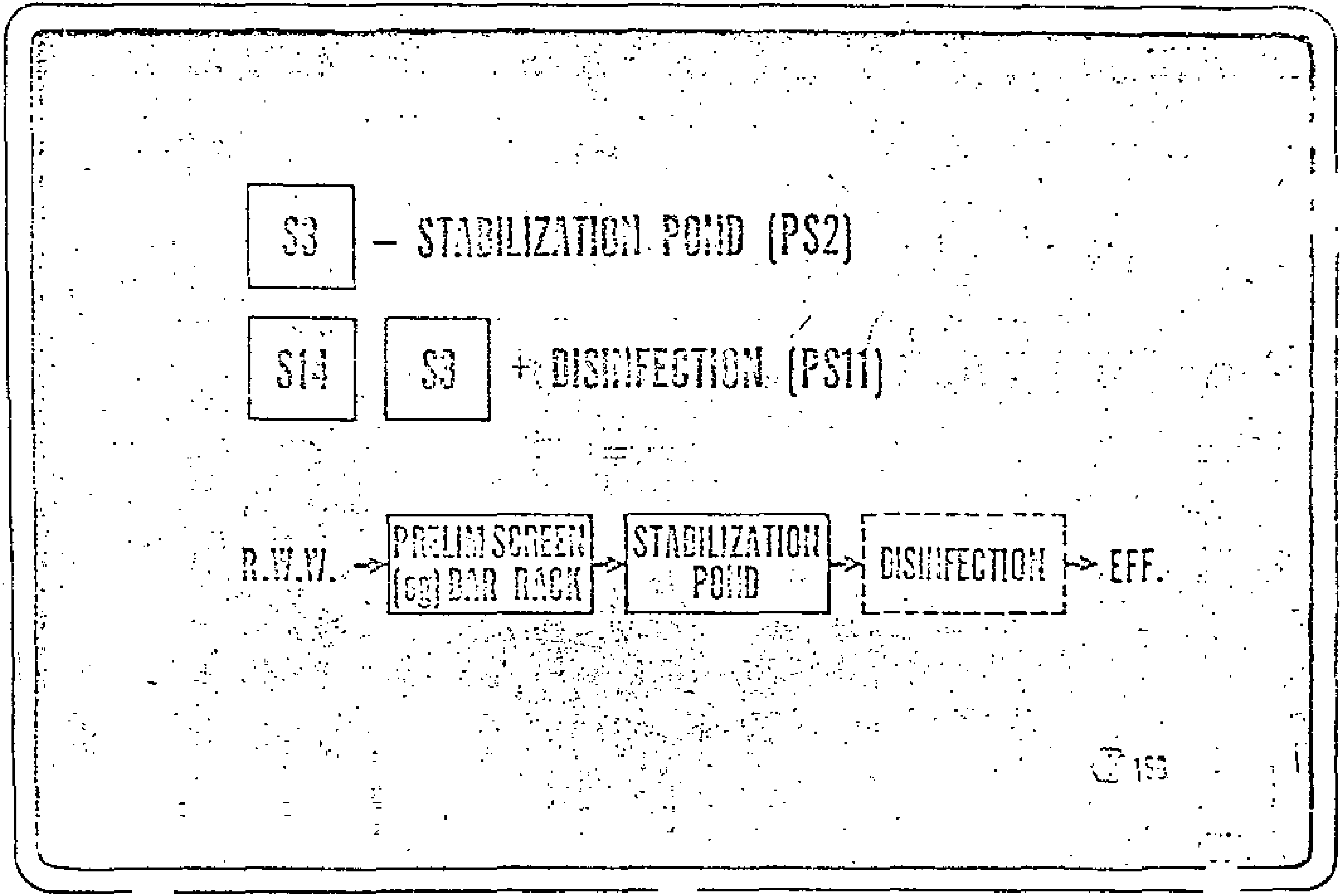
S2 – PRIMARY + SLUDGE –Conventional – (PS1+PS3)

S13 S2 + DISINFECTION (PS11)



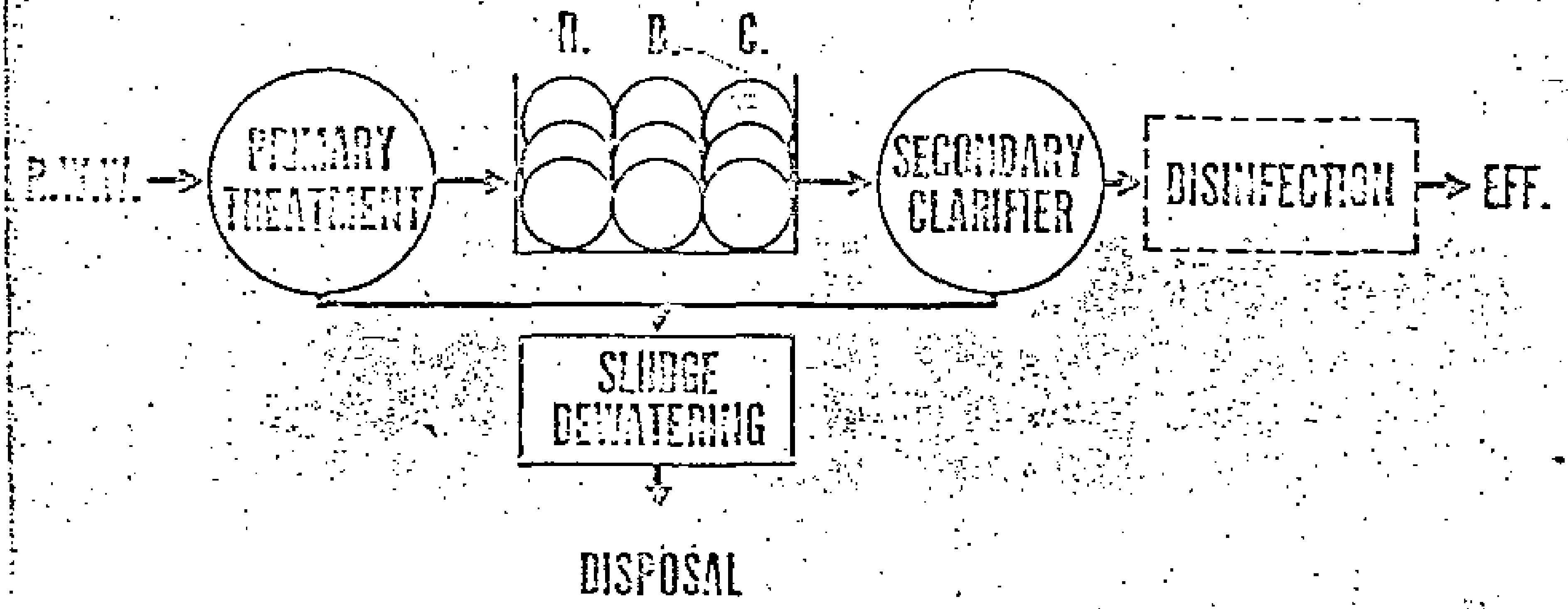
S2 = (PS1 + PS3)
S13 = (S2 +PS11)
= (PS1 + PS3 + PS11) = UN, SK, OE, PM, OMS, a CS

S3 = PS2
4 = (S3 + PS11)
4 = (PS2 + PS11) = UN, SK, OE, PM, OMS, and C



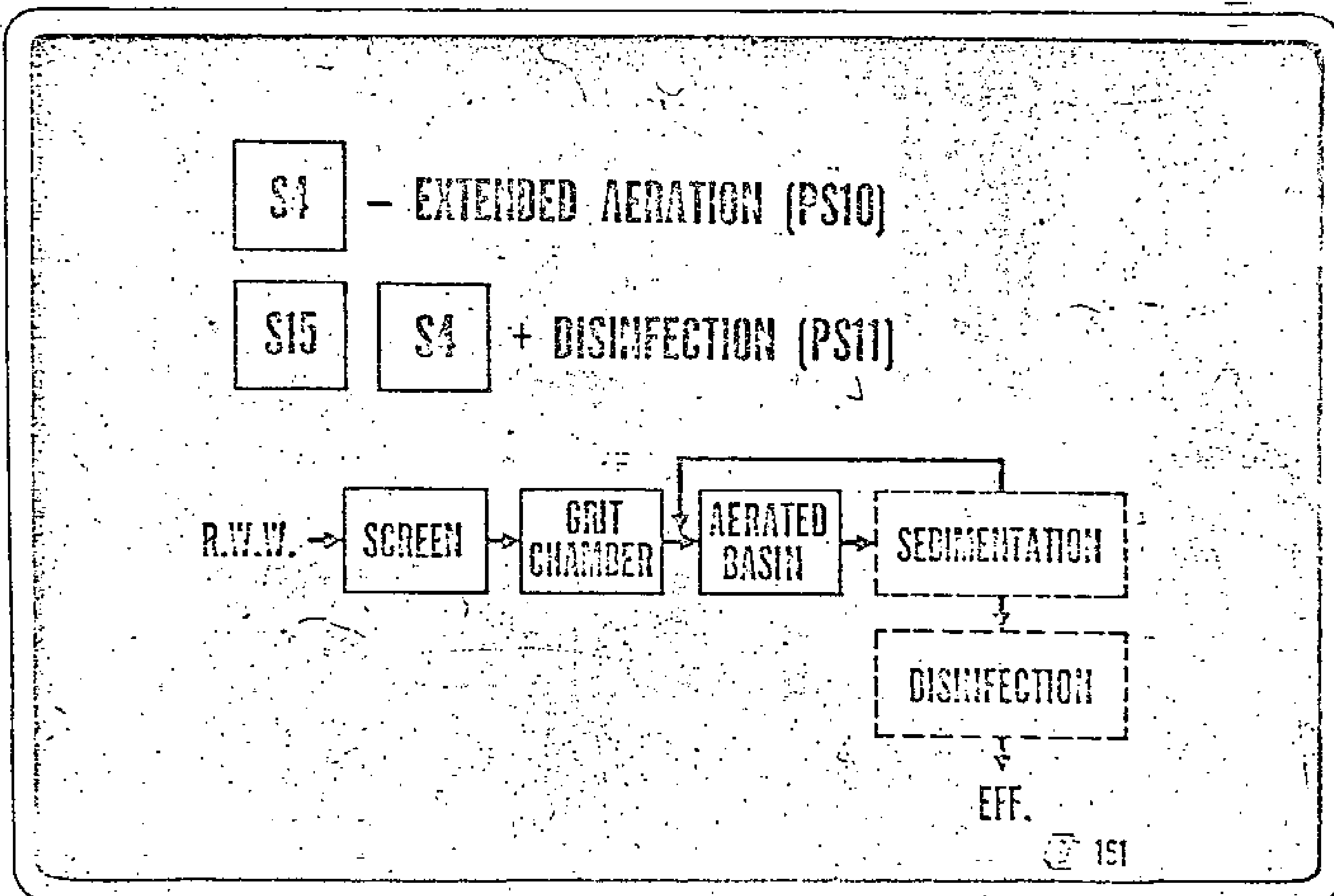
[illegible] | S2 + ROTATING BIOLOGICAL CONTACTOR (R.B.C.) (PS10)

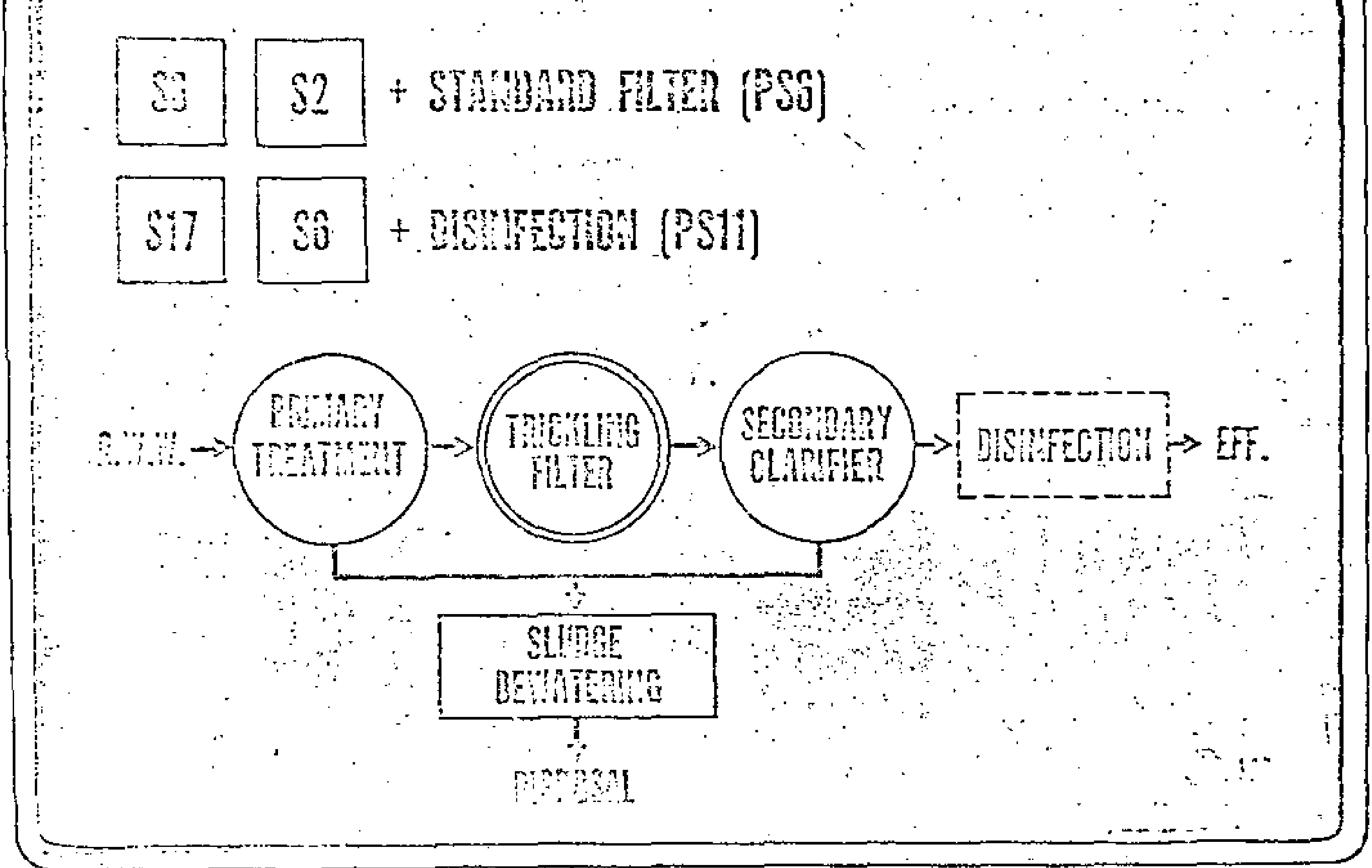
[illegible] | S5 + DISINFECTION (PS11)



S5 = (PS1 + PS10)
S2? = (PS1 + PS3)
= (S5 +PS11)
S16 = (PS1 + PS3 + PS10, + PS11) = UN, SK, OE, PM, OMS, and CS

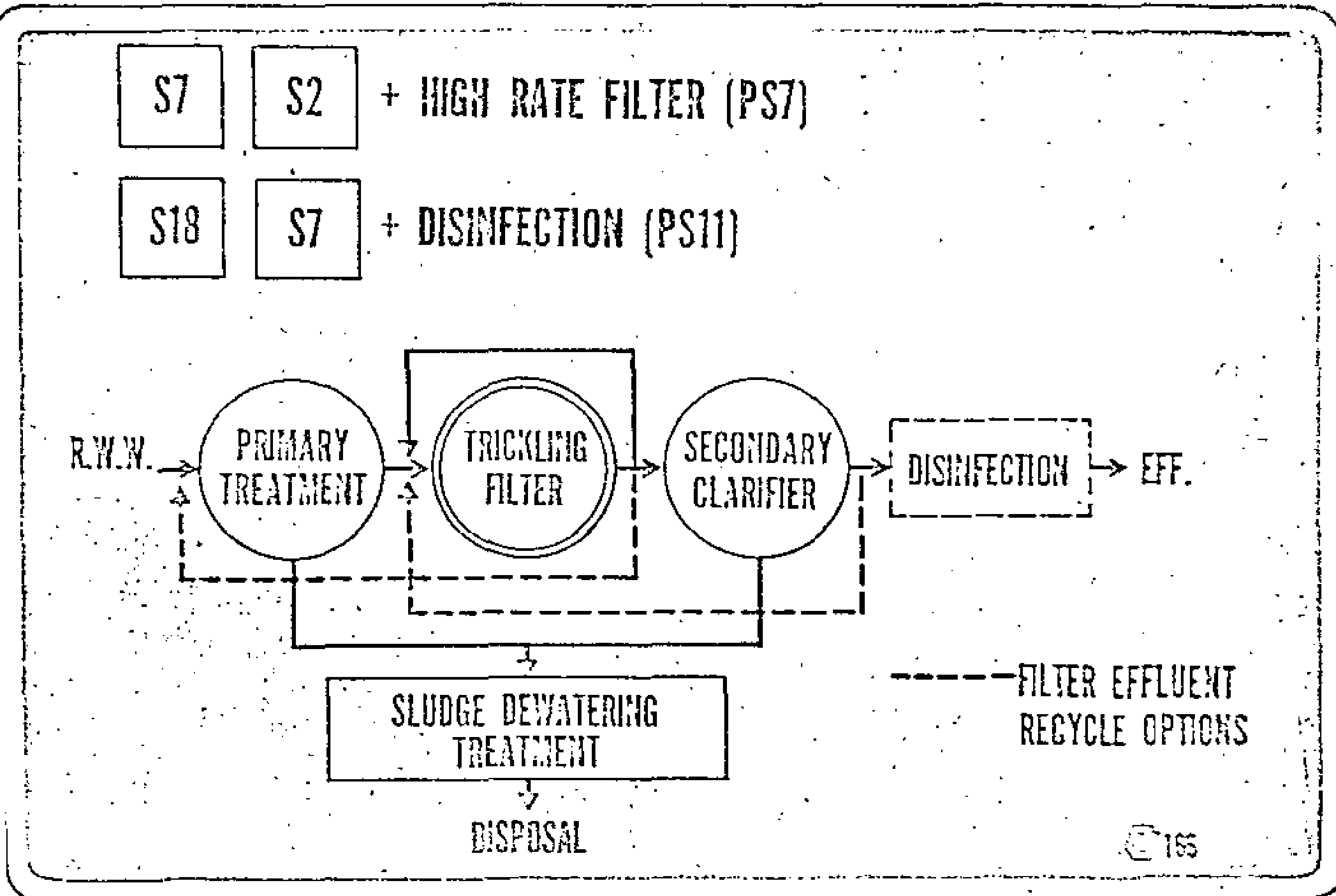
[illegible] = PS9
[illegible] = (S4 + PS11)
S15 = (PS9 + PS11) = UN, SK, PF, OE, PM, OMS, and CS

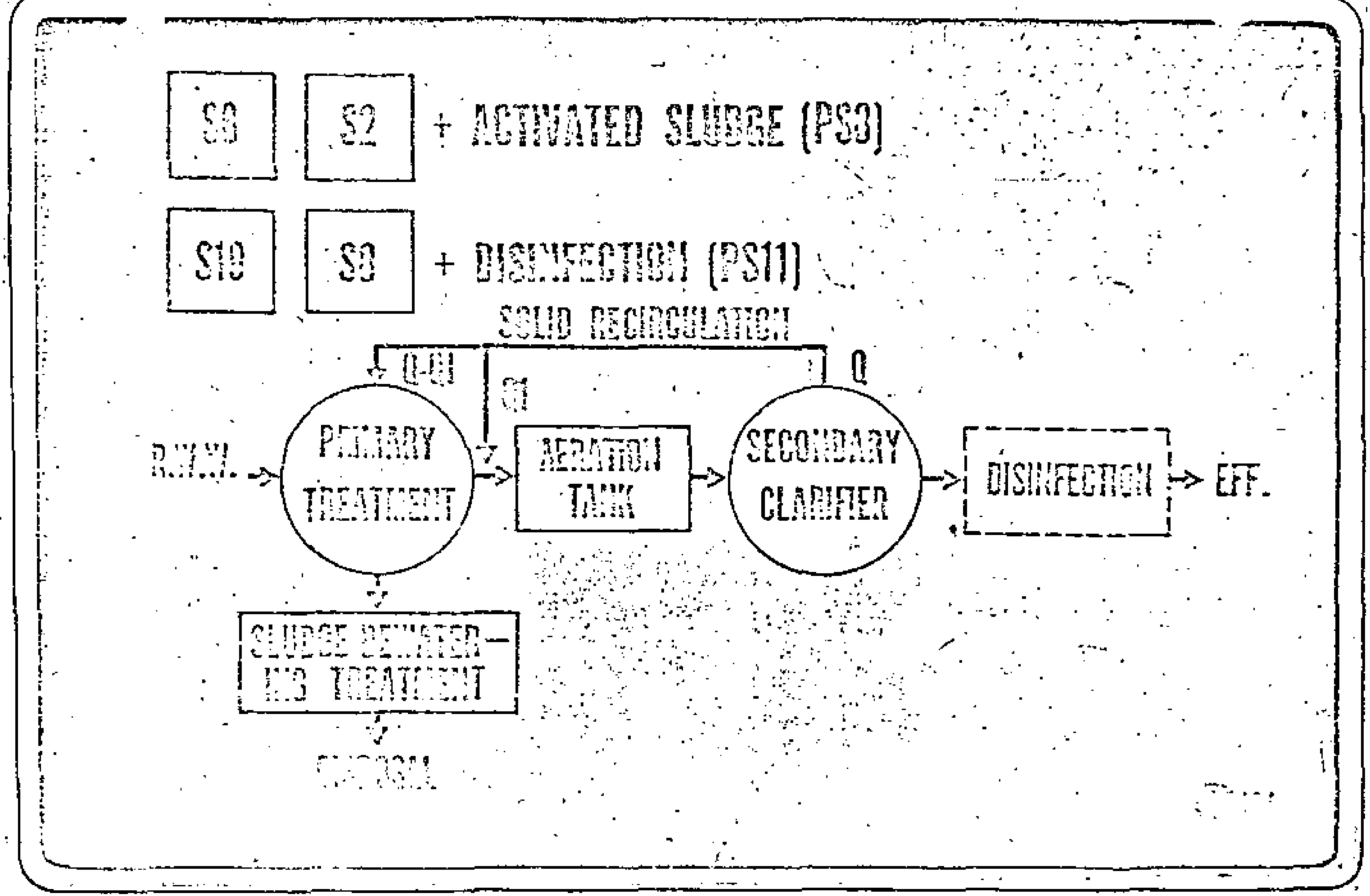




S2 = (PS1 + PS5)
S6 = (S2 + PS6)
S17 = (S6 +PS11)
[illegible] = (PS1 + PS5 + PS6 + PS11) = UN, SK, OE, PM, [illegible]MS, and CS

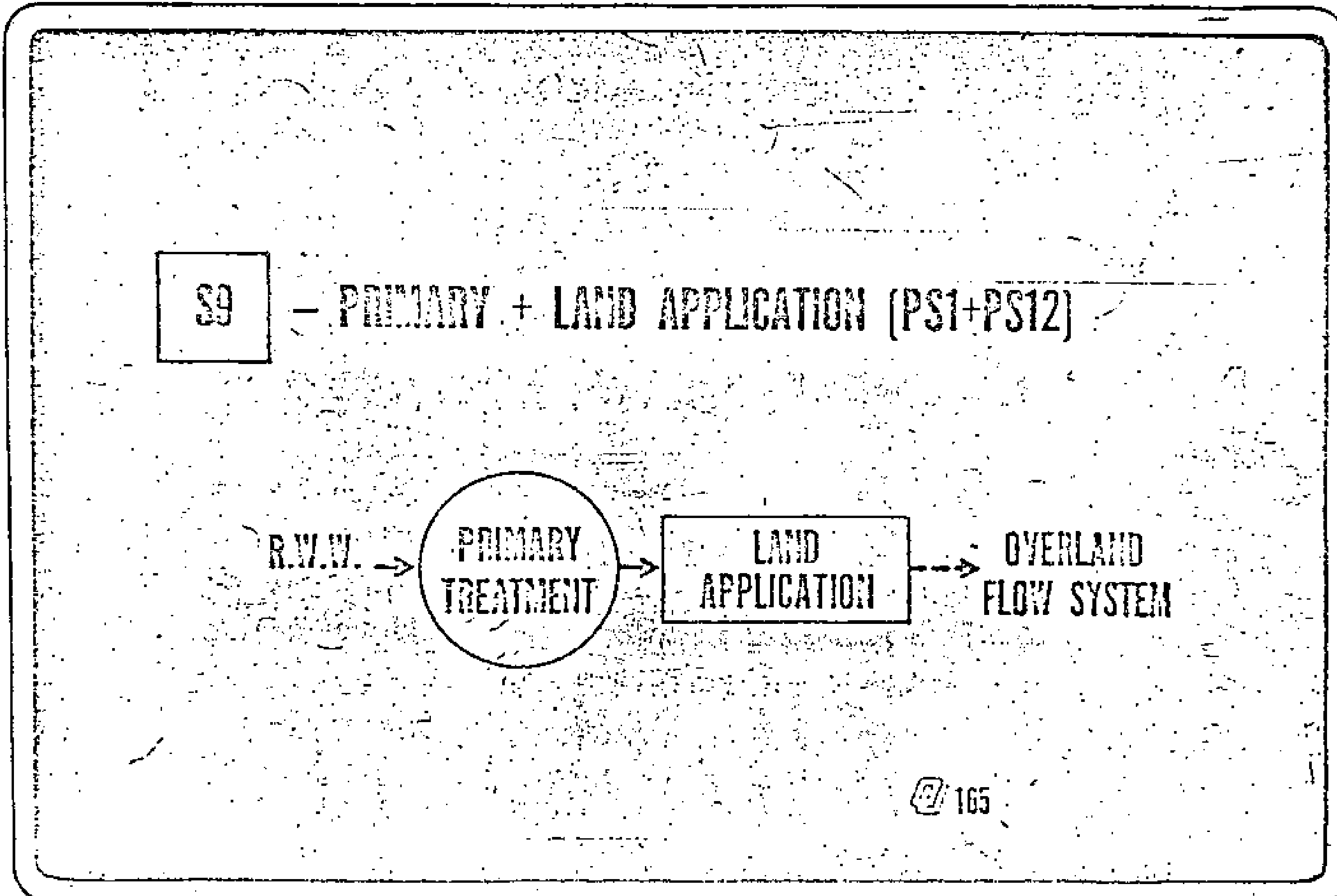
S2 = (PS1 + PS5)
= (S2 + PS6)
S18 = (S7 + PS11)
S18 = (PS1 + PS3 + PS7 + PS11) = UN, SK, OE, PM, OMS, and CS



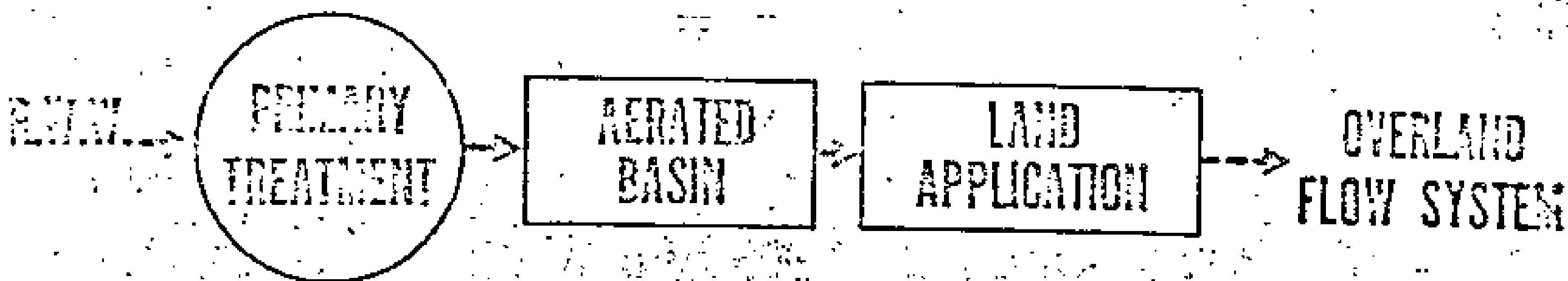


S2 = (PS1 + PS3)
S8 = (S2 + PS8)
19 = (S8 + PS11)
19 = (PS1 + PS3 + PS8 + PS11) = UN, SK, PF, O PM, OMS, CS

• (PS1 + PS12)
• (PS1 + PS12) = UN, SK, OE, PM, OMS



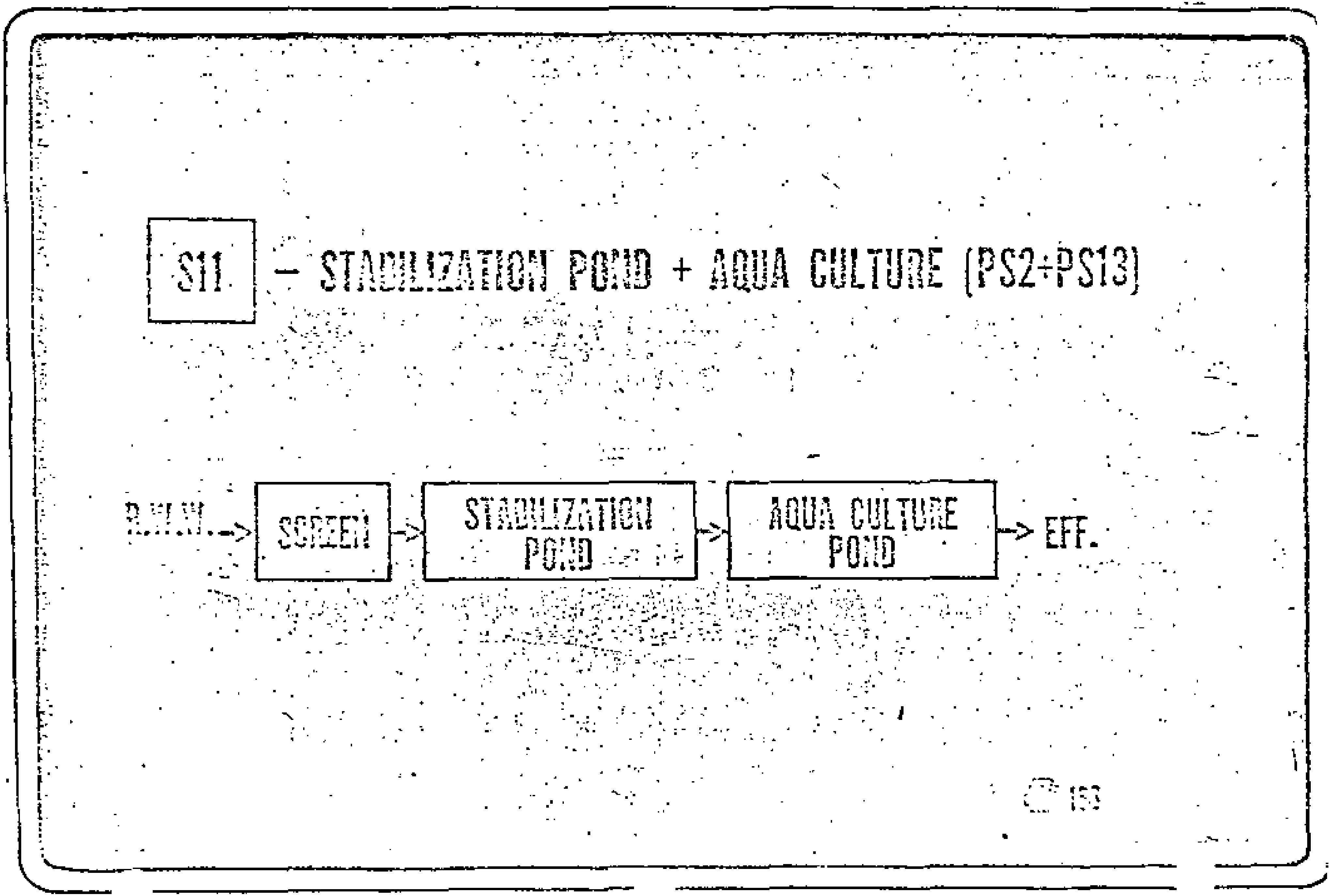
S10 S4 + LAND APPLICATION (PS12)

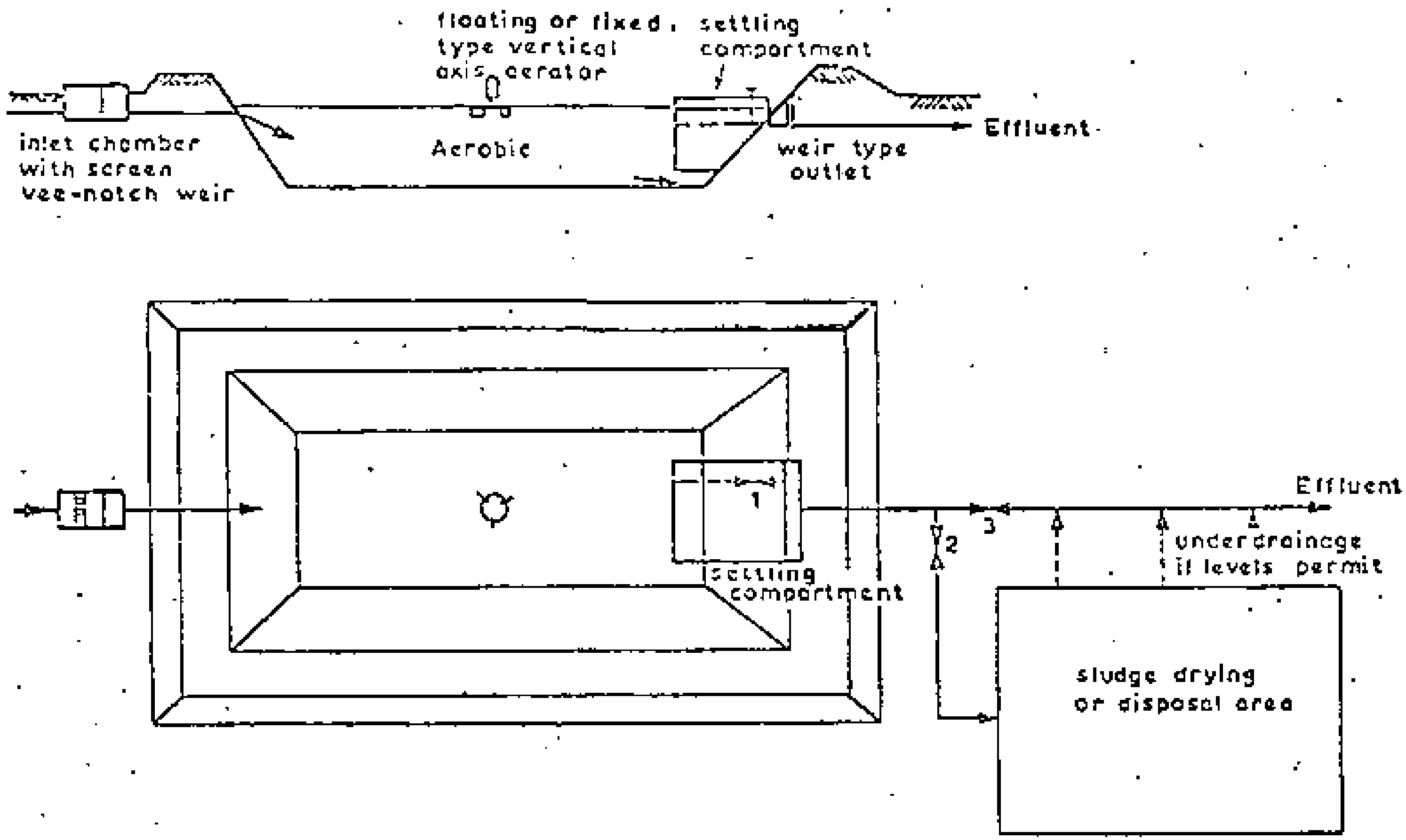


197

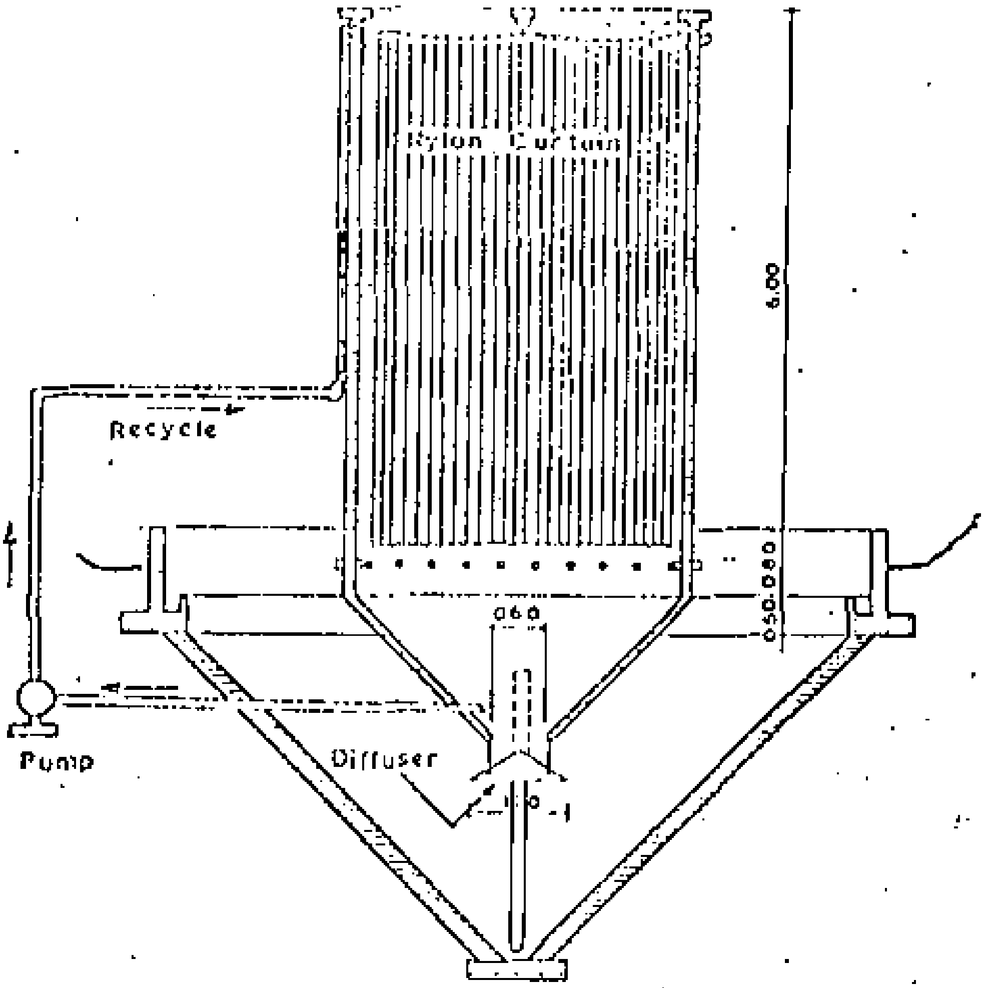
S4 = PS9
S10 = (S4 + PS12)
= (PS9 + PS12) = UN, SK, OE, PM, OMS

S11 = (PS2 + PS13)
= (PS2 + PS13) - UN, PM, and OMS





EXTENDED AERATION TYPE LAGOON WITH
SETTLING COMPARTMENT WITHIN THE LAGOON, TURKEY



SEWAGE TREATMENT
(NYLON CURTAIN PERCOLATOR)
URUGUAY

TABLE VIII.1.5

BOD LOADINGS PER UNIT AREA PER DAY UNDER
VARIOUS CLIMATIC CONDITIONS

Surface Loading (Lb. BOD_5/Acre/Day)[a]	Population Per Acre[b]	Detention Time (Days)[c]	Environmental Conditions
Less than 9	Less than 80	More than 200	Frigid zone with seasonal ice cover, uniformly low water temperature and variable cloud cover.
9 - 45	80 - 405	200 - 100	Cold seasonal climate with seasonal ice cover and temperate summer temperatures for short periods.
45 - 134	405 - 1,215	100 - 33	Temperate to semi-tropical zone with occasional ice cover and no prolonged cloud cover.
134 - 313	1,215 - 2,834	33 - 17	Tropical zone with uniformly distributed sunshine and temperature and no seasonal cloud cover.

SOURCE: Gloyna, 1971.

[a]Based on the assumption that the effluent volume is equal to the influent volume, i.e., that the sum of the evaporative and seepage losses is not greater than rainfall.

[b]Assuming a contribution of 0.11 lb. BOD_5 per person per day.

[c]Based on an influent volume of 260 gallons of waste per person per day.

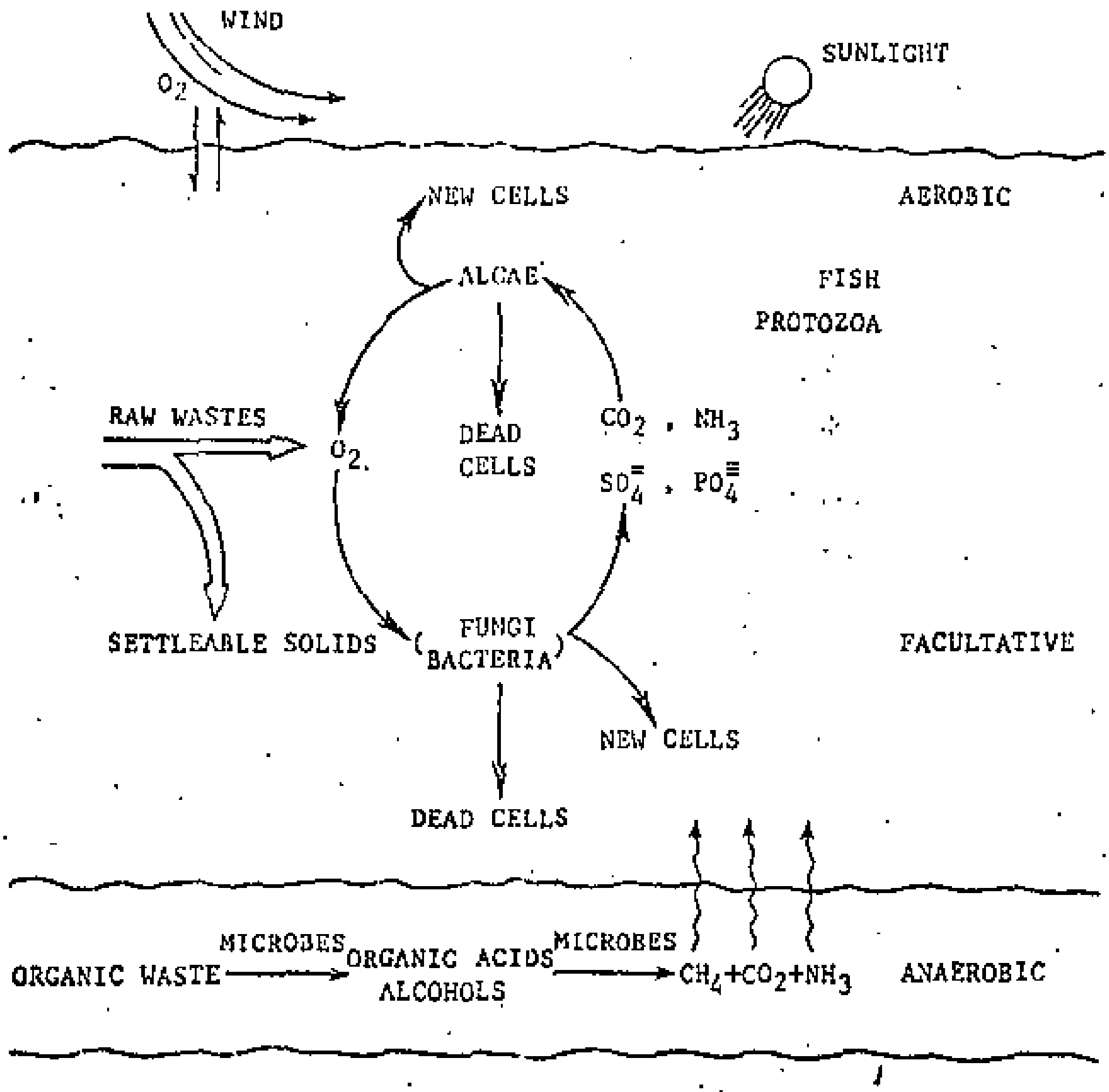


Fig. VIII.1.1. Schematic diagram of waste stabilization lagoon operati

TABLE VIII.1.6

AREAL LOADINGS USED IN TROPICAL AREAS

Location	Loading (Lb. BOD_5/Acre/Day)	Depth (Feet)	No. of Lagoons	Remarks	Source
<u>Latin America</u>					
Canas, Costa Rica	213	3-5	8	Facultative, parallel	1
Lima, Peru	254	2.3-40	1	Facultative	2
Lima, Peru	241	5.5^a	21	Facultative, series	2
Mexicali, Mexico	1062	15^a-4.6^b	No data	Anaerobic-facultative, series	2
Brasilia, Brazil	536^a-80^b	6.5^a-3.3^b	2	Anaerobic-facultative, series	2
Canal Zone, Panama	150	6^a-4^b	3	Anaerobic-facultative, series	3
Palmira, Colombia	150	3-5	3	Facultative, series and parallel	4
<u>Asia</u>					
Madras, India	180	2.75^a-5^b	5	Anaerobic-facultative, series	5
Ahmedabad, India	200-250	3-4	2	Facultative, series	6
Ahmedabad, India	325	4	1	Facultative	7
Nagpur, India	185^a	3.5^a	2	Facultative, series	7
Nagpur, India	417^a-394^b	$5^{a,b}$	2	Facultative, parallel	7
Bangkok, Thailand	5000	3	No data	Anaerobic	8
Bangkok, Thailand	200-400	8-15	24	High rate, parallel	9
Danang, Viet Nam	220	No data	2	Facultative, series	10

TABLE VIII.1.6 --Continued

Location	Loadings (Lb. BOD_5/Acre/Day)	Depth (Feet)	No. of Lagoons	Remarks	Source
Africa					
Mandarellas, Southern Rhodesia	168^a	4^a-3^b	6	Facultative, series	11
Nairobi, Kenya	91.5^a-57^b	$5.7^{a,b}$	2	Facultative, series	12

SOURCES: Formulation of table, Diaz, 1975

1. Saenz (1969)
2. Talboys (1971)
3. Eckley, Canter, and Reid (1974)
4. Canter (1969)
5. Purushothaman (1970)
6. Jayangoudar et al. (1970)
7. Dave and Jain (1966)
8. McGarry and Pescod (1970)
9. McGarry (1970)
10. Duttweiler and Burgh (1969)
11. Hodgson (1964)
12. WHO and Government of Kenya (1973)

[a]Primary ponds.

[b]Secondary Ponds.

TABLE VIII.1.7 254

DESIGN CRITERIA FOR PONDS AND AERATED LAGOONS IN BRAZIL

	Facultative Pond	Aerated Lagoon
Efficiency (%)	90	90
Depth (meters)	2	3
Detention time (days)	---	6
BOD_5 (gm/capita-day)	54	54
Flow (l/cap-day)	170	170
Temperature (°C)	17°C -- 21°C	20°C
BOD_u/BOD_5	1.46	1.46
Maximum area per pond (hectares)	8	8
Constant K_1 (per day)	--	0.35
Kg O_2 added/Kg BOD removed	--	0.7
Kg O_2 added/h.p./hr	--	1.2
Hp/1000 m^3	--	2.68

SOURCE: Correspondence with E. Jordao, Rio de Janeiro, Brazil.

TABLE VIII.1.10 255

LAND REQUIREMENTS OF WASTEWATER TREATMENT FACILITIES

Capacity (MGD)	Population	Acres (Ponds[a])	Acres (Aerated Lagoons[b])	Acres (Activated Sludge[c])
1	10,000	18	15	10
10	100,000	180	50	20
25	250,000	450	90	35
50	500,000	900	125	45
100	1,000,000	1,800	250	70

[a]Based on $V = (3.5 \times 10^{-5}) NqL_a\theta^{(35 - Tm)}$ and depth = 2 meters.
[b]Based on 6-day detention time.
[c]EPA estimates.

TABLE VIII.1.11

CAPITAL AND OPERATING COST FOR
WASTEWATER TREATMENT PLANT USING ACTIVATED SLUDGE FOR
BIOLOGICAL TREATMENT AND ANAEROBIC DIGESTION AND ENERGY RECOVERY
(1975 DOLLARS)

		Capital Cost		Operating Cost	
Capacity (MGD)	Population Served	Biological Wastewater Treatment ($/Capita)	Sludge Digestion and Energy Recovery ($/Capita)	Chemicals, Labor, etc. ($/Cap/yr)	Sludge Handling and Electrical ($/Cap/yr)
1	10,000	$53.70	$48.93	$3.35	$1.52
10	100,000	21.43	10.79	0.96	0.32
25	250,000	17.58	7.30	0.70	0.27
50	500,000	15.78	6.58	0.56	0.24
100	1,000,000	14.22	6.18	0.46	0.22

Sessions 252
4.3 & 4.4

TITLE: Computer Demonstration and Case History 259

OBJECTIVE:

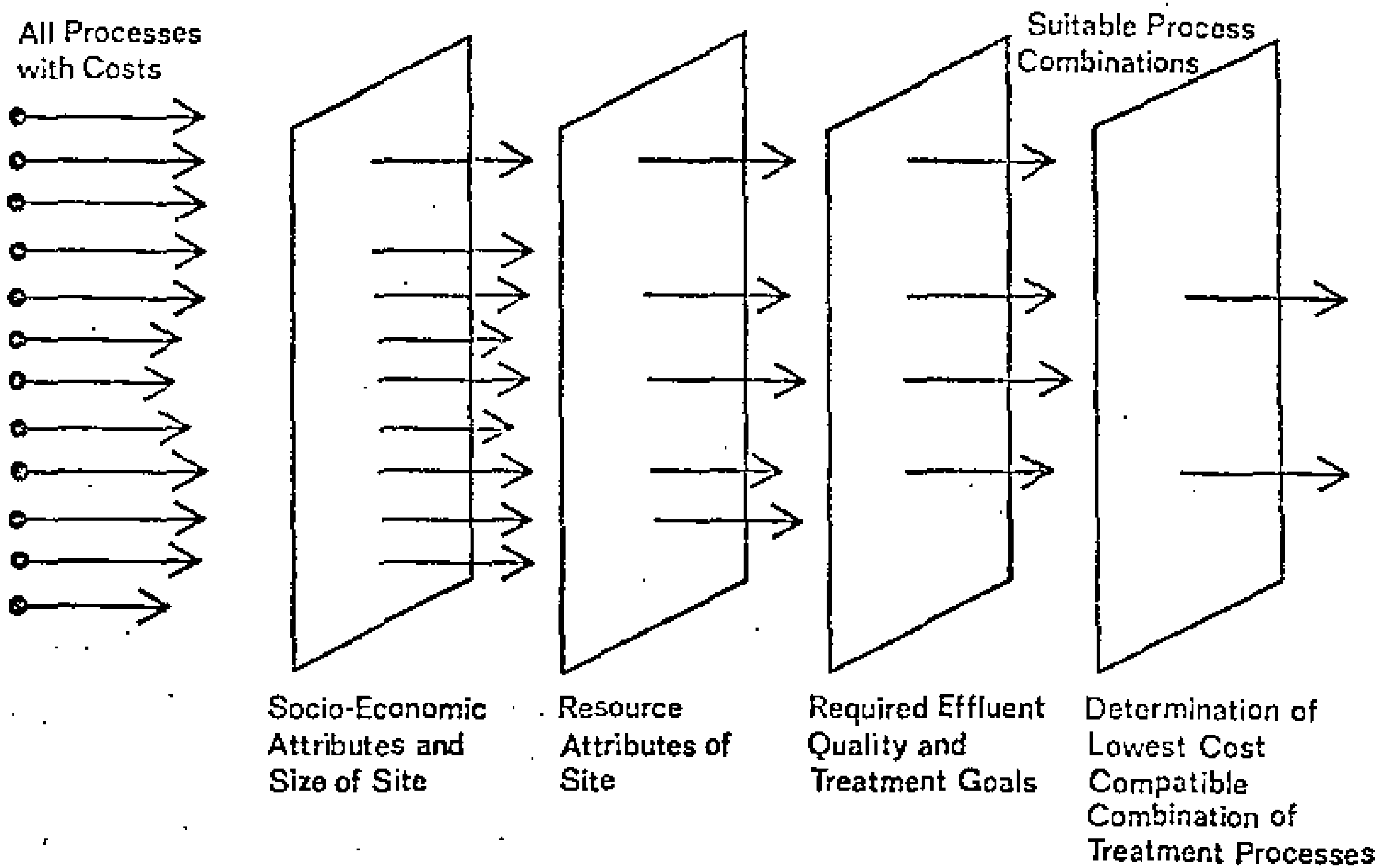
The purpose of this lecture is to acquaint the workshop participant with the use of the model on the microcomputer. The sequence of the lecture will be to briefly review the filtering process in the model then turn to the use of the microcomputer.

The goals of this lecture include the following:

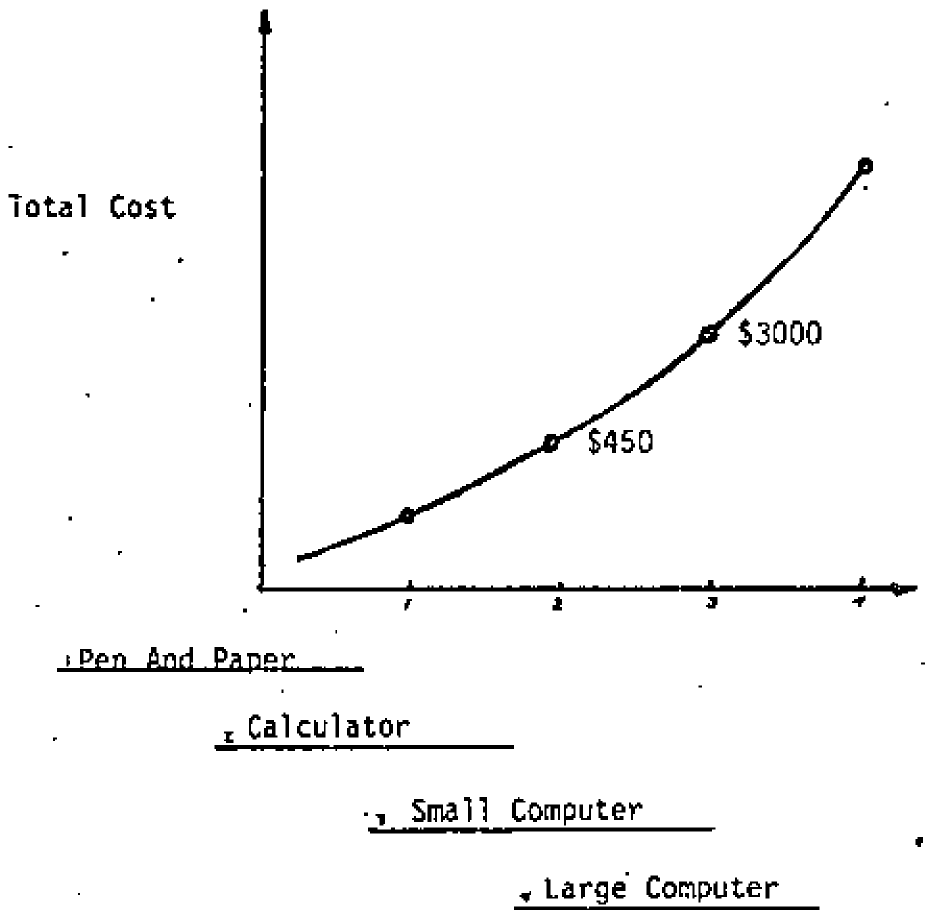
(a) to increase the participant's understanding of the water/waste treatment selection model; and

(b) to outline a comparison of information processing technology.

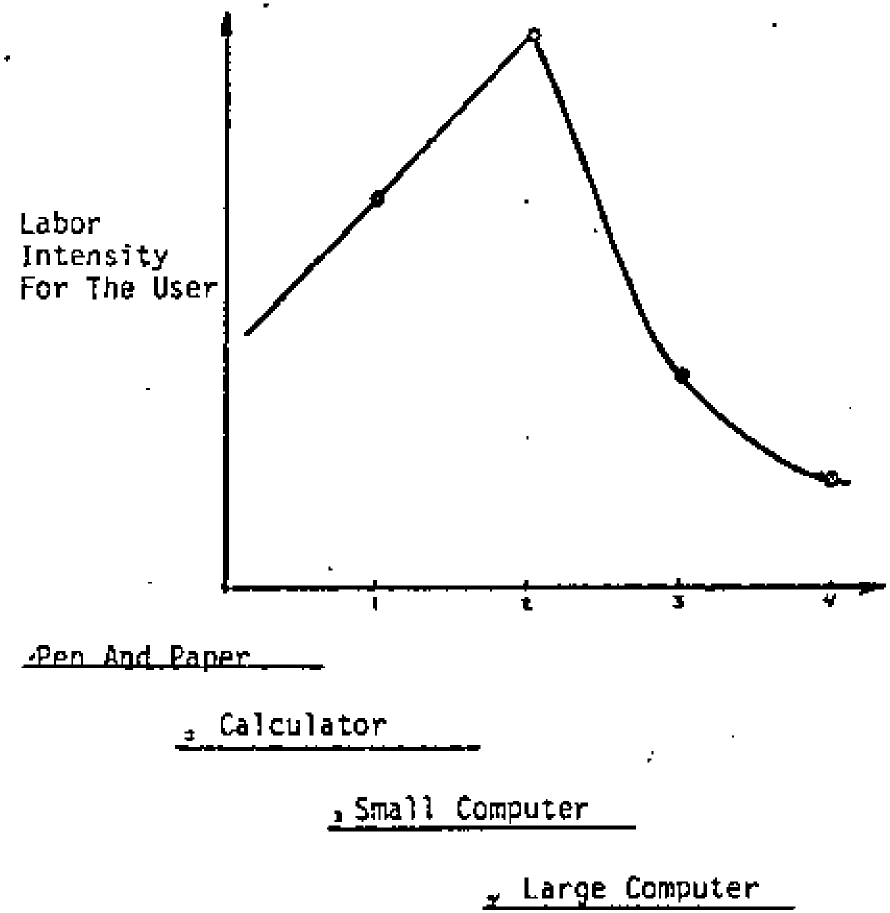
TYPES OF SCREENING INVOLVED IN THE SELECTION OF A COMPATIBLE LOWEST COST COMBINATION OF TREATMENT PROCESSES



Total Cost Comparison For Information Processing



Labor Intensity For Information Processing



PLEASE CHOOSE A SYSTEM FOR DATA INPUT AS FOLLOWS:

ENTER 1 IF YOU WANT DATA INPUT IN BLOCKS OF QUESTIONS, IN ENGLISH ONLY. PRESS RETURN.

ENTER 2 IF YOU WANT DATA INPUT BY SINGLE QUESTION, IN ENGLISH ONLY. PRESS RETURN.

?2

PUNCH IN DESIGN DATA IN THE FOLLOWING FORMAT :

YEAR OF THE AVAILABLE POPULATION,
POPULATION VALUE IN THAT YEAR,
POPULATION GROWTH RATE EXPRESSED AS A DECIMAL (1.8),
BASE YEAR OF DESIGN,
PROJECTED TERMINAL YEAR OF DESIGN
?1970,10181,1.7,1980,2000

PUNCH IN LOCATION DATA IN THE FOLLOWING FORMAT:

COMMUNITY,
STATE OR PROVINCE,
COUNTRY,
PLANNING GROUP
?SMALLVILLE,KANSAS,USA,
AVERAGE LEVEL OF EDUCATION OBTAINED BY INHABITANTS LIVING IN THE COMMUNITY

EDUC. LEVEL	NONE	PRI-MARY	HIGH SCHOOL	TECHNICAL INSTITUTE	COLLEGE
1	95%	4%	1%	0%	0%
2	70%	19%	7%	3%	1%
3	55%	22%	14%	6%	3%
4	9%	34%	42%	8%	7%

?3
AVERAGE DISTRIBUTION OF LABOR FORCE IN THE COMMUNITY

LEVEL	UNSKILLED	SEMISKILLED	PROFESSIONAL
1	97%	2%	1%
2	80%	16%	4%
3	61%	27%	12%
4	45%	30%	25%

?2
ANNUAL AVERAGE INCOME PER FAMILY IN APPROXIMATE U.S. DOLLAR EQUIVALENT

1 LESS THAN $100
2 $100 TO $500
3 $500 TO $1000
4 $1000 TO $3000
5 GREATER THAN $3000

?3
AMONG THE HIGHLY SKILLED AND TECHNICAL WORKERS (ECONOMIST/ENGINEER/CHEMIST ETC.) WHAT PERCENTAGE OF THESE IS NON-LOCAL OR NON-NATIVE PEOPLE?

1 LESS THAN 10%
2 10% TO 25%
3 25% TO 50%
4 50% TO 75%
5 75% TO 100%

?3
ARE THERE ANY PRIMARY OR SECONDARY SCHOOLS OPERATED BY VOLUNTARY OR MISSIONARY ORGANIZATIONS RATHER THAN THE GOVERNMENT ITSELF?

ENTER 1 IF YES
ENTER 2 IF NO

?2
WHAT IS THE HIGHEST GRADE OFFERED BY LOCAL SCHOOLS ON A REGULAR BASIS? (ENTER THE NUMBER. FOR 12+ ENTER 13.)

1 2 3 4 5 6 7 8 9 10 11 12 12+

?13
IF THE NUMBER SELECTED IN QUESTION 6 IS LESS THAN 12 HOW FAR AWAY IS THE NEAREST HIGH SCHOOL OFFERING THE 12TH GRADE? ENTER THE NUMBER

1 IF LESS THAN 10 MILES (16 KILOMETERS)
2 IF 10 TO 30 MILES (16 TO 48 KM)
3 IF 30 TO 50 MILES (48 TO 80 KM)
4 IF GREATER THAN 50 MILES (80 KM)

?0
ARE THERE ANY TECHNICAL OR VOCATIONAL SCHOOLS IN THE COMMUNITY?

ENTER 1 IF ANSWER IS YES
ENTER 2 IF ANSWER IS NO

?1
HAS THE COMMUNITY ACHIEVED COMPULSORY PRIMARY EDUCATION OF AT LEAST 6 YEARS?

ENTER 1 IF ANSWER IS YES
ENTER 2 IF ANSWER IS NO

?2
ARE THERE ANY FORMAL IN SERVICE TRAINING PROGRAMS BY EITHER THE GOVERNMENT OR LOCAL INDUSTRY FOR THEIR EMPLOYEES?

ENTER 1 IF ANSWER IS YES
ENTER 2 IF ANSWER IS NO

?1
IS THERE A COLLEGE OR UNIVERSITY IN THE LOCAL COMMUNITY?

ENTER 1 IF ANSWER IS YES
ENTER 2 IF ANSWER IS NO

?1
DOES THE UNIVERSITY HAVE A CHEMISTRY DEPARTMENT OR LABORATORY?

ENTER 1 IF ANSWER IS YES
ENTER 2 IF ANSWER IS NO

?1
IS UNEMPLOYMENT WIDESPREAD?

ENTER 1 IF ANSWER IS YES
ENTER 2 IF ANSWER IS NO

?1
ARE ADVISORY SERVICES WIDELY AVAILABLE TO FARMERS FOR COMMUNITY DEVELOPMENT OR FOR OTHER PROGRAMS DESIGNED TO UPGRADE THE SKILLS AND ENLIST THE PARTICIATION OF THE INHABITANTS?

ENTER 1 IF ANSWER IS YES
ENTER 2 IF ANSWER IS NO

?2
DO MOST COLLEGE OR UNIVERSITY STUDENTS OF THE COMMUNITY RECEIVE THEIR EDUCATION IN NEIGHBORING COMMUNITIES OR NEIGHBORING COUNTRIES OR OTHER FOREIGN COUNTRIES?

ENTER 1 IF ANSWER IS YES
ENTER 2 IF ANSWER IS NO

?1
THE LEVEL OF TECHNOLOGY AVAILABLE CAN GENERALLY BE CLASSIFIED AS

1 HAND TOOLS ONLY
2 MECHANICAL TOOLS
3 CHEMICAL PRODUCTS
4 ELECTRONIC TECHNOLOGY

?2
DOES THE GOVERNMENT DOMINATE THE LABOR MARKET?

ENTER 1 IF ANSWER IS YES
ENTER 2 IF ANSWER IS NO

?2
ARE PUBLIC EMPLOYMENT SERVICES READILY AVAILABLE?

ENTER 1 IF ANSWER IS YES
ENTER 2 IF ANSWER IS NO

?1
(COUNT EACH "NOT AVAILABLE" ANSWER LINE AS 1 AND EACH "AVAILABLE" ANSWER LINE AS 0. ENTER THE SUM OF THIS COUNT.)

FOR OPERATION EQUIPMENT HOW MANY OF THE FOLLOWING ARE NOT AVAILABLE IN THE COMMUNITY?

1 Meters; water; gas, thermostats
2 Sheet metal fabrication, etc
3 Gauges; vacuum, flow, etc
4 Labortory equipment; test tubes
5 Portable power plants
6 Electric motors
7 Pumps, fans, etc

?2
(COUNT EACH "NOT AVAILABLE" ANSWER LINE AS 1 AND EACH "AVAILABLE" ANSWER LINE AS 0. ENTER THE SUM OF THIS COUNT.)

FOR PROCESS MATERIALS HOW MANY OF THE FOLLOWING ARE NOT GENERALLY AVAILABLE IN THE LOCAL COMMUNITY?

1 Pipe(clay, asbestos, cement, etc)
2 Pipe(cast iron, steel, copper)
3 Concrete, cement
4 Valves, pipe fittings
5 Tanks
6 Structural steel
7 Heat exchangers

?3
(COUNT EACH "NOT AVAILABLE" ANSWER LINE AS 1 AND EACH "AVAILABLE" ANSWER LINE AS 0. ENTER THE SUM OF THIS COUNT.)

FOR OPERATION AND MAINTENANCE SUPPLIES WHICH OF THE FOLLOWING ARE NOT GENERALLY AVAILABLE IN THE LOCAL COMMUNITY?

1 Silica sand and gravel
2 Paint
3 Water sealing compound, epoxy
4 Petroleum
5 Electricity

?1

(COUNT EACH "NOT AVAILABLE" ANSWER LINE AS 1 AND EACH "AVAILABLE" ANSWER LINE AS 0. ENTER THE SUM OF THIS COUNT.)

FOR CHEMICAL SUPPLIES HOW MANY OF THE FOLLOWING ARE NOT GENERALLY AVAILABLE IN THE LOCAL COMMUNITY?

1 Aluminum sulfate(AL2(SO4)3); ferric chloride(FECL3); polyelectrolytes.
2 Soda ash(NA2CO3); activated charcoal; lime(CAO)
3 Chlorine(CL2); ozone(O3); chlorindioxide; bromine
4 KTH; copper sulfate(CUSO4)

IS GROUNDWATER AVAILABLE?

1 YES
2 NO

?1

USING DATA INDICATED BY THE RAW WATER QUALITY SECTION OF YOU QUESTIONAIRE ANSWER THE FOLLOWING QUESTIONS

ENTER THE NUMBER OF COLIFORM BACTERIA (MPN/100 ML)**

?50

ENTER THE TURBIDITY (JACKSON TURBIDITY UNITS)**

?50

ENTER THE HARDNESS (MG/L)**

?100

ENTER THE TOTAL DISSOLVED SOLIDS(TDS)**

?1000

ENTER FE AND MN (MG/L)**

?.5

THE LDC WATER AND SEWAGE TREATMENT PLANNING MODEL

FOR THE COMMUNITY	SMALLVILLE
IN THE STATE OR PROVINCE OF	KANSAS
IN THE COUNTRY OF	USA
FOR THE PLANNING GROUP	
BASEYEAR =	1980

**** ENTER THE NUMBER 5 WHEN YOU WISH TO CONTINUE****
?5
*** SUITABLE WATER TREATMENT PROCESSES FOR IMPLEMENATION IN...1980...***

FEASIBLE PROCESS COMBINATIONS	INITAL CONSTRUCTION COST RATIO	AVERAGE MAINTENANCE COST RATIO
W2	14.66	3.14
W5	17.66	7.13

ENTER 5 WHEN YOU WISH TO CONTINUE
?5

FEASIBLE	TOTAL	MANPOWER		
PROCESS	COST RATIO	REQUIRED		
COMBINATION	20 YEAR	UNSKIL	SKIL	PROF
W2	77.53	2	0	0
W5	160.23	3	1	0

THE LOWEST TOTAL COST RATIO IS
W2 AT A 20 YEAR SUM OF 77.53

ENTER 5 WHEN YOU WISH TO CONTINUE
?5

THE PROGRAM WILL NOT PROCEED UNTIL YOU PUNCH IN A NUMBER FROM THE KEYBOARD. PLEASE ENTER THE NUMBER WHICH INDICATES YOUR CHOICE

0 INDICATES THAT YOU DO NOT WISH TO USE THE WASTE TREATMENT SECTION OF THE MODEL.

1 INDICATES THAT YOU DO WISH TO USE THE WASTE TREATMENT SECTION OF THE MODEL.
?1

DO YOU PREFER THE DILUTION RATIO TO BE BASED ON BOD OR COLIFORM?

ENTER 1 IF YOU PREFER THE BOD BASE
ENTER 2 IF YOU PREFER THE COLIFORM BASE
?1

INPUT THE DILUTION RATIO
?15

*** SUITABLE WASTE TREATMENT PROCESSES FOR IMPLEMENATION IN...1980...***

FEASIBLE PROCESS COMBINATIONS	INITAL CONSTRUCTION COST RATIO	AVERAGE MAINTENANCE COST RATIO
S3	2.07	3.75
S4	18.2	16.05
S9	28.72	12.7
S10	37.14	21.92

THE PROGRAM WILL NOT PROCEED UNTIL YOU PUNCH IN A NUMBER FROM THE KEYBOARD. PLEASE ENTER THE NUMBER WHICH INDICATES YOUR CHOICE

0 INDICATES THAT YOU DO NOT WISH TO USE THE WATER TREATMENT SECTION OF THE MODEL.

1 INDICATES THAT YOU DO WISH TO USE THE WATER TREATMENT SECTION OF THE MODEL.
?1

ENTER THE NUMBER WHICH CORRESPONDS TO YOUR PREFERENCE IN DISPLAYING THE COST DATA

1 REPRESENT NO COST ANALYSIS NEEDED

2 REPRESENTS RELATIVE COST RATIOS BASED ON U.S. DOLLARS IN 1978 PRICES

3 REPRESENTS LOCAL COSTS WHICH YOU MUST SUPPLY TO THE COMPUTER AS DATA. IF YOU CHOOSE 3 INSTRUCTIONS WILL BE DISPLAYED FOR YOUR DATA ENTRY.
?2

WHAT DISCOUNT RATE AND TIME SPAN WOULD YOU LIKE TO USE IN THE PRESENT VALUE CALCULATIONS? ENTER DATA IN THE FOLLOWING FORMAT

DISCOUNT RATE EXPRESSED AS A DECIMAL VALUE (ENTER .0725 FOR A DISCOUNT RATE OF 7.25%.)
THE NUMBER OF YEARS TO BE USED FOR THE DISCOUNTING (20 FOR EXAMPLE)

*** NOTE ***

IF YOU DO NOT WISH TO DISCOUNT THE OPERATION AND MAINTENANCE COST THEN ENTER THE NUMBER ZERO FOR THE DISCOUNT RATE. ENTER THE NUMBER OF YEARS IN A NORMAL FASHION.
A TYPICAL DATA ENTRY WOULD BE

.0725,20
?.0725,20

Session 5.1

Title: Land Application, Aquaculture, and On-site Treatment

(excerpt from Chapters VIII & IX)

I. Aqua-Culture (pg 478 & 481)

Objective: A. The primary objective for Aqua-Cultures is food production in developing countries.

B. In the United States or developed countries, the primary interest is in the removal of suspended solids.

C. Problem is that the guidelines that maximize fish production are not the same guidelines that would remove the greatest amounts of contaminates or suspended solids.

D. Guidelines:

1. Maintain 3 p.p.m. dissolved oxygen.

2. Elimination of toxic substances.

   a. ammonia
   b. sulfides

3. Maintain proper pH.

4. Maintain consistent "proper temperatures."

5. Maintain proper biological balance that yields adequate quantities of fish food.

(Example #1)

In Europe dilutions of two to five volumes were used per volume of settled sewage.

1. Depth one to two and one-half feet
2. Loadings of 800 to 1000 people per surface acre of pond.
3. Ducks were used to keep the pond clear of weeds.
4. One acre of pond produced 400 to 500 pounds of fish and 200 to 250 pounds of duckmeat.
5. Ponds were drained and cleaned during winter when ice retarded aquatic life.

II. Lagoons

tables text pg 453, 454, 463, 464, 470

A. Example Oklahoma Lagoon Projects

B. Fish used

1. Carp
2. Goldfish
3. Flathead Minnow
4. Golden Shiner
5. Blackbull Head
6. Channel Catfish

7. Mosquito Fish

8. Blue Gill

9. Green Sunfish

10. Large Mouth Bass

11. Tilopia

C. Six cell Lagoon

1. first and second were aerated

2. The mean BOD removal level from June to October was 95%.

3. Suspended Solids removed 94%

   a. effluent 12 mg/l

4. fical coliform bacteria reduced from 3 x 10^6 to 10/100 ml.

D. Growth rates in sewage ponds in Oklahoma

1. Third Cell an increase from 1500 - 4300 lbs/per acre for Tilipia in 191 days.

2. Third and Fourth Cells Catfish increased from 600 to 4400 lbs/per acre in 120 days.

3. Fifth and Sixth Cells Shiners increased from 5 to 536 lbs in 120 days.

4. The Tilipia will increase (4 to 5 times) more when fed grain, in the amount of 3% of their body wt/per day, as when fed algae, and (20 to 40) times more when fed on sewage effluent.

E. Factors influencing production

1. Species of fish

2. Age of fish

F. Income 2.5 c/per 1000 gal. of sewage treated.

III. Vascular Plants

A. Water Hyacinth are a prime candidate for nutrient removal.

B. Plant production: can be used as ruminant feed, or for methane production.

C. Fish production can be used for animal feed and fertilizer.

IV. Health Considerations

A. Potential health problems associated with fish and shell fish grown in a wastewater environment.

1. Salmonella

2. Polio viruses

3. Coxsackie viruses

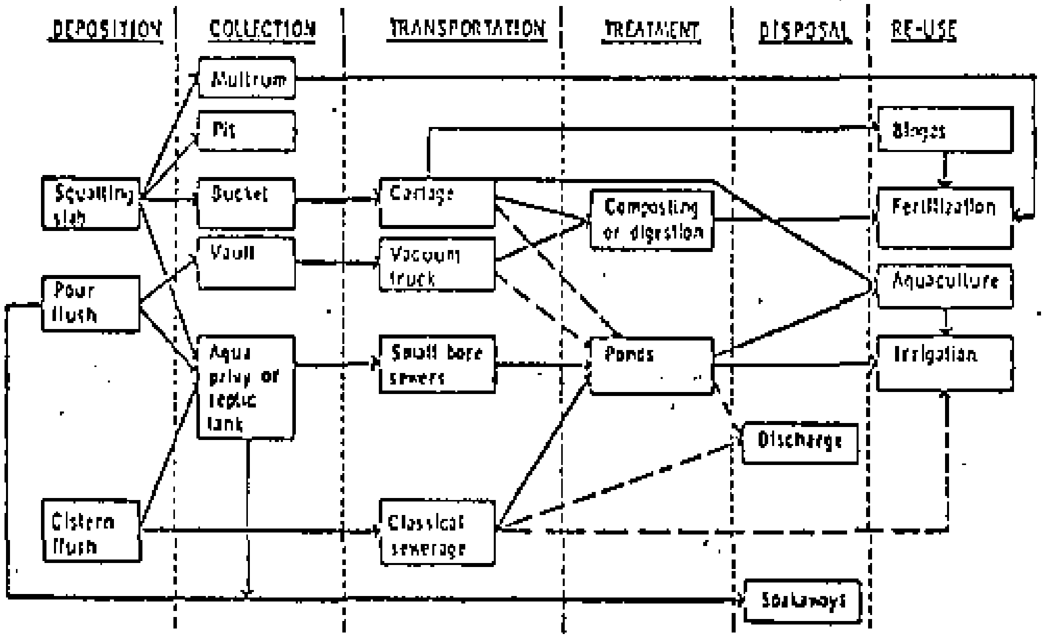
4. Shigella

5. Cholera

6. Enterpathogenic Viral Hepatitis

B. From the European market recommendations were:

1. That the fish grown in the wastewater be placed in a fresh water environment for a period of two to three weeks prior to harvesting.



The elements of an excreta disposal system and the various ways in which they can be combined.

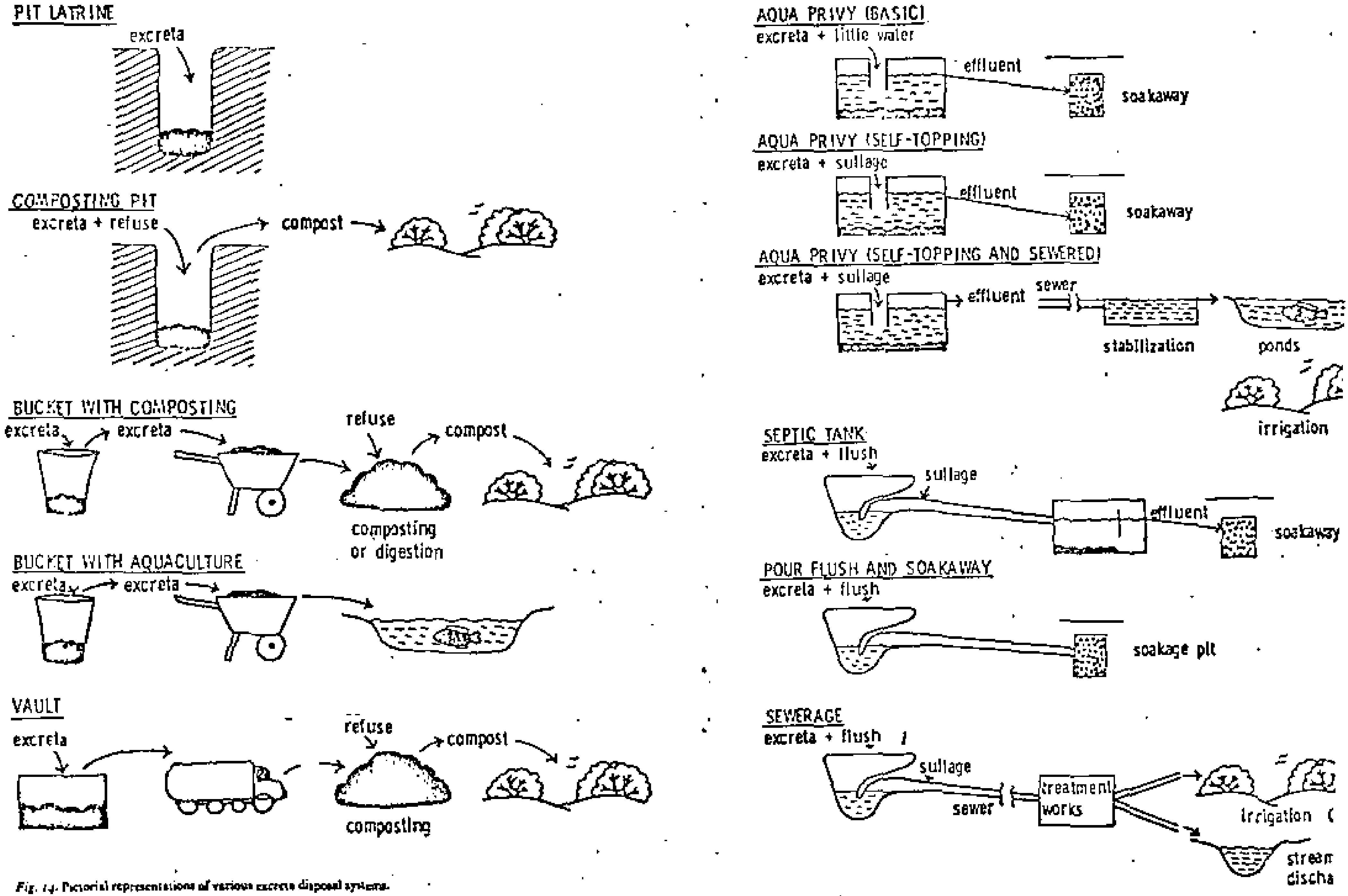


Fig. 14. Pictorial representations of various excreta disposal systems.

(a) 'Dry' or nightsoil systems.

(b) 'Wet' or sewage systems.

Session 5.2

Title: Policy/Sensitivity Analysis Demonstration

Objective: The purpose of this lecture is to demonstrate a sensitivity analysis approach to the selection of water/waste treatment technology. The demonstration will input a set of test data to the computer, and use that data in a sensitivity analysis framework.

The goals of the lecture are:

(a) to indicate the application of sensitivity analysis;

(b) to reinforce the computer usage of the water/waste treatment selection model.

PLEASE CHOOSE A SYSTEM FOR DATA INPUT AS FOLLOWS:

ENTER 1 IF YOU WANT DATA INPUT IN BLOCKS OF QUESTIONS, IN ENGLISH ONLY. PRESS RETURN.

ENTER 2 IF YOU WANT DATA INPUT BY SINGLE QUESTION, IN ENGLISH ONLY. PRESS RETURN.

?1

PUNCH IN DESIGN DATA IN THE FOLLOWING FORMAT :

YEAR OF THE AVAILABLE POPULATION,
POPULATION VALUE IN THAT YEAR,
POPULATION GROWTH RATE EXPRESSED AS A DECIMAL (1.8),
BASE YEAR OF DESIGN,
PROJECTED TERMINAL YEAR OF DESIGN
?1970,10181,1.7,1980,2000

PUNCH IN LOCATION DATA IN THE FOLLOWING FORMAT:

COMMUNITY,
STATE OR PROVINCE,
COUNTRY,
PLANNING GROUP
?SMALLVILLE,KANSAS,USA,
PLEASE INPUT DATA FROM THE QUESTIONAIRE (SECTION III LABELED SOCIO-TECHNOLOGICAL DATA QUESTIONS 1 THROUGH 19) IN THE FOLLOWING FORMAT

NUMERIC CHOICE FOR QUESTION 1,
NUMERIC CHOICE FOR QUESTION 2,. ETC.

AN EXAMPLE OF THE INPUT DATA WOULD BE:

3,2,3,1,ETC.

*** NOTE ***

QUESTION 13 IS NOT INCLUDED IN THIS ANALYSIS. THE RESPONSE TO QUESTION 14 FOLLOWS THE RESPONSE TO QUESTION 12.
?3,2,3,3,2,13,0,1,2,1,2,1,1,2,1,2,2,1

INPUT INDIGENOUS RESOURCE DATA IN THE FOLLOWING FORMAT

OPERATION EQUIPMENT AVAILABILITY,
PROCESS MATERIALS AVIALABILITY,
OPERATION AND MAINTENANCE SUPPLIES AVAILABILITY,
CHEMICAL SUPPLIES AVAILABILITY,
GROUNDWATER AVAILABILITY

*** NOTE ***

AVAILABILITY IS DETERMINED BY ADDING THE NUMBER OF ITEMS CHECKED (NOT AVAILABLE). FOR EXAMPLE IF QUESTION 20 HAD THREE ITEMS CHECKED AS NOT AVAILABLE THEN THE NUMBER 3 WOULD BE ENTERED AS OPERATON EQUIPMENT AVAILABILITY.
?2,3,1,2,1

INPUT RAW WATER QUALITY DATA (SEE THE QUESTIONAIRE PART IV) IN THE FOLLOWING FORMAT

NUMBER OF COLIFORM BACTERIA,
TURBIDITY,
HARDNESS,
TOTAL DISSOLVED SOLIDS,
FE AND MN
?50,50,100,1000,.5

THE PROGRAM WILL NOT PROCEED UNTIL YOU PUNCH IN A NUMBER FROM THE KEYBOARD. PLEASE ENTER THE NUMBER WHICH INDICATES YOUR CHOICE

0 INDICATES THAT YOU DO NOT WISH TO USE THE WATER TREATMENT SECTION OF THE MODEL.

1 INDICATES THAT YOU DO WISH TO USE THE WATER TREATMENT SECTION OF THE MODEL.
?1

ENTER THE NUMBER WHICH CORRESPONDS TO YOUR PREFERENCE IN DISPLAYING THE COST DATA

1 REPRESENT NO COST ANALYSIS NEEDED

2 REPRESENTS RELATIVE COST RATIOS BASED ON U.S. DOLLARS IN 1978 PRICES

3 REPRESENTS LOCAL COSTS WHICH YOU MUST SUPPLY TO THE COMPUTER AS DATA. IF YOU CHOOSE 3 INSTRUCTIONS WILL BE DISPLAYED FOR YOUR DATA ENTRY.
?2

WHAT DISCOUNT RATE AND TIME SPAN WOULD YOU LIKE TO USE IN THE PRESENT VALUE CALCULATIONS? ENTER DATA IN THE FOLLOWING FORMAT

DISCOUNT RATE EXPRESSED AS A DECIMAL VALUE (ENTER .0725 FOR A DISCOUNT RATE OF 7.25%.)
THE NUMBER OF YEARS TO BE USED FOR DISCOUNTING (20 FOR EXAMPLE)

*** NOTE ***

IF YOU DO NOT WISH TO DISCOUNT THE OPERATION AND MAINTENANCE COST THEN ENTER THE NUMBER ZERO FOR THE DISCOUNT RATE. ENTER THE NUMBER OF YEARS IN A NORMAL FASHION.
A TYPICAL DATA ENTRY WOULD BE

.0725,20
?.0725,20

THE LDC WATER AND SEWAGE TREATMENT PLANNING MODEL

FOR THE COMMUNITY	SAMLLVILLE
IN THE STATE OR PROVINCE OF	KANSAS
IN THE COUNTRY OF	USA
FOR THE PLANNING GROUP	
BASEYEAR =	1980

**** ENTER THE NUMBER 5 WHEN YOU WISH TO CONTINUE****
?5
*** SUITABLE WATER TREATMENT PROCESSES FOR IMPLEMENATION IN...1980...***

FEASIBLE PROCESS COMBINATIONS	INITAL CONSTRUCTION COST RATIO	AVERAGE MAINTENANCE COST RATIO
W2	14.66	3.14
W5	17.66	7.13

ENTER 5 WHEN YOU WISH TO CONTINUE
?5

FEASIBLE PROCESS COMBINATION	TOTAL COST RATIO 20 YEAR	MANPOWER REQUIRED UNSKIL	SKIL	PROF
W2	77.53	2	0	0
W5	160.23	3	1	0

THE LOWEST TOTAL COST RATIO IS W2 AT A 20 YEAR SUM OF 77.53

ENTER 5 WHEN YOU WISH TO CONTINUE
?5

THE PROGRAM WILL NOT PROCEED UNTIL YOU PUNCH IN A NUMBER FROM THE KEYBOARD.
PLEASE ENTER THE NUMBER WHICH INDICATES YOUR CHOICE

0 INDICATES THAT YOU DO NOT WISH TO USE THE WASTE TREATMENT SECTION OF THE MODEL.

1 INDICATES THAT YOU DO WISH TO USE THE WASTE TREATMENT SECTION OF THE MODEL.
?1

DO YOU PREFER THE DILUTION RATIO TO BE BASED ON BOD OR COLIFORM?

ENTER 1 IF YOU PREFER THE BOD BASE
ENTER 2 IF YOU PREFER THE COLIFORM BASE
?1

INPUT THE DILUTION RATIO
?.5

*** SUITABLE WASTE TREATMENT PROCESSES FOR IMPLEMENATION IN...1980...***

FEASIBLE PROCESS COMBINATIONS	INITAL CONSTRUCTION COST RATIO	AVERAGE MAINTENANCE COST RATIO
S3	2.07	3.75
S4	18.2	16.05
S9	28.72	12.7
S10	37.14	21.92

ENTER 5 WHEN YOU WISH TO CONTINUE
?5

FEASIBLE PROCESS COMBINATION	TOTAL COST RATIO 20 YEAR	MANPOWER REQUIRED UNSKIL	SKIL	PROF
S3	76.99	2	0	0
S4	339.19	2	1	0
S9	282.68	3	1	0
S10	475.44	4	2	0

THE LOWEST TOTAL COST RATIO IS S3 AT A 20 YEAR SUM OF 76.99

ENTER 5 WHEN YOU WISH TO CONTINUE
?5

297

DO YOU WISH TO USE THE SENSITIVITY
ANALYSIS SECTION OF THE MODEL?

ENTER 1 IF YOUR ANSWER IS YES
ENTER 2 IF YOUR ANSWER IS NO
?1

BASED ON THE SOCIO-TECHNOLOGICAL DATA
WHICH YOU ENTERED ABOVE THE MODEL HAS
DETERMINED THE FOLLOWING

****

ORIGINAL DATA

STL = 3
UNSKILLED = 1
SKILLED = 1
PROFESSIONAL = 0

*** NOTE : ***

1 MEANS THE PARAMETER IS AVAILABLE
0 MEANS THE PARAMETER IS NOT AVAILABLE

DO YOU WISH TO CHANGE THE STL LEVEL?

ENTER 1 IF YOUR ANSWER IS YES
ENTER 2 IF YOUR ANSWER IS NO
?2

298

BASED ON THE INDIGENOUS RESOURCE DATA
WHICH YOU ENTERED ABOVE THE MODEL HAS
DETERMINED THE FOLLOWING

ORIGINAL DATA

RESOURCE TYPE	1=YES 0=NO AVAILABILITY
OE	1
PM	1
OMS	1
CS	0
GW	1

****

1 = AVAILABLE 0 = NOT AVAILABLE

DO YOU WISH TO CHANGE THE AVAILABILITY
OF THE ABOVE RESOURCES (1=YES 2=NO)?
?1
OPERATION EQUIPMENT (OE) =1
PROCESS MATERIALS (PM) =2
OPERATION & MAINTENANCE SUPPLIES (OMS) =3
CHEMICAL SUPPLIES (CS) =4
GROUNDWATER AVAILABILITY (GW) =5
ENTER THE NUMBER OF THE RESOURCE WHICH
YOU WISH TO CHANGE (OE=1, PM=2, ETC.).
?4
INPUT CS AVAILABILITY
?1

NEW DATA

RESOURCE TYPE	1=YES 0=NO AVAILABILITY
OE	1
PM	1
OMS	1
CS	1
GW	1

ANOTHER CHANGE (1=YES 2=NO)?
?2

BASED ON THE RAW WATER QUALITY DATA WHICH YOU ENTERED ABOVE THE MODEL HAS DETERMINED THE FOLLOWING

ORIGINAL DATA PARAMETER	LEVEL
COLIFORM	50
TURBIDITY	50
HARDNESS	100
TDS	1000
FE & MN	.5
DILUTION	15

****

1 = AVAILABLE   0 = NOT AVAILABLE

DO YOU WISH TO CHANGE THE LEVEL OF THE ABOVE PARAMETERS(1=YES 2=NO)?
?2

THE PROGRAM WILL NOT PROCEED UNTIL YOU PUNCH IN A NUMBER FROM THE KEYBOARD. PLEASE ENTER THE NUMBER WHICH INDICATES YOUR CHOICE

0 INDICATES THAT YOU DO NOT WISH TO USE THE WATER TREATMENT SECTION OF THE MODEL.

1 INDICATES THAT YOU DO WISH TO USE THE WATER TREATMENT SECTION OF THE MODEL.
?1

ENTER THE NUMBER WHICH CORRESPONDS TO YOUR PREFERENCE IN DISPLAYING THE COST DATA

1 REPRESENT NO COST ANALYSIS NEEDED

2 REPRESENTS RELATIVE COST RATIOS BASED ON U.S. DOLLARS IN 1978 PRICES

3 REPRESENTS LOCAL COSTS WHICH YOU MUST SUPPLY TO THE COMPUTER AS DATA. IF YOU CHOOSE 3 INSTRUCTIONS WILL BE DISPLAYED FOR YOUR DATA ENTRY.
?2

WHAT DISCOUNT RATE AND TIME SPAN WOULD YOU LIKE TO USE IN THE PRESENT VALUE CALCULATIONS? ENTER DATA IN THE FOLLOWING FORMAT

DISCOUNT RATE EXPRESSED AS A DECIMAL VALUE (ENTER .0725 FOR A DISCOUNT RATE OF 7.25%.)
THE NUMBER OF YEARS TO BE USED FOR DISCOUNTING (20 FOR EXAMPLE)

301

*** NOTE ***

IF YOU DO NOT WISH TO DISCOUNT THE OPERATION AND MAINTENANCE COST THEN ENTER THE NUMBER ZERO FOR THE DISCOUNT RATE. ENTER THE NUMBER OF YEARS IN A NORMAL FASHION.
A TYPICAL DATA ENTRY WOULD BE

.0725,20
?.0725,20

THE LDC WATER AND SEWAGE TREATMENT PLANNING MODEL

FOR THE COMMUNITY	SAMLLVILLE
IN THE STATE OR PROVINCE OF	KANSAS
IN THE COUNTRY OF	USA
FOR THE PLANNING GROUP	
BASEYEAR =	1980

302

**** ENTER THE NUMBER 5 WHEN YOU WISH TO CONTINUE****
?5
*** SUITABLE WATER TREATMENT PROCESSES FOR IMPLEMENATION IN...1980...***

FEASIBLE PROCESS COMBINATIONS	INITAL CONSTRUCTION COST RATIO	AVERAGE MAINTENANCE COST RATIO
W2	14.66	3.14
W5	17.66	7.13
W6	29.74	16.06
W7	17.6	9.66
W8	20.6	13.64

ENTER 5 WHEN YOU WISH TO CONTINUE
?5

FEASIBLE PROCESS COMBINATION	TOTAL COST RATIO 20 YEAR	MANPOWER REQUIRED UNSKIL	SKIL	PROF
W2	77.53	2	0	0
W5	160.23	3	1	0
W6	351.04	2	1	0
W7	210.77	3	1	0
W8	293.47	4	2	0

THE LOWEST TOTAL COST RATIO IS W2 AT A 20 YEAR SUM OF 77.53

ENTER 5 WHEN YOU WISH TO CONTINUE
?5

303

THE PROGRAM WILL NOT PROCEED UNTIL YOU PUNCH IN A NUMBER FROM THE KEYBOARD. PLEASE ENTER THE NUMBER WHICH INDICATES YOUR CHOICE

0 INDICATES THAT YOU DO NOT WISH TO USE THE WASTE TREATMENT SECTION OF THE MODEL.

1 INDICATES THAT YOU DO WISH TO USE THE WASTE TREATMENT SECTION OF THE MODEL.
?1

*** SUITABLE WASTE TREATMENT PROCESSES FOR IMPLEMENATION IN...1980...***

FEASIBLE PROCESS COMBINATIONS	INITAL CONSTRUCTION COST RATIO	AVERAGE MAINTENANCE COST RATIO
S3	2.07	3.75
S4	18.2	16.05
S9	28.72	12.7
S10	37.14	21.92
S14	9	10.95
S15	25	23.25

***ENTER 5 WHEN YOU WISH TO CONTINUE**
?5

TECNOLOGIA APROPIADA PARA EL TRATAMIENTO DE AGUA Y AGUAS RESIDUALES

EXPERIENCIA EN EL TRATAMIENTO DE AGUAS RESIDUALES EN MEXICO

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EXPERIENCIA EN EL TRATAMIENTO DE AGUAS RESIDUALES EN MEXICO

I. INTRODUCCION

1.- Uno de los parámetros de cuantificación y control de la contaminación del agua que más atención ha recibido en México y en otros países, ha sido la Demanda Bioquímica de Oxígeno (DBO). En base a este parámetro se han llevado a cabo numerosas actividades, tales como estudios de monitoreo, aplicaciones de modelos de simulación digital, estudios y proyectos, construcción de plantas de tratamiento de aguas residuales, planeación de la administración del manejo del agua, establecimiento de normas para cuerpos receptores y enseñanza e investigación en los centros de educación superior.

2.- Esta situación se ve reflejada en la mayoría de los sistemas de tratamiento de aguas residuales, municipales que existen en México, los cuales han sido diseñados para remover principalmente la materia orgánica, medida a través de la DBO, contenida en las aguas residuales. La razón de que exista una tendencia a implantar este tipo de sistemas es obvia, la tecnología para el control de la contaminación del agua que se está aplicando ha sido importada de otros países.

3.- Sin embargo, las condiciones en México difieren considerablemente de las que prevalecen en los países donde se ha originado y desarrollado dicha tecnología. Un aspecto en el cual se observa una marcada diferencia, es el alto porcentaje de aguas residuales municipales que en México se utiliza (sin previo tratamiento) para el riego agrícola en las áreas rurales circunvecinas a los centros de población. Esta práctica se ha venido efectuando desde hace muchos años, por lo que dicha situación implica la necesidad de plantear alternativas de solución apropiadas para controlar las descargas de aguas residuales municipales.

4.- En este trabajo se hace un análisis del inventario de las plantas de tratamiento de aguas residuales construidas en el país, incluyendo tipos de procesos seleccionados y los objetivos para los que se construyeron dichas plantas. También se consideran las condiciones de operación y mantenimiento.

5.- El enfoque del trabajo esta dirigido a plantear la problemática que presentan los procesos de tratamiento orientados a reducir la carga orgánica basada en la DBO, cuando son aplicados en los casos antes mencionados y proponer áreas de investigación que permitan desarrollar una tecnología que se adapte a las condiciones y posibilidades económicas de la mayoría de los municipios.

II. MARCO LEGAL PARA EL CONTROL DE LA CONTAMINACION DEL AGUA

1.- El programa para el control de la contaminación del agua en México se fundamenta en los instrumentos jurídicos siguientes:

a) Ley Federal para Prevenir y Controlar la Contaminación Ambiental (Marzo 1971)

b) Reglamento para la Prevención y Control de la Contaminación de Agua (Marzo 1973)

c) Ley Federal de Aguas

d) Ley Orgánica de la Administración Pública y Federal

e) Acuerdo del C. Presidente de la República en el Diario Oficial de la Federación el día 21 de febrero de 1977, que determina la competencia de las dependencias federales involucradas.

2.- Hasta antes del mes de marzo de 1973 cuando entró en vigencia el Reglamento para la Prevención y Control de la Contaminación de Aguas, la legislación que existía no contemplaba normas específicas para la calidad de las aguas residuales y de los cuerpos receptores donde son vertidas. El plan contenido en este Reglamento contempla tres etapas que consisten en:

a) *Primera Etapa.* Inventario (registro) de las descargas de aguas residuales provenientes de los usos municipales, industriales, comerciales, agrícolas y pecuarios, con excepción de las provenientes de casas habitación.

b) *Segunda Etapa.* Realización de las instalaciones para tratamiento indicadas por los responsables de descargas en los informes preliminares de Ingeniería (IPI), de tal forma que todas las descargas de aguas residuales no sobrepasen los límites de los cinco parámetros (pH, temperatura, grasas y aceites, materia flotante y sólidos sedimentables).

c) *Tercera Etapa.* Clasificación de los cuerpos (receptores) de agua del país en función de sus usos y establecimiento de condiciones particulares a las descargas de aguas residuales que se vierten a los cuerpos de agua clasificados.

3.- El llevar a la práctica el plan anterior implica un gran esfuerzo y tiempo. Se requiere estudiar y analizar el comportamiento de un gran número de cuerpos de agua que existen en cerca de 220 cuencas hidrológicas del país. Una investigación realizada[3] respecto a la cantidad de descargas de aguas residuales en el país con el fin de estimar el número de registros esperados indicó las cifras mostradas en la tabla 1.

ORIGEN DE LA DESCARGA	NUMERO DE DESCARGAS
Industriales	120,000
Poblaciones	1,900
Servicios	80,000
Comercios	71,100
Agrícolas	27,000
Total	300,000

Tabla 1. Estimación del Número de Descargas de Aguas Residuales en México.

II. DISTRIBUCION DE LA POBLACION

1.- El crecimiento de la población el país es de 3.5%, lo que implica que de cerca de 70 millones de habitantes que actualmente (1980) tiene México se pasará a 135 millones de habitantes en el año 2,000[4]. En la Tabla 2 se muestra la distribución de la población y el número de localidades en el país, de acuerdo al IX Censo General de Población de 1970[5].

RANGO DE POBLACION (hab.)	POBLACION (millones de hab.)	TOTAL %	NUMERO DE LOCALIDADES
2,500	19.9	41.3	95,410
2,500 - 10,000	6.6	13.6	1,476
10,000 - 50,000	4.7	9.8	251
50,000 -100,000	2.1	4.4	30
100,000 -860,000	6.0	12.4	61
Monterrey, N.L.	0.9	1.8	1
Guadalajara, Jal.	1.2	2.5	1
Distrito Federal	6.9	14.3	1
	48.2	100.0	97,228

Tabla 2. Distribución de la Población y Número de localidades en México.

IV. INFRAESTRUCTURA DE AGUA POTABLE Y ALCANTARILLADO

1.- En un estudio[3] realizado en 314 ciudades de más de 10,000 habitantes, que en forma agregada sumaban una población de 21.0 millones de habitantes (excluyendo el D.F.), se encontró, que el 98.4% de dichos asentamientos contaban con agua potable y el 80.4% de sus habitantes recibía este servicio. Por lo que respecta al alcantarillado se determinó que el 87.9/ de estas localidades tenía servicio, beneficiando al 60.9% de sus habitantes. En las poblaciones menores de 10,000 habitantes estos porcentajes se reducen considerablemente.

2.- La dotación media de agua en los sistemas de abastecimiento municipal del país es muy variable, va de 100.0 a 450.0 1/hab./día. La distribución de dicha dotación[5] se ejerce en los usos domésticos (81.0%), industrial (3.0%) y servicios públicos (10.0%).

3.- En el país se generan del orden de 75.0 m^3/seg. de aguas residuales municipales. Asumiendo que el año 2,000, el 80% de la población cuente con servicios de alcantarillado, entonces se tendrá un caudal descargado de aguas residuales de aproximadamente 295.0 m^3/seg.[4].

4.- La situación antes descrita, aunada a la problemática que presenta el gran número de localidades menores de 50,000 habitantes cuya infraestructura para estos servicios es mucho más limitada, demanda una considerable inversión económica en los próximos años.

V. INVENTARIO DE PLANTAS DE TRATAMIENTO DE AGUAS RESIDUALES

1.- A través de un análisis del avance en la construcción de plantas de tratamiento de aguas residuales en México, se puede observar que este aspecto de saneamiento ambiental no no ha recibido la atención que en otros países ha tenido. En la Tabla 3. Se muestra un inventario, si bien no exhaustivo, de las obras realizadas en México.

2.- En dicho inventario se han identificado 70 sistemas de tratamiento de aguas residuales, cuyo diseño, proyecto y construcción ha estado a cargo de dependencias oficiales, tales como DDF, SARH , SSA y SAHOP y empresas privadas. En su mayoría, estas plantas fueron construidas en el período de 1960-1970. De los procesos empleados en dichos sistemas, 27 tienen algún tipo de lagunas, 22 son de lodos activados, 16 tanques Imhoff, 4 filtros rociadores, 3 sedimentadores primarios 1 zanja de oxidación, 1 fosas sépticas y 2 emisores submarinos, tal como se indica en la Tabla 4. Además se han detectado más de 35 proyectos,[7 10] en los cuales se incluyen 27 procesos de algún tipo de lagunas.

3.- Es interesante destacar que en el Area Metropolitana de la ciudad de México se ubican 9 plantas y en la ciudad de Monterrey, N.L. existen 5 instalaciones de esta naturaleza.

De las 20 principales poblaciones fronterizas con los Estados Unidos, 14 cuentan con sistemas de tratamiento para las aguas residuales.

4.- Existen varias razones a las que se le puede atribuir el reducido número de plantas de tratamiento en el país, entre los principales motivos se pueden mencionar los siguientes:

a) Carencia de instrumentos jurídicos para controlar las descargas de aguas residuales hasta 1973 en que entró en vigor el Reglamento para la Prevención y Control de la Contaminación de Aguas.

b) Costos de construcción y operación de las obras de tratamiento de aguas residuales.

	Localidad	Entidad	Tipo de Planta de Tratamiento	Objetivo de la Planta	Inicio de su Operación.	(1) Condiciones en que se encuentra la Planta
1	Algodones	B.C.N.	Laguna Facultiva	c.c.	1966	En operación s/c, s/e
2	Ensenada	B.C.N.	Tanque Imhoff	c.c.	1965	En operación
3	Mexicali	B.C.N.	Lagunas de Estabilización	c.c.	1969	En operación
4	Tecate	B.C.N.	Tanque Imhoff y Filtros Rociadores	c.c.		Abandonada
5	La Paz	B.C.S.	Tanque Imhoff y Laguna Facultiva	c.c.	1962	En operación
6	Villa Constitución	B.C.S.	Laguna Facultiva	c.c.	1970	Sobrediseñada, s/e
7	Cd. Acuña	Coah.	Tanque Imhoff y Laguna Facultiva	c.c.	1962	Sobrediseñada, s/e
8	Piedras Negras	Coah.	Lagunas de Estabilización	c.c.	1969	En operación, azolvadas s/c
9	Parras de la Fuente	Coah.	Filtros Rociadores	c.c.		En operación
10	Villa Frontera	Coah.	Lodos Activados	c.c.		En operación
11	Monclova (2)	Coah.	Filtros Rociadores	R.		En operación
12	Monclova (2)	Coah.	Lodos Activados	R.		En operación
13	Saltillo (2)	Coah.	Lodos Activados	R.		En operación
14	Nueva Rosita	Coah.	Lagunas de Estabilización	c.c.		En operación
15	Ojinaga	Chih.	Lagunas de Estabilización	c.c.		En operación s/c, s/e
16	Durango	Dgo.	Lagunas de Estabilización	c.c.		En operación s/c
17	León	Gto.	Lagunas de Estabilización	c.c.		En operación
18	Acapulco	Gro.	Laguna de Oxidación	c.c.		En operación
19	Meztitlán	Hgo.	Lagunas de Estabilización	c.c.		En operación
20	Cd. Sahagún	Hgo.	Tanque Imhoff	c.c.		Abandonada
21	Cd. Guzmán	Jal.	Tanque Imhoff	c.c.	1960	Abandonada
22	Puerto Vallarta	Jal.	Lodos Activados	c.c.		En operación
23	Puerto Vallarta	Jal.	Tanque Imhoff	c.c.		En operación s/c
24	Puerto Vallarta	Jal.	Sedimentador Primarios-Emisor	c.c.	1976	En operación
25	Atenquique	Jal.	Fosas Cépticas	c.c.		En operación
26	San Marcos	Jal.	Sedimentador Primario	c.c.		En operación
27	Jocotepec	Jal.	Lodos Activados	c.c.	1977	En operación s/c
28	Tlaltizapán	Mor.	Lagunas de Estabilización	c.c.		En operación
29	Jiutepec	Mor.	Lodos Activados	c.c.	1978	En construcción
30	San Blas	Nay.	Lagunas de Estabilización	c.c.		En operación
31	Monterrey (2)	N.L.	Lodos Activados	R.	1954	En operación
32	Monterrey (2)	N.L.	Lodos Activados	R.	1961	En operación
33	Monterrey (2)	N.L.	Lodos Activados	R.	1963	En operación
34	Monterrey (2)	N.L.	Lodos Activados	R.	1963	En operación
35	Monterrey (2)	N.L.	Lodos Activados	R.	1976	En operación
	Cerralvo	N.L.	Tanque Imhoff	c.c.		Abandonada
	Bustamante	N.L.	Tanque Imhoff	c.c.		Abandonada
	Santiago	N.L.	Tanque Imhoff	c.c.		Abandonada
39	Cd. Serdán	Pue.	Lagunas de Estabilización	c.c.		Abandonada
40	Querétaro	Qro.	Tanque Imhoff	c.c.	1967	En operación
41	Cancún	Q.R.	Lodos Activados	c.c.	1974	En operación
42	Cancún	Q.R.	Lodos Activados	c.c.	1974	En operación
43	Chetumal	Q.R.	Lagunas Facultativas	c.c.		Abandonada
44	Mazatlan	Sin.	Lodos Activados	c.c.		Abandonada
45	Agua Prieta	Son.	Lagunas de Estabilización	c.c.	1968	En operación
46	Empalme	Son.	Lagunas de Estabilización	c.c.	1969	En operación
47	Magdalena	Son.	Tanque Imhoff	c.c.		En operación
48	Naco	Son.	Lagunas de Estabilización	c.c.	1964	En operación
49	S.L. Río Colorado	Son.	Tanque Imhoff	c.c.		En operación
50	Guaymas	Son.	Lagunas de Estabilización	c.c.		En operación
51	Benjamín Gil	Son.	Laguna de Oxidación	c.c.		En operación
52	Sahuaripa	Son.	Laguna de Oxidación	c.c.		En operación
53	Nogales	Son.	Laguna de Oxidación	c.c.		En operación
54	Altamira	Tamps.	Lagunas de Estabilización	c.c.	1968	En operación
55	Nuevo Laredo	Tamps.	Tanque Imhoff	c.c.		Abandonada
56	Nueva Cd. Guerrero	Tamps.	Tanque Imhoff	c.c.		Abandonada
57	Cd. Miguel Alemán	Tamps.	Laguna de Oxidación	c.c.		En operación s/c, s/e
58	Reynosa	Tamps.	Tanque Imhoff y Laguna de Estabilización	c.c.	1963	Tanque Imhoff-Abandonado Lagunas en operación s/c
59	Río Bravo (2)	Tamps.	Laguna de Sedimentación	c.c.		En operación
60	Veracruz	Ver.	Tratamiento Primario-Emisor	c.c.	1972	En operación
61	México	D.F.	Lodos Activados	R.	1960	En operación
62	México	D.F.	Lodos Activados	R.	1960	En operación
63	México	D.F.	Lodos Activados	R.	1968	En operación
64	México	D.F.	Lodos Activados	R.	1965	En operación
65	México	D.F.	Lodos Activados	R.		En operación
66	México (2)	D.F.	Filtros Rociadores	R.		En operación
67	México (2)	D.F.	Lodos Activados	R.		En operación
68	México	D.F.	Lodos Activados	R.		En operación
69	México (2)	D.F.	Lodos Activados	R.		En operación
70	Toluca (2)	Edo. de Méx.	Zanjas de Oxidación	c.c./R	1975	Sobrediseño s/e

(1) c.c. = Control de la Contaminación del Agua; R. = Reuso; s/c = Sin control; s/e = Sin efluente, aguas estancadas

(2) Instalaciones del Sector Privado e Industrial

TABLA 3. INVENTARIO DE LAS PLANTAS DE TRATAMIENTO DE AGUAS RESIDUALES DE LA REPUBLICA MEX.

ENTIDAD	FOSAS SEPTICAS	TANQUES IMHOFF	SEDIMENTADOR PRIMARIO	ALGUN TIPO DE LAGUNA	FILTROS ROCIADORES	LODOS ACTIVADOS	ZANJAS DE OXIDACION	EMISORES SUBMARINOS	NO. TOTAL DE PLANTAS	PLANTAS EN OPERACION
B.C.N.		2		2	1				4	2
B.C.S.		1		2					2	1
COAH.		1		3	2	3			8	7
CHIH.				1					1	0
DGO.				1					1	1
GTO.										
GRO.				1					1	1
HGO.		1		1					2	6
JAL.	1	2	2			2		1	7	6
MOR.				1		1			2	1
NAY.				1					1	1
N.L.		3				5			8	5
PUEB.				1					1	0
QRO.		1							1	1
Q.R.				1		2			3	2
SIN.						1			1	0
SON.		2		7					9	9
TAMPS.		3		4					6	3
VER.			1					1	1	1
D.F.					1	8			9	9
EDO DE MEX.							1		1	0
TOTAL	1	16	3	27	4	22	1	2	70	52

TABLA 4 . PLANTAS DE TRATAMIENTO DE AGUAS RESIDUALES EN MEXICO

c) Falta de una planeación a nivel nacional al respecto.

d) Fuentes de financiamiento para este tipo de instalaciones

e) Falta de orientación sobre la tecnología disponible por parte de los responsables de descargas de aguas residuales.

f) Desconocimiento del problema que ocasiona la descarga de este tipo de residuos por parte de las autoridades municipales.

5.- Esta situación ha ocasionado que sólo se construyan obras de esta naturaleza cuando los efectos son palpables (molestias, daños, etc.), y la presión del público o de alguna dependencia obligada a las autoridades a instalar los dispositivos de tratamiento.

6.- Hasta ahora solamente se han descrito las obras construidas, independientemente de su funcionamiento. Es importante que muchos de los sistemas de tratamiento citados estan siendo operados en forma inadecuadas o han sido abandonados.[7,11]

7.- La mayoría de las plantas de tratamiento municipales han sido diseñadas para controlar la contaminación del agua (75% del total inventariado). En algunos casos, como ocurre en los sectores industriales y oficiales, la finalidad de las plantas es el reuso del agua en las actividades industriales y en el riego de áreas verdes. En una investigación realizada por la SARH en 1974, se encontró que con excepción de las plantas cuyo objetivo es el reuso del agua, un gran número de instalaciones carecen de una adecuada organización para su administración, operación y mantenimiento, presentando bajas eficiencias de tratamiento y demandando trabajos de rehabilitación en sus obras y equipo.

8.- En algunos centros de población se observa que el Porcentaje de habitantes servidos con alcantarillado es menor del 60.0%, lo que ocasiona que el flujo de aguas residuales a las plantas de tratamiento sea mucho menor que el estimado para su diseño.

A falta de flujo, el agua residual se estanca en las unidades de tratamiento, evaporándose e infiltrándose. Cabe mencionar que en 6 plantas, se encontró esta situación. Se ha detectado que el 11 de los sistemas de lagunas se encuentran en operación sin control, sobrediseñados o abandonados. Por lo que respecta a los tanques Imhoff se observa que 11 unidades presentan condiciones similares a dicha laguna.

En este último caso, uno de los problemas que se presenta con más frecuencia es el manejo y disposición de los lodos acumulados en los tanques.

9.- Se considera que el principal problema del deficiente funcionamiento de los sistemas municipales de tratamiento existentes en el país radica en el área administrativa, de donde se originan las fallas de operación y mantenimiento[11].

'I. PROBLEMATICA MUNICIPAL EN EL CONTROL DE DESCARGAS DE AGUAS RESIDUALES

1.- Las actividades que se desarrollan en los centros urbanos requieren del suministro de una gran cantidad de bienes de consumo, que se generan en parte en las zonas rurales dentro de los municipios, como son el agua, alimentos, materias primas, etc. A cambio, dichos centros desalojan una gran cantidad de residuos, tales como aguas residuales y desechos sólidos, que por su carácter indeseable, son transportados y depositados en las áreas rurales circunvencinas.

2.- Uno de los problemas más graves que afrontan los municipios es el manejo y disposición de las aguas residuales. Se ha estimado[11,12] que para controlar las descargas de aguas residuales municipales de cerca de 291 localidades (ubicadas en los 2,388 municipios que existen en el país) que cuentan con sistemas de alcantarillado y exceden los límites permisibles de los cinco parámetros que marcan el Reglamento, se requiere establecer *plantas de tratamiento primario* que implican una inversión en construcción y equipos de aproximadamente 500 millones de pesos a precios de 1980.

3.- En 1970 se habían identificado únicamente 40 plantas de tratamiento municipales en un total de 331 poblaciones mayores de 10,000 habitantes. Por otro lado, en estas localidades[3] se encontró que solamente en el 77.6% tenía establecido el cobro por el servicio de alcantarillado, del cual el 64.0% lo obtenía únicamente al realizarse la conexión.

4.- En general, la evacuación de las aguas residuales municipales se efectúa a través de un cuerpo receptor (río, lago, mar) que provee un medio de transporte para alejar estos residuos de las áreas de asentamientos humanos. En un considerable número de casos los sistemas de drenaje municipales se conectan a dichos cuerpos receptores a través de pequeños cauces naturales.

5.- Desde hace varios años, se ha venido incrementando en el país la práctica de irrigación agrícola con el empleo de las aguas residuales municipales (crudas o tratadas) en las zonas rurales aledañas a los centros de población, interceptándose los escurrimientos de los cauces naturales antes mencionados.

6.- En un estudio[3] llevado a cabo por SARH, en 1975, en 314 ciudades con más de 10,000 habitantes, se determinó que en cerca de 100 localidades se estaban utilizando las aguas residuales municipales para el riego agrícola. A continuación se mencionan algunos de estos sitios:

Cd. Juárez, Chih.	Naco, Son.
Ojinaga, Chih.	Celaya, Gto.
Piedras Negras, Coah.	Toluca, Edo. de Méx.
Cd. Miguel Alemán, Tamps.	Durango, Dgo.
Reynosa, Tamps.	Querétaro, Qro.
Ensenada, B.C.N.	Cd. Cerdán, Pue.
Cd. de México	Tula, Hgo.
Valle del Mezquital, Hgo.	Cd. de México, D.F.

7.- Otra práctica que se está efectuando en el país es la descarga de aguas residuales al mar. Tales son los casos de la Paz, B.C.S., Empalme, Son., Guaymas, Son., Puerto Vallarta, Jal., Veracruz, Ver. y Acapulco, Gro.

8.- En algunos lugares, la escasez del recurso agua, ha obligado a las industrias y a las autoridades municipales a establecer sistemas de reuso del agua, aprovechando las aguas residuales municipales. En esta situación se encuentran las ciudades de México, D.F., Monterrey, N.L., Saltillo, Coah. y Monclova. Coah.

ALTERNATIVAS DE TECNOLOGIA DISPONIBLE

1.- Tomando en cuenta las condiciones socio-económicas que actualmente prevalecen en México, y los valores máximos tolerables para los cinco parámetros estipulados en el Reglamento para la Prevención y Control de la Contaminación de Aguas, la selección de alternativas de procesos de tratamiento de aguas residuales municipales, deberá tener como objetivo el remover principalmente los sólidos sedimentables, materiales gruesos y flotantes y grasas y aceites. Por investigaciones realizadas en la calidad de las aguas residuales de numerosas localidades, se considera que los parámetros de temperatura y pH no exceden dicha norma excepto en aquellos sitios donde se localizan industrias que descargan a los sistemas de alcantarillado municipales.[13]

2.- Las alternativas a considerar deberán implicar bajos costos de construcción y simplicidad en su mantenimiento. Además deberá efectuarse un estudio de impacto ambiental que evalúe las diferentes alternativas propuestas.

3.- De acuerdo a la tecnología disponibles y tomando en cuenta los criterios antes mencionados, se plantean las siguientes alternativas de procesos de tratamiento: a) tanques Imhoff, sedimentadores primarios, lagunas de oxidación, lagunas aereadas y zanjas de oxidación. En la Tabla 5. se muestran algunos criterios para la selección de los procesos de tratamiento.

VIII. PROBLEMATICA DE LOS PROCESOS DE TRATAMIENTO BASADOS EN LA REDUCCION DE LA DBO

1.- A través del parámetro de la Demanda Bioquímica de Oxígeno (DBO) se puede medir indirectamente la concentración de materia orgánica biodegradable contenida en el agua, que define la cantidad de oxígeno requerido para la respiración de los microorganismos responsables de la estabilización de la materia orgánica en condiciones aerobias.

2.- Este índice ha sido extensamente utilizado para cuantificar el grado de contaminación del agua. Dado que la degradación de la materia orgánica se pueden efectuar en forma natural (autopurificación) en los cuerpos receptores o en forma artificial en las instalaciones de tratamiento, este parámetro ha sido empleado también para evaluar la rapidez y eficiencia en que se lleva a cabo dicho proceso.

3.- Un alto porcentaje de las aguas residuales que se generan

Tipo de Planta	Clasificación del Nivel de Tratamiento	Objetivos de los Procesos de Tratamiento	Procesos Antecedentes	COSTOS Construcción.	Operación y Mant.	Características de las Plantas. Grado de Dificultad en Operación y Mantenimiento.
Fosas Sépticas	Primario	Remoción de SSe, materia flotante, y DBO. Digestión de lodos	Ninguno	Bajos	Bajos	Mínimo (4)
Tanque Imhoff	Primario	Remoción de SSe y DBO. Digestión de lodos.	Rejillas y desarenador	Bajos	Bajos	Mínimo (4)
Sedimentador primario	Primario	Remoción de SSe (1)	Rejillas y desarenador	Bajos	Medios	Medio (5)
Laguna de Oxidación	Secundario	Remoción de SSe y DBO. Digestión de lodos	Ninguno	Bajos	Bajos	Mínimo
Lagunas de Estabilización	Secundario	Remoción de SSe y DBO. Digestión de lodos	Ninguno	Bajos	Bajos	Mínimo
Zanjas de Oxidación	Secundario	Remoción de DBO	Rejillas, desarenador y sedimentador primario(3)	Medios	Medios	Medios (5)
Lagunas Aereadas	Secundario	Remoción de DBO	Rejillas, desarenador y sedimentador primario	Medios	Medios	Medios (4)
Filtros Rociadores	Secundario	Remoción de DBO	Rejillas, desarenador y sedimentador primario(3)	Altos	Altos	Alto (5)
Lodos Activados	Secundario	Remoción de DBO	Rejillas, desarenador y sedimentador primario(3)	Altos	Altos	Alto (5)

(1) En forma indirecta se remueve DBO

(2) En ocaciones se aplican productos químicos para efectuar precipitación en sedimentador

(3) Requiere de sedimentador secundario y cloración

(4) Requiere mantenimiento periódoco para remover y disponer lodos acumulados

(5) Requiere de manejo y disposición de gran cantidad de lodos

TABLA 5. CARACTERISTICAS DE LOS SISTEMAS DE TRATAMIENTO DE AGUAS RESIDUALES MAS COMUNES provienen de los usos domésticos del agua y uno de los principales contaminantes que acarrean dichas aguas es la materia orgánica. Por tal motivo, la mayoría de los procesos de tratamiento de las aguas residuales estan orientadas a reducir la carga de materia orgánica, medida por medio de la DBO. Otros contaminantes indeseables en las aguas residuales de origen doméstico son los organismos patógenos que presentan el peligro de transmitir enfermedades. De acuerdo a la tecnología disponible, es necesario remover en un alto porcentaje el contenido de materia orgánica antes de aplicar el proceso de cloración, con el fin de reducir las dósis requeridas del agente desinfectante.

4.- Existen otros tipos de contaminantes, como son los sólidos suspendidos, grasas y aceites, materiales gruesos, nutrientes y detergentes, cuyas concentraciones en las aguas negras son también indeseables. Existen procesos específicos para remover estos contaminantes.

Cabe mencionar que en las unidades de tratamiento dirigidas a reducir las concentraciones de sólidos suspendidos sedimentables en forma indirexta se remueve un porcentaje significativo de la materia orgánica biodegradable.

5.- Es importante indicar que un alto porcentaje (96.0%) de las plantas de tratamiento que existen en el país cuentan con algún tipo de proceso biológico para remover la materia orgánica medida como DBO. En algunos casos quizá se justifiquen dichos procesos, con otros la decisión para implantar este tipo de unidades no fue acertada, tales son los casos de las localidades que vierten al mar y en aquellas en que sus aguas residuales son utilizadas para el riego agrícola. Dichos tipos de disposición no requieren de un control de la DBO.

6.- En algunos casos, quizá por desconocimiento de la tecnología disponible, en otros por intereses de los fabricantes y vendedores de equipo los procesos de tratamiento escogidos no han sido los adecuados. Lo más grave del problema es que dichas soluciones demanda considerables inversiones y posteriormente los municipios abandona dichas instalaciones por no contar con los recursos económicos, administrativos y técnicos para operarlas. Esta situación crea desconcierto entre las autoridades y el público en general, que a final de cuentas es el que paga dichas inversiones.

IX. CONCLUSIONES Y RECOMENDACIONES

1.- La disponibilidad del recurso agua en México, su distribución y la demanda existente y prevista en los próximos años, exige que el manejo de este bien se efectúe bajo una planeación adecuada que incluya el control de las descargas de aguas residuales.

2.- El principal instrumento jurídico para controlar la contaminación del agua que existe en el país es el Reglamento para la Prevención y Control de la Contaminación de Aguas. en lo que respecta a las descargas de aguas residuales municipales, este Reglamento contempla en forma muy adecuada la situación socioeconómica que prevalece en el país y en las entidades municipales. En principio, las normas que se han establecido demandan la instalación de plantas de tratamiento primario para las descargas municipales que exceden los límites permisibles, por lo que es muy importante que las autoridades responsables y los técnicos involucrados no pierdan de vista este concepto. Cabe mencionar que la aplicación de dichas normas no se puede generalizar a todos los casos, ya que algunos cuerpos receptores pueden demandar sistemas de tratamiento secundario de las descargas de aguas residuales municipales y en tales situaciones deberá llevarse a cabo un estudio de impacto para establecer el proceso de tratamiento más apropiado.

3.- Existe en el país un alto número de pequeñas y medianas localidades con un bajo porcentaje de habitantes servidos con servicios de agua potable y alcantarillado. Esto implica que las soluciones técnicas que se apliquen para el control de la contaminación del agua consideren tal situación.

Uno de los problemas más graves que actualmente afrontan los municipios del país para establecer medidas para controlar sus descargas de aguas residuales es la carencia de fuentes de financiamiento accesibles a sus posibilidades. Urge entonces que se creen los mecanismos financieros que apoyen a estas entidades.

4.- Se han identificado aproximadamente 70 plantas de tratamiento de aguas residuales municipales en el país. El 96.0% de estas instalaciones cuentan con algún tipo de proceso biológico para reducir la DBO. Si bien dichas plantas se construyeron en su mayoría en el período de 1960-1970, los procesos escogidos no deben ser siempre la pauta a seguir por las autoridades responsables, ya que en algunos casos la disposición de los efluentes de las plantas no justifica dicha solución, tal como ocurre en las descargas al mar y en el aprovechamiento de las aguas negras para riego agrícola, así como cuando la capacidad de autopurificación de los cuerpos receptores es muy amplia.

5.- En los casos antes mencionados, el alto contenido de bacterias coliformes en las aguas negras puede ser indeseable por el tipo de disposición de dichos residuos. De acuerdo a la tecnología disponible, el proceso de desinfección por medio de cloro requiere de un tratamiento previo de las aguas residuales para remover la materia orgánica. Este aspecto es una de las áreas de investigación que demandan mayor atención.

6.- La construcción de plantas de tratamiento de aguas residuales en el país se ha efectuado sin una planeación a nivel nacional. Dichas obras se han realizado debido a la presión del público local o de alguna dependencia gubernamental cuando los efectos son palpables. Se puede afirmar que es mínimo lo que se ha realizado en el aspecto de construcción de obras de prevención.

7.- El 75% de las plantas existentes se han diseñado para controlar la contaminación del agua (en su mayoría para resolver problemas ya existentes), y el resto tiene por objetivo el reuso del agua para las actividades industriales y el riego de áreas verdes. En este último caso, la escasez del agua ha creado la necesidad de implantar su reuso.

8.- Un alto porcentaje de los sistemas de tratamiento identificados están siendo operados en forma inadecuado o han sido abandonados. Se ha detectado que la mayoría de estos sistemas carecen de una adecuada organización para su administración, operación y mantenimiento.

9.- Se ha detectado que la práctica de utilizar las aguas negras para riego agrícola en el país se ha incrementado y generalizado en los últimos años. Dado el carácter agrícola del país se prevee que dicha práctica aumentará en forma considerable. Las investigaciones realizadas al respecto son incipientes y sus resultados no permiten establecer conclusiones determinantes. Por tal motivo, es necesario que los estudios sobre los efectos del uso de aguas negras, (crudas o tratadas) en irrigación sean intensificados. Cabe mencionar que, si bien esta práctica se efectúa en los países donde se ha originado la tecnología disponible para el tratamiento de las aguas residuales, el avance en éste aspecto ha sido limitado, debido a que no es una práctica común y a que las condiciones socioeconómicas difieren considerablemente de las que existen en México.

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"TECNOLOGIA APROPIADA PARA EL TRATAMIENTO DE AGUA
Y AGUAS RESIDUALES"

"CONSUMER ACCEPTANCE OF PREDICTIVE MODELS OF APPROPRIATE TECHNOLOGY"

Dr. George W. Reid

Agosto, 1980

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Appropriate Technology Supplemental Lectures
Workbook, p. 107-116

Consumer Acceptance of Predictive Models of Appropriate Technology

by

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July 10-12

3rd International Symposium on
Large Engineering Systems

We have had understudy for five years the problem of how to reduce disease, and promote social and economic development by assisting the lesser developed countries in their quest for pure water. Potable water is a necessary but not sufficient condition for development. In fact, this very well may be, the stem of serious problems of social acceptance - acceptance not only of modelling, aggregate (large systems) models, appropriate technology, but of piped purified water.

The water problem is global, and quite serious. Over a 1000 million people have inadequate water supplies, and over 75% of the earth's population are without adequate sewage disposal. As development takes place, one shifts to piped water and high water demands, and also brings about a need for disposal of liquid wastes.

Our study initially was concerned with Low Cost Water and Waste Water Treatment for LDC's. This project (financed by USAID) developed concurrently with worldwide interest in the concepts technology transfer, intermediate technology, retrogressive technology, appropriate technology, and; of course, responsive large systems models. A model was developed that would enable a community in the developing world, or anywhere else for that matter, to select from all the available technologies to treat water or sewage those that were compatible with quality goals; and economic and societal, and human and material resources. The model is central to our problem solution.

The model along with supportive material has been put in the form of a workshop that is being presented to 19 LDC's around the globe. The model is fully computerized, on an Apple II, and on a hand-programmable computer or in manual format. In addition to the model, a delphi based, prioritizing model also has been developed. It became apparent after several workshops that

"If one has a better mouse trap the question is how does one get others to use it?" Put another way, in the overall project, I suggested three phases, where the first is science, the second is technology and technology transfer, and the third is utilization or acceptance of the technology sometimes called penetration. What kinds of mechanisms, what kinds of judgments can be made to assist in the last phase, is of current interest, and the subject of this paper.

Consumer acceptance requires a value judgment. Who is to say what is better? One talks about water and health, and with each technological advance (or change) there is a technological impact. Sometimes it's good, and sometimes it's bad. The question perhaps is "which is better?" In my opinion, the judges of which is better should be the consumer, not a technician, public official, politician, engineer, who represents a consumer interest. Frequently, I have found in the United States; for instance, when plans are for a large reservoir to provide water, that when given a chance, people may vote against it. For their own reasons they prefer to have that land for agriculture and some might even prefer to have the land completely unused. Left the way it was with nature. The question then is who makes that judgment? Technicians are supposed to make the judgments, that are considered best for the whole over time, and not for the immediate. This brings you to a basic concept in systems approach that one is always a part of a larger system. This is called embedment. By this I mean you are inside of a world that rolls in time. Also adequate water is inside of the whole delivery service which is inside of a town inside of a country which is a part of our world. The expert tends to represent those that are not yet to be born. He tends to protect our children and our grandchildren from the over-allocation and utilization of resources by us. We have a problem here of asking the question: If we as decision-makers feel that his is better for the whole, how do we convince the current portion of the whole that it is better so that they will accept it?

I have attempted to work out several ways of approaching that problem. I studied with behavioral scientists much the same way they might come to me about engineering. I took a course in theories of perception. So my first point developed to one of how do people perceive things? What is one's paradigm? Your eye to eye view. Skinner's theory is that there are three parts to the brain, three tiers. One part simply reacts in an animal fashion, one part has the conditioned responses, the third part has the reasoning capability. The difference between the animal and the human being is this difference between the ability to simply respond and the ability to reason. Shumaker has five tiers that he talks about in perception. In the inanimate world, one knows quite a bit about it. We know it's chemistry. The next level of these five tiers, is the vegetable or plant. They can't think, they can't reason, they can't react. But they create and actually we know very little about that. We cannot yet create life. The next tier is the animal world, and we know less and less about that. On each tier we know less and less. So less is tangible and real to us. More and more is left up to the imagination. Schumaker's fifth tier is everything untouchable has no material substance. Herein is the problem of communicating. These are some of the theories coming out of the behavioral sciences. And in the perception concept is the concept of reinforcement. One puts out an idea, or model. Then, next time goes into a little more detail, so each time you go over it, it is reinforced. In the mechanics of the brain if you see something, it is registered in the brain. If you see something and then write it down, you will remember it better because you can see it again. You have transferred from a visual interpretation to a sensory one. Then you take one theme and go over and over it, you may get the idea across better. If we can document it with pictures, with odors, it reinforces the theme. As to sewage, take me to a sewage plant. What I am trying to point out is that there are levels of perception to get the idea across. In trying to sell a new idea, there's a problem of personal communication. If I am offensive to somebody then I will have trouble communicating. This is personal; it has nothing to do with science and technology. If I say right away that I have something against lawyers, right away they aren't going to have anything to do with me. On the other hand, I may say something that will get them to listen to me so that they can pick at me. And if this happens, communication is now happening. So, all of these things are what the social scientist looks at in trying to get an idea across.

In terms of this particular issue, I have built a model I want others to use. How could I get the idea across? I put forward two questions, one of them says "Why waste my time?" and "Why not concentrate my time on a person that's important?" For example, if I want to sell a man an automobile, I won't talk to the man; I will talk to his wife. Because maybe she has more influence on the decision to buy the automobile. The point is to locate the person who makes the decision. If you are going to build a large water plant in a town in a developing country, and you want the idea to go across that it is being built with low cost, appropriate technology, you've got to talk to who is going to decide what kind of technology is to be used. So you must define somehow or other who is going to be the decision-maker.

Then there is the second question. And that is, what is it that the decision-maker will base his decision on? I believe there are two kinds of things that he makes his decision on. As I have just said, he makes his decision on the one hand on purely personal things, so he may not like the way I look, or he may not like the fact that I am an American and not an

Indonesia. All of these kinds of things can be there. The relative strengths of these likes and dislikes reside in the individual. Also, he may have trouble in his own life that morning. Or he may have an ulcer that is working on him today. Or he may not like another member of the committee, and if that member likes me then he won't like me simply because he doesn't like the other member. These are personal things. I would like to say, "Let's forget them." You may not agree, but let me tell you why I think we should forget them. I think my role is to identify how the decision-maker thinks about technical part. All I want to do is not to convince him of anything, but simply show him something. And if he can understand what it is that I am showing him, then he can make his own decision. And that is exactly what I want. So my problem is one of communication, and not one of satisfying the personal likes and dislikes, and that includes such things as kickbacks, etc, which happens and not just in LDC's. To reinforce this concept I would like to address the bribery idea. If I am a politician, and I have the role of making a decision; I am obviously going to make that decision in favor of a man that helped get me elected. But I'm going to do it if he gives me something that is not going to work. Most politicians want to stay in business. So they would like to have their advisors be friends, and they would like their advisors to make a little money. But they don't want to get some bad information that is going to cause them to lose their next election. They don't want white elephants. So there is a certain amount of control within this mechanism. At least I find it so. So my job is to make sure that the technical information that the politician gets is correct, and that I can show him several systems and inform him of the consequences of his decision in each case. Then it's up to him to make the decision, and I don't care which decision he makes, as long as I have told him the consequences. To make the decision is his problem, as long as he has been informed of the consequences of his actions.

In the case with several options of water treatment, say a slow sand filter against a rapid sand filter, sophisticated versus a simple solution. Again, I don't care which one the politician picks; just so he understands the consequences. In the case of the slow sand filter he'll probably be able to operate the thing. In the fancy one, he may never get the thing to run one day correctly. So he must decide if he is willing to put up with the "flack" from the local people when they have something that won't work. So, I asked the question, "If I identify the decision-maker, then I want to identify how the decision-maker thinks. Because I want to put my ideas across to him, and to do so I have to know how he thinks." To identify his thinking process I would use his cognitive experience. Cognitive experience is the experience one goes through in his formative years. And the best identifier that I can give for cognitive experience is what you do in school. If you study law, you tend to think one way. And that is to win the argument. If you studied science, you tend to search for the truth. You don't care how much it will cost or how long it will take. If you study engineering, you tend to give a solution as quickly as possible, and as cheaply as possible. And so on. So if I can identify the decision group in terms of the way they learned to think, then I may be able to present my arguments to them so that they will think it through. So, I must overcome a personal contact barrier, and a technical language barrier, and a cognitive thinking barrier. To properly communicate. Now that would be ideal. A practical extention of that idea would be to work with the surrogate. Knowing that the members of the decision making group are non-technical and will get a technical equipped friend that they can trust to give them the straight information on consequences of their decision. So, I am attempting to categorize the decision-makers cognitive response, to identify the approach I would use to communicate, such a tabulation is still under development and testing.

An additional approach could be called a benefit analysis. This is a little different approach. The basic question is "Who benefits?" You can see how this approach differs. Here-in, one develops a schedule of possible benefits, on negative benefits. In the other instance, the idea was to get the information across and then let them decide whether they will benefit or not among themselves. Let them make that total decision. Now I am asking who benefits in another context. I have broken this down into an individual, a group (a specialized group of people), a community, and or the donor. The community is the one that gets this system that we have been talking about. The individual may be one who has designed the system. Or he might be a mayor, and his administration was responsible for putting in the water system. Or it might be a special group, the businessmen in town because the water treatment plant means they can put in a new factory and have more business, the donor might be USAID. So I tried to divide this into those four groups. In terms of who benefits, I have sorted this out as to what phase they will benefit from, because there are phases that I classify as the design, the construction, the financing, and the operation. The phase costs differ; and in the selection of a system we can spend more money on one phase and less on another. But each of these has a different role to play. Now from the standpoint of the community, a water supply system generally means industrial development. It means growth. It means a better lifestyle, maybe. Depends on who you are talking to. I think in the aggregate, in a larger sense, it does mean a better lifestyle. In the long run, people live longer, although some people might argue, is this an advantage? We know we live longer and better in this kind of development (industrialized). There are fewer diseases.

And generally there is more employment. So the community may have everything to gain. So, here-in, one would simply arrange by category, all kinds of benefits, impacts, externalities, tangible, direct, etc., benefits, or the consequences of impacts of appropriate or inappropriate technology. There is a great deal of information on this subject.

However, the problem or in my case the predictive model is cast, marketing concepts are also important. There are perhaps two distinct parts, first dissemination of the concept of appropriate technology, its worth, etc., and secondly dissemination of the model for conceptual design of appropriate technology systems. One the idea, the other use of a mathematical, computerized model. So one might be called awareness, acceptance of concepts, the other to demonstrate the use in real situations.

Again in terms of the market, the user community is divided into two groups. Customers for treatment systems, and suppliers of those systems. There are additional problems, assuming those of communicating are solved.

1. Both groups are somewhat victimized by technological fads. We want what Chicago has or it must use a computer, etc.
2. Customers are more or less at the mercy of the suppliers. They offer a limited menu.

Once penetration of appropriate decision groups has been accomplished, customer acceptance appears to rest with at least five interdependent groups:

1. Decision-Makers, in-county, local, and central
2. Technical staffers, in-county, local, and central
3. Political staff, in-county, central
4. Consultants and advisory staff, in-county, local, and central
5. Foreign sponsors staff, technical and programmable

Suppliers acceptance would add four additional groups:

1. Foreign architectural and engineering firms
2. Foreign equipment suppliers
3. Foreign financiers, WHO, AID
4. Foreign governments agencies promoting trade
5. International institutions.

So one can see, that penetration, more specifically of a computerized, large system model to identify the appropriate technology for water treatment process selection in lesser developed countries in quite a complicated affair. In away, one is trying to identify a very low cost, basic, perhaps historic process, by using a very advanced search technology.

There are some practical methods and techniques that are helpful. Demonstrations, workshops, short courses, publication, etc. Information directed through unofficial channels, rotary international, etc., to leaders, information through industrial groups, etc.

The long term acceptance of the concepts, and aggregate models depend then on the education of the user (and supplies) community. One essential ingredient might be the development of key communicators (gate keepers). A man with one foot in each camp. A local that under funds the site and sources of technology.

I've been to several countries to-date with a 5 day workshop and the predictive model with certain conclusives.

1. The decision model appears to be a good demonstration of the utility of concepts of appropriate technology, but
2. The model is not marketable but the concept is.
3. Models and computers, are still somewhat mysteries, to LDC's
4. System analysts are their own worst enemies, because they conserve with one another, and not the client.

I have suggested that acceptance is the third step and essential to the proper utility of schemes and of course, of large system models. I have analyzed some of the problems of acceptance and suggested some avenues of approaching the problem. These ideas and conclusions have been drawn from personal experience in attempting to put across to LDC's a predictive model for the selection of most appropriate technology for water and waste water treatment.

There are ample examples of unsuccessful technology transfers, either direct or adoptive, and very few examples of indigenous technologies in the field of water and waste water treatment. There is even less evidence requiring, or volunteer exploration of alternative processes, particularly with attention to "soft" technology, so lessons of history, failures and successes can help in a benefit analysis of demonstration of value of appropriate water treatment technology, but not of a model.

The use of a model illustrates the type of information required by in-country decision-makers, immediate value can be derived from its manipulation, if such data can be identified and action initiated for its collection, but our experience to-date would indicate little reason to believe that funding agencies, or regulation agencies will promote or require the use of a model for decision-making. In a global reuse, it would be very helpful at a high prestige, internationally active consultant firm could be influenced to use this type of model to assist the LDC decision-makers. The most promising avenue at present serve to be through in-country universities assisting in the development of a "cell", or "gate keeper", who will develop the concept of appropriate technology, and the application of the model, or a modified model. The concept of appropriate technology is several times more valuable through the application of the model, and the concept is broad enough to be transferred to other social/engineering applications.

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"TECNOLOGIA APROPIADA PARA EL TRATAMIENTO DE AGUA Y AGUAS RESIDUALES"

"APPROPRIATE TECHNOLOGY SUPPLIMENTAL LECTURE-WORKBOOK, p. 107-116"

Dr. George H. Reid

Agosto, 1980

Appropriate Technology Supplimental Lecture-Workbook p. 119-134

The author has developed a model, aggregrate model, to be used to assist the decision-maker or makers in selection of appropriate technology with a treatment water or wastewater as a particular application in developing countries. A model that is fully developed including computerization. It has been presented to many audiences and was tested in depth in Panama and in Indonesia, and is currently being given in the form of short courses in twenty-one countries around the world. Including such countries in South America, Guatemala, Panama, Barbados, Columbia, Peru, Bolivia, Jamiaca, in Africa, such cities as Nirobi, Abajohn, Dekar, and in the Far East in Manila, Indonesia, Bandung, Bangkok, Decca, Delhi to name a few. There are additional lectures or papers given in these five day workshops that are used to present the model and these have been with two exceptions have been incorporated in a text that is currently undergoing publication. The text is entitled "Interface for Decision Appropriate Technology Prediction and Selection Methodologies State of the Art," by Reid and Coffey.

The purpose of this paper is to further develop some of the concepts that come out of the attempt to test the application of the model; as well as, some management implications, and some of the limitations. Most of these thoughts have developed through the tests in Panama and Indonesia; as well as, the feedback from seven workshops to date. Of course the object of this paper would be to demonstrate some of the economic and management concerns with their relationship to this model. In general I propose to cover the effect of the demand for water on the models use; the costs and delays and concepts of aggregate projects; the relationship between capital cost and O & M costs; as well as, the O & M ratio. Some of the counter intuitive, capital intensive problems relating to unit cost and scale; the unique ideas of potentials through volunteerism; the relationship of total cost to the aforementioned factors and some of the concerns with size and lifestyle on the demands for water. The model itself takes all the available processes for treatment of water or sewage, and screens them for their exceptability, socially and economically with appropriate technology in the larger sense or what could be called "soft technology", and arriving at a cost comparison or an array of those that survived the various screens.

The first topic that I would like to discuss would be the demand for water and its related scale and lifestyle problems. This is shown in Figure 1 (in lecture workbook on page 122). Here, I have plotted the unit requirement for water in gallons/per capita/per day against the scale or the size of the operation or the lifestyle either one. In starting with a small scale and working to a larger scale; a small community working to a larger community, one can see that the unit requirement for water escalates. It isn't simply the same gallons/per capita/per day for a small community as it is for a larger one. The reason for this is we go from a small community to the larger there are more community or public services. The larger scale the unit use might range somewhere in the neighborhood of 150 gallons/per capita/per day; where as, in the smaller communities it might be only about 20% of this which would be 30 gallons per day/per capita. The idea being that there is included, just not the water being used domestically, but now water that is used for public services, flushings of streets, fountains, and things of this sort, and water that is used by industry that relies on the community for water; as well as, the water that is used commercially. On the other hand as one works on the low lifestyle standard to a high, one can see the smaller communities with the lower lifestyles, etc, and escalation to higher STL's. That is to say as the STL increases the unit use of water is greater, and so the population served for the same quantity of water is less, and this is one of the imputs into the model. Now there is a counter concern and that is if I could put a dotted line on this chart which would indicate the increase aridness obviously as we get to higher lifestyles and larger scales the amount may go down. Figure 2 relates to costs and delays and this is a very important issue too. Most of the water supplies or sewage systems (that we are discussing or will be discussing) relate to public concerns that is the model was designed for nucleated systems-period. In this case generally, these are done by private concerns on competitive bids. In the bidding procedure, the delays that are involved are not only in the bidding procedure but of other issues much as impact studies. Obviously as one delays the construction of something that has been designed the cost goes up mostly due to growth inflation and so it isn't infrequent that one finds that the engineer's cost estimate maybe by the time one gets the bids it maybe inadequate and requiring a complete revised design which is a further loss. So due to growth inflation one can expect increased costs. There's another delay which is particularly of importance in developing countries and that relates to the proposition that many of the developing countries would like nationwide programs of waste treatment or water treatment. These programs would do several at one time, and having aggregrate projects. When you get aggregrate projects, you begin to tie-up the construction industry and then the construction industry raises the price. And so I've tried to show you effective aggregrate projects which is of course detrimental in the sense that they also increase the costs. Another interesting Figure 3 (found on page 124) is the cost and their relationship to the STL. Now the costs are made up of equipment or capita costs and operation maintenance cost. I'm trying to indicate that one would start out in the lower technologies where the two costs might be equal or fifty-fifty in other words, and that as you increase the ratio might change and really what the Figure says is that in the higher technologies only 20 percent might be on O & M and 80 percent could be on equipment, and also that there is a considerable escalation in the total of course. On top of that, a relatively larger portion of this seems to be embedded in capital cost. In Figure 4 (on page 125) I've tried to show the problems associated with cost with particular reference to the idea of volunteerism. In volunteerism the key issue is that there is a point beyond which it's necessary to hire trained people to operate the facility but below that, the operation can be shared on a rational basis by the recipients. So up to a point say 3 to 500 people, in developing countries, we are able to operate on a volunteer basis. So the cost is the return on the capital investment up to that point. In Figure 5 (on page 126) as the lifestyle and the size both increase the total cost increases but not in direct proportion. In Figure 6 (on page 127) is a sketch that relates the relative cost by scale and components, finance, construction, and engineering. So with a breakdown of the costs in three parts, perhaps 10 percent for the engineer and 45 percent each for financing and construction. Now as it gets larger the relative amounts will change a little bit as you can see e.g. the relative imput of the engineer is less but at the same time his absolute amount could be about the same.

Second concern with the use of the model deals with sensitivity analysis. This is particularly of interest in the selection of goals and perhaps elements embedded in the goals. You may recall in the model itself the preformance goals that have been used are Coliform, BOD, and to some degree TDS. Also an indication one might use in developing countries are various levels of these elements. For example on Coliform in the United States or developed countries because of any contamination that occurs that is known to be dangerous we have established one to two most probable number of coli per hundred milliter sample for Coliform. The value may be 10 to 30 in the developing country. So there is a chance to articulate these and this can be done on the model. To stress this, one might look at Table I (on page 129) at the relationship between the socio-technological level (STL) and the test parameters, and their levels. I'm really saying that as society develops more you not only increase rigor of the level of a particular parameter but you may also add additional parameters. As I've noted here you might start out in a underdeveloped country with 30 most probable number Coliform and work you're way up to maybe 1 most probable number as you go from the underdeveloped to the developed areas. On the other hand if you just go from one developed area to a slightly more developed you might include hardness etc., and then if you continue because there are additional problems now associated with industrial contaminates you might include such things as metallic ions. Then when you get to highly developed countries TDS and temperature also become important. In Table II (on page 130) is a more detailed tabulation from the developing country to the developed and both in terms of water and sewage treatment process of the various kinds of tests that one might find necessary. So in the very underdeveloped situation Coliform and Turbidity are perfectly adequate, but then when you get up perhaps with the more sophisticated level the rapid sand filter on water you will still have Coliform, but now you are interested in pH and suspended solids, coagulants, and color, etc. This is also true with sewage treatment. There are many more processes that can be brought into this thing, but it's here primarily for purposes of illustration. So we have different tests that can be added and different goals within the tests themselves that one has to talk about.

Another area of importance is that that relates to systems reliability, these reliabilities can be sought by manipulating the computer inputs and outputs, and this is of particular interest because of the implication that it's just unnecessary (or fool-hardy) to computerize a rather simple model that can be "cranked out" by hand or with sever iterations on a hand programmable calculator. But on the other hand if you can make calculations quite rapidly as we've done on using the Apple II (our mini-computer) you can vary a great many of the different imputs and see the effect on the output. In other words by changing the goals as indicated earlier one might decide about a policy that requires a developing country to use 1 Coliform or a policy that means that we may have to include metallic ions for some reason. The impact then on the selection of the processes can be sought. In many instances because the selection of processes are incremental and not continuous this becomes a very interesting thing. That is to say in sewage treatment for example 30 percent reduction of BOD is accomplished by primary treatment and 85 percent by secondary. There's no in between unless you delibertly attempt to pass by a portion, where you go full treatment to only a fraction of the total, and blending it with untreated waste to give you the level you want. This would not be ordinarily done, but in a sense one can look at them and can modify goals and certainly in terms of the imput parameter. One that is of particular interest is of course the STL and it's just possible and has been noted before in our studies that when you jump in time 1980-1990 and on your way up there may be a jump do to another STL level, and this could have substantial impact on the selection of treatment processes.

As it has been noted earlier the delivery system consists of a whole group of things for water and the removal of wastewater, and not just treatment. The initial emphasis of the model was on treatment primarily because this lent itself to the largest perhaps gain by the selection of appropriate materials and processes; mostly processes because the appropriate processes minimize the O & M costs and certainly increase the reliability. Individual reliability studies have been made and been discussed elsewhere, but to refresh your memory one can look at the more sophisticated processes that are capital intensive that certainly are costing more, but also being subject to the whole societal breakdown in the transfer of technology. The question, of course, has arisen why not look at the whole delivery system of water. This is being undertaken at the present time by looking at the various alternatives that are available. The system can be described as seen on both drawings on Figure VII, and VIII (page 132 and 133) as being one that starts out with water supply and then the pump, an adequate or pipeline with storage then treatment, distribution, and collection. Then the sewage can be collected and disposed of by truck farming and returned for reuse discharge and/or treated. So the whole scheme of things should be looked at, and the relationship of each to the entire delivery system. There are many opportunities and possibilities. For example distribution systems need not supply water for.fire protection other techniques can be used. The distribution system need not be interlocked thus eliminating fittings, crosses, and tees. Other things that can make a cheaper system relate to many alternative materials. One could go to plastic. One concept that has been suggested in which you could get enough water for STL level is by using a ¼ inch plastic tube that could be hung right along with the electrical conduits. So if there is a "light bulb" in every home then there is a possibility of having pasteurized water in every home and a toilet.

Other systems could relate water and health care, water and education, water and transportation, etc., or water can be interrelated to the entire public delivery system. Once we have some way of defining the benefits from public water supply and the main thrust has been health benefit cost analysis or cost effectiveness analysis can be done through computerized manipulation of the model. As sort of as a final "rap-up" statement of these considerations and things that can be done in the management of the model, perhaps it might be well to suggest that it's educational potential rather than the cranking out of definitive numbers is perhaps the greatest at the present time, and particularly its use to demonstrate the value of selection of appropriate technology. The educational problems can lead to a way of thinking where one tends to think in terms of alternatives, goals, and aggregrate systems. Then the two can be put to greater use. To speculate on its use would be to suggest that a model be built that can be used in community after community as one begins to get more of the things that needs more simulation study with alternative goals, alternative materials, a strategies, and then the model itself can be used in two modes. One would be reactive and the other would be the proactive model. The proactive model would make studies and suggest treatment processes etc or a whole delivery system that might be useful to various cities and communities in an area. On the other hand the reactive mode would be when the cities themselves discover a need or interest and initiate a program so a proposed project can be checked out. Both of these modes are very useful and the whole scheme lends itself nicely to this consideration. The model is of a type that the type itself could be used on health delivery systems, or educational systems and any other of the things that are so vital to the planning function of the developing countries. Once it gets some reasonable use in the hands of the young people coming up through the indigenous educational systems it will probably find its way into more active numbers crunching and real field results.

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TECNOLOGIA APROPIADA PARA EL TRATAMIENTO DE AGUA Y AGUAS RESIDUALES

MODELO DE PRIORIDADES PARA ABASTECIMIENTO DE AGUA

DR. UBALDO BONILLA DOMINGUEZ

AGOSTO, 1980

MODELO DE PRIORIDADES PARA ABASTECIMIENTO DE AGUA.

DATOS GENERALES

- Objetivo: Determinar que poblados deben recibir agua y en que orden

- Jerarquias gubernamentales

  Nacional, Estatal, Municipal, ciudad ó Pueblo.

- Población

Urbana	Por grupos de edad	Tasas de crecimiento.
Rural		

- Aspectos relacionados con el abastecimiento de agua
  - Precipitación media anual
    Distribución regional Periodo de lluvias
  - Facilidades existentes
    - Población servida (urbana, rural)
    - Calidad y tipo de servicios. Fuentes.
  - Disposición de excreta
    - Tipo de servicios
    - Población servida
  - Salud Pública
    - Principales causas de morbilidad y mortalidad, tasas
    - Relaciones con el ambiente y servicios

- Programas existentes
  - Organización
  - Recursos
  - Objetivos
  - Avances
    - Demandas y dotaciones.
  - Procedimientos existentes de jerarquización o selección de poblados.
- Restricciones
  - Recursos económicos. Presupuesto
  - Costos de construcción, operación, etc. costos/cápita
  - Metas. Porcentajes por servir
    - crecimiento de población -
  - Recursos humanos. Estímulos
    - Programas de entrenamiento
- CRITERIOS
  - Criterios básicos
    - Necesidad
    - Potencial
    - Costos
    - Interés
    - Abastecimiento existente, calidad
    - Enfermedades existentes.
  - Poblados con instituciones educativas y buen nivel cultural son más aptas de participar en programas y recuperar inversiones.
  - Los nucleos más densamente poblados necesitan menor inversión per cápita.

- Economía y políticas
  - Decisión tipo "político"
  - Economía de escala — Jerarquiza primero a los pueblos más grandes
  - Inversión para el desarrollo (atracción de la industria, etc)
  - Redistribución del ingreso. Los poblados más desfavorecidos deberían ser considerados primero. choca con el punto de vista económico. Estos poblados muestran el menor interés
  - Economía en la construcción. Jerarquiza primero a los poblados que pueden ser servidos a menor costo.
- Encuesta sobre criterios (WHO, 1975)
  - Tamaño y densidad de población
  - Escaces de servicios
  - Desarrollo
  - Salud
  - Razones sociales
  - Demanda de la comunidad
  - Costo.

- MODELOS DE JERARQUIZACION
  - Programación lineal (1973, WHO)
  - Método pragmático (1973, WHO)
  - Modelo de Reid y Discenza (1975, O.U.)
  - Fórmula PAHO (1974, PAHO)
  - Método de Soetiman (1975, O.U.)

- METODO DE SOETIMAN

$$PI_j = \sum_{i=1}^{10} w_i S_{ij}$$

PI - índice de prioridad
w - peso de cada parámetro
S - valor de cada parámetro en cada poblado
i - orden del parámetro
j - orden del poblado

Datos → Filtrado → Pesado y valor → Procesado → Indices

Entradas

- Inf. general
- Población
- Enfermedades
- Sistema agua. Existente
- Fluctuaciones en capa freática
- Fuentes y capacidad
- Calidad del Agua
- Potencial económico
- Participación e interés
- Recursos humanos
- Lugares públicos
- Disposición de excreta
- Comunicaciones
- Energía eléctrica

Parámetros

- Enfermedades
- Dificultad en obtener agua
- Alternativas tecnológicas
- Población
- Interés y contribución
- Potencial
- Lugares públicos
- Método de disposición de excreta
- Comunicaciones. condición
- Suministro energía eléctrica

Matriz de escor	salidas
$W_1S_{11}+W_2S_{21}+\cdots+W_{10}S_{10.1}$	PI_1
$W_1S_{12}+W_2S_{22}+\cdots+W_{10}S_{10.2}$	PI_2
$\vdots$	$\vdots$
$W_1S_{1n}+W_2S_{2n}+\cdots+W_{10}S_{10.n}$	PI_n

Poblados → renglones

Parámetros → columnas

- PESO DE LOS PARAMETROS
  - Método de Delfos
    (Juicio de grupos de expertos)
    - Cuestionarios (10 parametros)
    - Distribución de 100 puntos entre los parámetros
    - Promedios de las puntos asignados por cada miembro

Enfermedades, 14.9; Dificultad en obtener agua, 14.4; ... Energía eléctrica, 4.4; Transporte, 3.5

- DATOS
  - Colección de datos
    - Organización gubernamental
    - Elaboración de cuestionarios
    - Aplicación
    - Concentración de resultados
  - Cuestionarios en poblados
    - Identificación, N° casas, N° gente
    - Croquis (fuentes, etc.)
    - Forma de obtener el agua y características. Fuentes.
    - Población servida
    - Calidad del agua
    - Distancia fuente - comunidad
    - Topografía. Nivel tabla freática
    - Actitud de la comunidad
    - Solución sugerida
    - Sumario.
  - Tabulación a nivel municipal
    - Identificación; N° de poblados; N° de familias; habitantes
    - Tablas de concentración para cada concepto en poblados

CONCENTRACION MUNICIPIO

Poblado	Sin proteccion										Con protección									
	Fuentes			Sistemas		Tuberias				Nº Usuarios	Fuentes				Sistemas		Tuberias			Nº Usuarios
	Manantial	Rio	Otros	Gravedad	Bombeo	F.G.	P.V.C	Asbesto	Otros		Manantial	Pozo	Rio, Tratada	Otros	Gravedad	Bombeo	F.G	P.V.C	Asbesto	
Totales.																				

Poblado	Nº de familias	Nº de habitantes
Totales		

- Tabulación a nivel estatal
  - Identificación. Nº de municipios; numero de poblados. Habitantes

- CATEGORIZACION DE PARAMETROS
  - Los parámetros se categorizan y se asigna un valor a cada categoria

Enfermedad	Recursos humanos	Energía
-1 presente	- Ingenieros	< 1.5 Kw
-2 presentes	- Técnicos	1.5 - 3.0
⋮	- Sanitaristas	⋮
-5 presentes	- Asistentes	> 5 Kw.
-Tifoidea		
-Ninguna.		

- VALORACION DE PARAMETROS

Enfermedad	Puntos (valor)
- Colera	5
- Gastroenteritis	4
- Tifoidea	3
- Tracoma	2
- Dermatosis	1
- Ninguna	0
	15 puntos ≈ 5 presentes

Energía	Puntos
< 5 kw	1
1.5 - 3.0	2
3.0 - 5.0	3
> 5.0	4

Ejemplo: Aplicado a 30 poblados

1 - Enfermedad: No se indicó ninguna en ningún poblado
puntos — 0

2 - Dificultad en obtener agua.

Poblado	Puntos
1- Podal	1
2 - Tengiwango	6
3 - Togowo	6
⋮	
30 - Ngawet	4

- Indices de prioridad

Poblado	$W_i S_{ij}$ Parámetro 1	2	3	. . .	10	PI
1- Podal	0	14	111	. . .		321
⋮						
10 - Toguis	0	115	42	. . .		330 ←
⋮						
30 Ngawet	0	58	111			285

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TECNOLOGIA APROPIADA PARA EL TRATAMIENTO DE AGUA Y AGUAS RESIDUALES

TRATAMIENTO DE AGUA POTABLE

M. en I Arnulfo Paz Sánchez

Agosto, 1980

TRATAMIENTO DE AGUA POTABLE

M.I. ARNULFO PAZ S.

1 9 8 0

C O N T E N I D O

I PROCESOS

1.- TRANSFERENCIA DE GASES.

a) Adición de :

oxígeno
ozono
cloro
dióxido de cloro
bióxido de carbono
amoníaco

b) Remoción de:

oxígeno
ácido sulfhídrico
substancias volátiles
bióxido de carbono

2.- TRANSFERENCIA DE SOLIDOS.

a) Cribado:

Rejillas
Tamices
Micro tamices

Para la remoción de:

Hojas, palos, peces, materia suspendida y algas.

b) Sedimentación.-

Simple y con coagulantes .

Remoción de materia suspendida sedimentable y flóculos.

c) Flotación.-

Usada en potabilización ocasionalmente para remoción de sólidos suspendidos empleando como agentes de flotación compuestos cuaternarios de amonio.

d) Filtración.-

La filtración es un proceso complejo que involucra dos acciones complementarias.

d1) Transporte de partículas por medio de :

Cribado, sedimentación, intercepción, difusión, impacto.

d2) Adherencia de partículas a los granos en la que intervienen:

las fuerzas de Van der Waals, fuerzas electrostáticas y puentes químicos de cadenas poliméricas

En los filtros lentos hay ademas transferiencia de nutrientes por contacto interfacial.

3.- TRANSFERENCIA DE IONES.

a) Coagulación química.

Para remoción de colóides.

b) Precipitación química.

Para remoción de substancias disueltas como fierro, manganeso, dureza , fluoruros.

c) Intercambio iónico.-

Para ablandamiento y desmineralización.

d) Adsorción.-

Para remoción de olores y sabores.

4.- ESTABILIZACION.

Para volver innocuas substancias disueltas en el agua, sin removerlas.

Ejemplos típicos son la adición de polifosfatos, la recarbonatación , la super cloración la decloración.

5.- PROCESOS ESPECIFICOS.

a) Desinfección.

Aniquilamiento de organismos patógenos por medio de cloro, ozono, radiaciones U.V., acción oligodinámica de metales.

b) Desalación.

De aguas salinas y salobres por :

Filtración iónica (electrodiálisis, ósmosis inversa y utrafiltración).

Destilación
Congelación
Intercambio iónico

c) Floruración.-

d) Adición de Sulfato de cobre.

6.- DISPOSICION DE SEDIMENTOS

Con motivo de los problemas de contaminación debidos a la descarga de sedimentos de plantas clarificadoras, ablandadoras y desferrizadoras, se necesitan procesos para su adecuada disposición.

Fundamentalmente son procesos para secado y recuperación de productos químicos.

II SISTEMAS

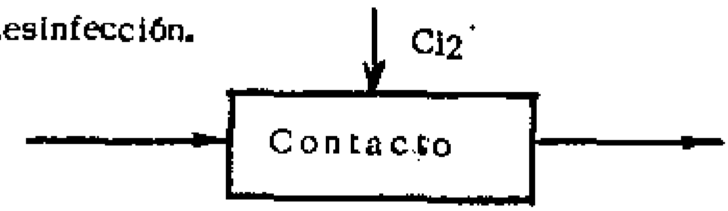
La secuencia de procesos conduce a los sistemas de Potabilización.

La elección de los procesos que constituyen un sistema depende de :

Calidad del agua cruda
Calidad del agua tratada (Normas de Calidad)
Costo del tratamiento.

Los tipos de sistemas mas comunes son:

1.- Plantas de desinfección.



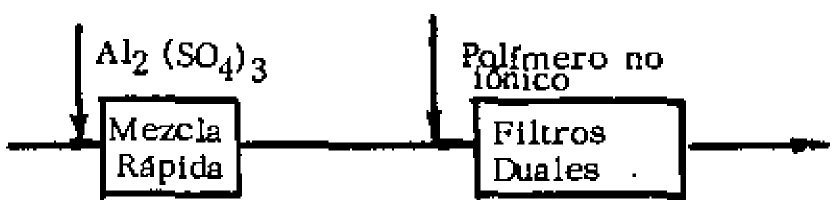
2.- Plantas de clarificación.

a) Por filtración lenta.

b) Por filtración rápida convencional

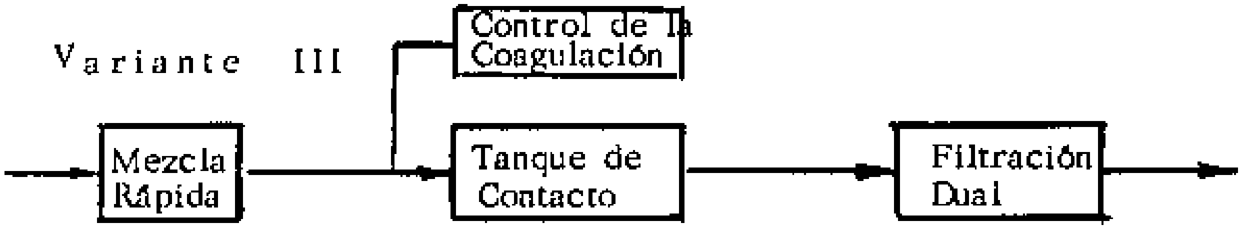
c) Por filtración rápida directa.

Variante I



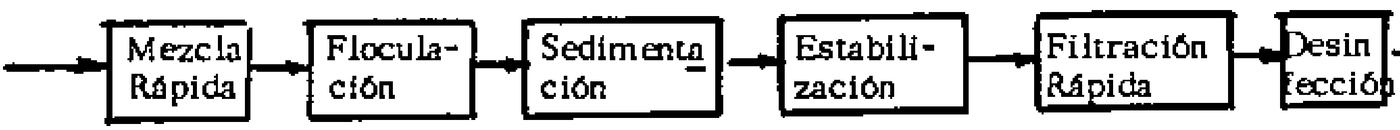
Variante II

Variante III



3.- Plantas de ablandamiento.

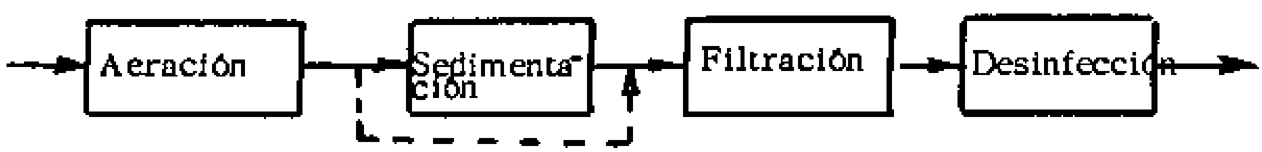
a) Por precipitación química.



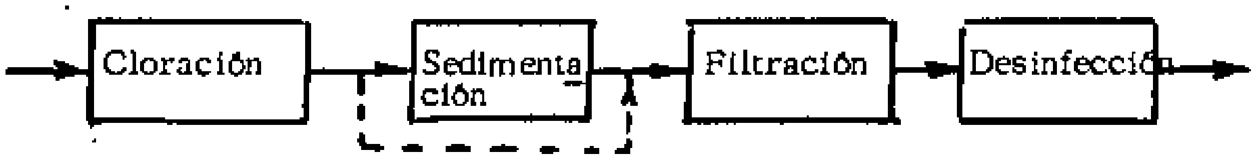
b) Por intercambio iónico.

4.- Plantas desferrizadoras.

Variante I



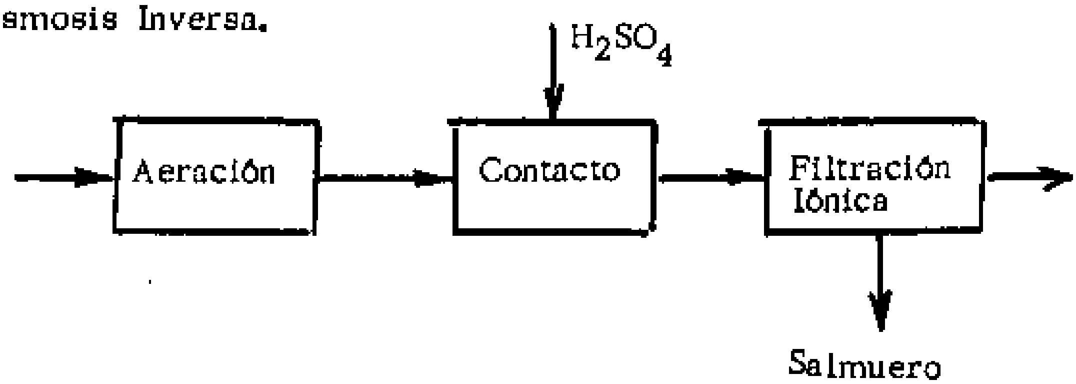
Variante II



5.- Plantas desaladoras.

a) Por filtración iónica

a1) Osmosis Inversa.



a2) Electrodiálisis

b) Por destilación

c) Por congelación

6.- Adiciones Comunes.

Los procesos mas usuales que se incluyen a los sistemas antes señalados son:
Adsorción, utilizando carbón activado.
Estabilización, empleando polifosfatos.

El uso de las Unidades de contacto de sólidos.

Como una de las herramientas más importantes para los sistemas de clarificación y ablandamiento está el uso de las unidades de contacto de sólidos, cuyas ventajas pueden conducir, en donde sean aplicables, a diseños económicos y más eficientes.

El avance tecnológico y la simplificación de operación y equipos.

Se destaca el cambio de orientación en el diseño de Planta Potabilizadoras a partir de la decada de los sesenta, empleando mayor soporte científico y aprovechando nuevos equipos, materiales y productos químicos.

III EFICIENCIAS.

Remoción o Control de	Aeración	Sedimentación con coagulantes	Ablandamiento por precipitación	Filtración Lenta	Filtración Rápida	Desinfección (cloración)
Turbiedad	0	+ + +	(+ +)(1)	++++(2)	++++	0
Color	0	+ + +	0	+ +	++++	0
Olores y Sabores	++(3)	(+)	(++) (1)	+ +	+ +	++++(4) - - (5)
Dureza	+	(- -)(6)	++++(10)	0	(- -)(6)	0
Corrosión	+++(7) ---(8)	(- -)(9)		0	(- -)(9)	0
Fierro y Manganeso	+++	+ (11)	(+ +)	----(11)	++++(11)	0
Bacterias	0	+ +	(+ + +)(12)	----	++++	++++

NOTAS.

El signo + y - representan grado relativo de eficiencia de los sistemas.

El parentesis indica un efecto indirecto.

(1) Por inclusión en el precipitado.

(2) Pero los filtros se colmatan muy rapidamente a turbiedades mayores de 60 UTN.

(3) No incluyen sabores a clorofenol

(4) Cuando se emplea cloración al. punto de quiebra o supercloración y decloración.

(5) Cuando no se emplea (4) en la presencia de olores intensos.

(6) Algunos coagulantes convierten carbonatos en sulfatos.

(7) Por remoción de CO_2

(8) Por adición de oxígeno

(9) Algunos coagulantes liberan CO_2

(10) Variable, algunos metales son atacados a pH alto

(11) Despues de aeración

(12) Cuando se produce muy alto pH por exceso de cal.

IV COSTO DE EQUIPOS

IV.1 Criterios para la Estimación de Costos.

Se acepta generalmente que la producción de agua se caracteriza por economías de escala.

El departamento de tratamiento de Aguas del Estado de Illinois (Ref. Journal AWWA Mayo 1975) ha realizado un estudio de economía de escala en la producción de agua tratada.

Basados en el análisis de 42 plantas, se estimó que la relación entre el costo de la Planta de Tratamiento y su capacidad es:

$$Y = 22.66\ K^{0.65}$$

en donde:

Y = costo total de la planta de tratamiento (miles de pesos).

K = capacidad de la planta (m3/día).

Esta ecuación debe afectarse de un coeficiente que la adapte a los costos que se obtienen en el país, -- que en forma aproximada son el orden del 50 al 75 % -

de los que se obtienen en Estados Unidos para este tipo de instalaciones.

En el estudio de referencia se recomienda no incrementar indefinidamente las economías de escala, por lo cual se redujo gráficamente la tendencia, prolongando tangencialmente la curva en el costo de una planta de 2 m^3/s, que es el tamaño máximo recomendado para usar la ecuación anterior.

Se trazó también la recta de valores medios entre la tangente y la recta de valores que no toma en cuenta la economía de escala con objeto de obtener, en esta etapa, una serie de valores "bajos" y otra de valores "altos". Esto se puede observar en la gráfica anexa.

Se utiliza también el criterio de Fair, Geyer y Okun que dice: "Los costos de construcción de plantas de filtración se aproximan a $ 826,000 por cada 1 000 m^3/día de capacidad de planta, variando aproximadamente con:

$$1.55 \; Q^{2/3}$$

siendo Q la capacidad nominal (miles m^3/día)"

En virtud de la sugestión de utilizar plantas con la tecnología más moderna se empleó también la gráfica de la Environmental Protection Agency (EPA), relativa al costo de instalaciones con el uso de filtros de diseños actualizados. Este criterio indica:

"En términos generales los procesos de remoción de sólidos suspendidos tienen una economía de escala. Es decir, las unidades de capacidades mayores producen menores costos de tratamiento por unidad de volúmenes de agua tratada. Esto se debe principalmente a dos factores:

a) Costos reducidos de capital por unidad de volumen.
b) Costos decrecientes de operación debido a un empleo más eficiente del terreno, personal y tiempo".

Es pertinente aclarar que el uso de los criterios anteriores se hizó necesario en esta etapa del estudio, en virtud de la carencia absoluta de datos actualizados de costos de plantas existentes en el país y sólo para fines de la modulación.

IV.2 Actualización de costos de plantas de tratamiento al 1er. Semestre de 1977.

Los costos se pueden dividir en:

1.- Obra Civil 70 %

2.- Equipos 30 %

Los factores de actualización son:

1.- Obra Civil: 1.45 del 1er. Semestre de 1976 al 1er Semestre de 1977.

2.- Equipos: 1.8 del 1er. Semestre de 1976 al 1er Semestre de 1977.

Por lo tanto el Factor Global será:

Obra Civil:	1.45 x 0.70 = 1.015
Equipos:	1.80 x 0.30 = 0.540
	Factor Global = 1.555

IV. 3. Valores corregidos para el trazo de la gráfica según el criterio del Departamento de Tratamiento de Aguas de Illinois.

COSTOS APROXIMADOS EN MEXICO
(INDICE: 1er. Semestre de 1977)

(Miles de Pesos)

GASTO NOMINAL	VALORES BAJOS	VALORES ALTOS	VALORES SIN ECONOMIA DE ESCALA
1 m3/seg	63 000	-	50 000
2 m3/seg	-	100 000	-
4 m3/seg	-	180 000	-
6 m3/seg	-	-	300 000
8 m3/seg	300 000	345 000	

IV. 4. Valores corregidos para el trazo de la gráfica según el criterio de la Enviromental Protection Agency.

COSTOS APROXIMADOS EN MEXICO
(INDICE: 1er. Semestre de 1977)

(Miles de Pesos)

GASTO NOMINAL	VALORES CORREGIDOS
0.3 m3/seg	6.2
30.0 m3/seg	466.5

IV. 5 : Corrección del factor en la ecuación de Fair, Geyer y Okun.

El factor considerado inicialmente fué de -- 1.99. Por tanto el actual será:

$$1.99 \times 1.555 = 3.09$$

Y la ecuación general se modifica como sigue:

$$\frac{1.55\ Q^{0.667} \times 826\ 000 \times 3.09}{1 \times 10^{6}} = 3.956\ Q^{0.667}$$

IV. 6 . Elección de capacidades para la modulación - de una Planta de 22 m3/seg.

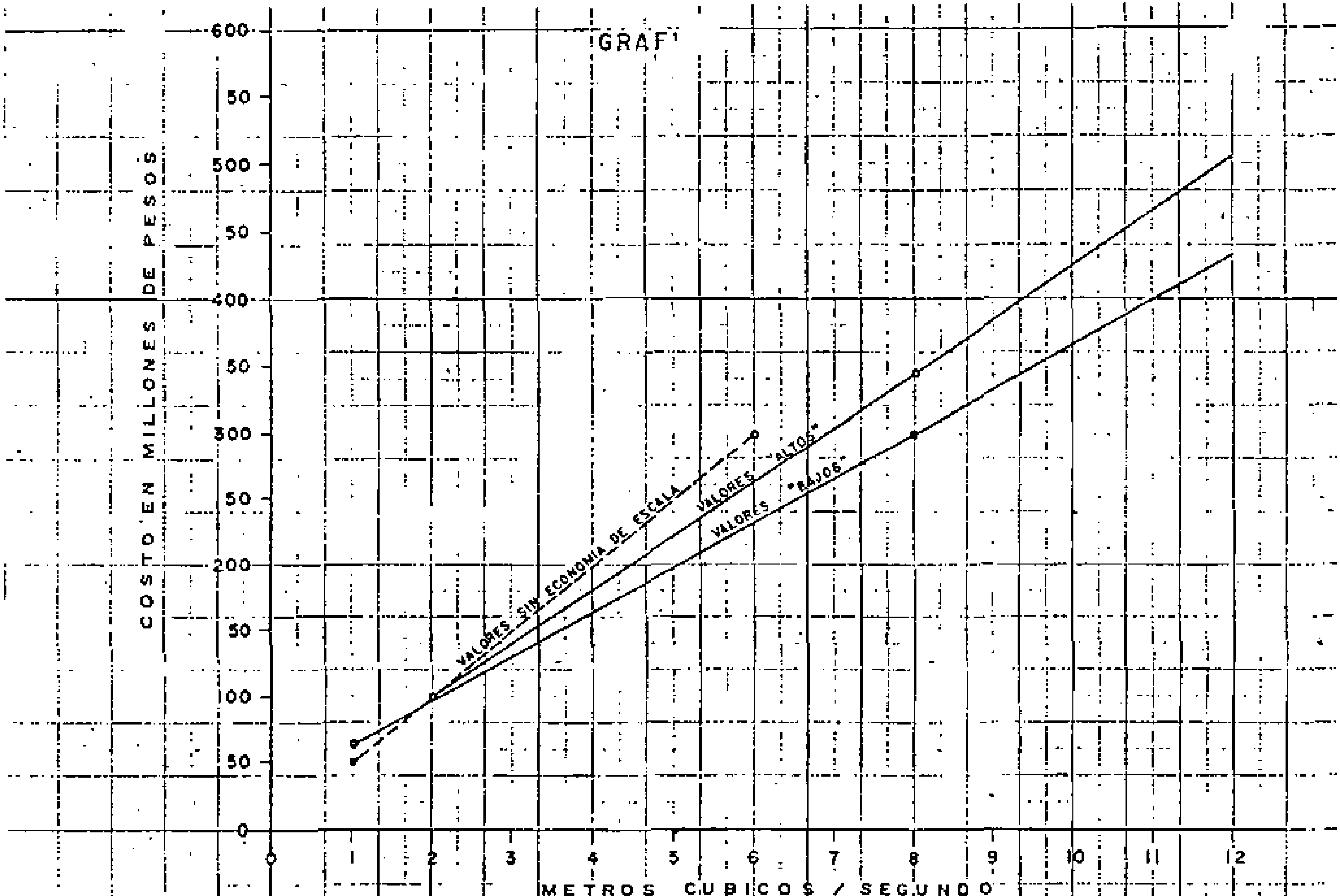
1a. ETAPA: Planta de 12 m3/seg.

6 unidades de 2 m3/seg
4 unidades de 3 m3/seg
3 unidades de 4 m3/seg
2 unidades de 6 m3/seg

2a. ETAPA: Planta de 10 m3/seg.

5 unidades de 2 m3/seg
2 unidades de 5 m3/seg.

Los costos de la 1a. ETAPA, utilizando los criterios expuestos arriba se indican en la tabla siguiente:



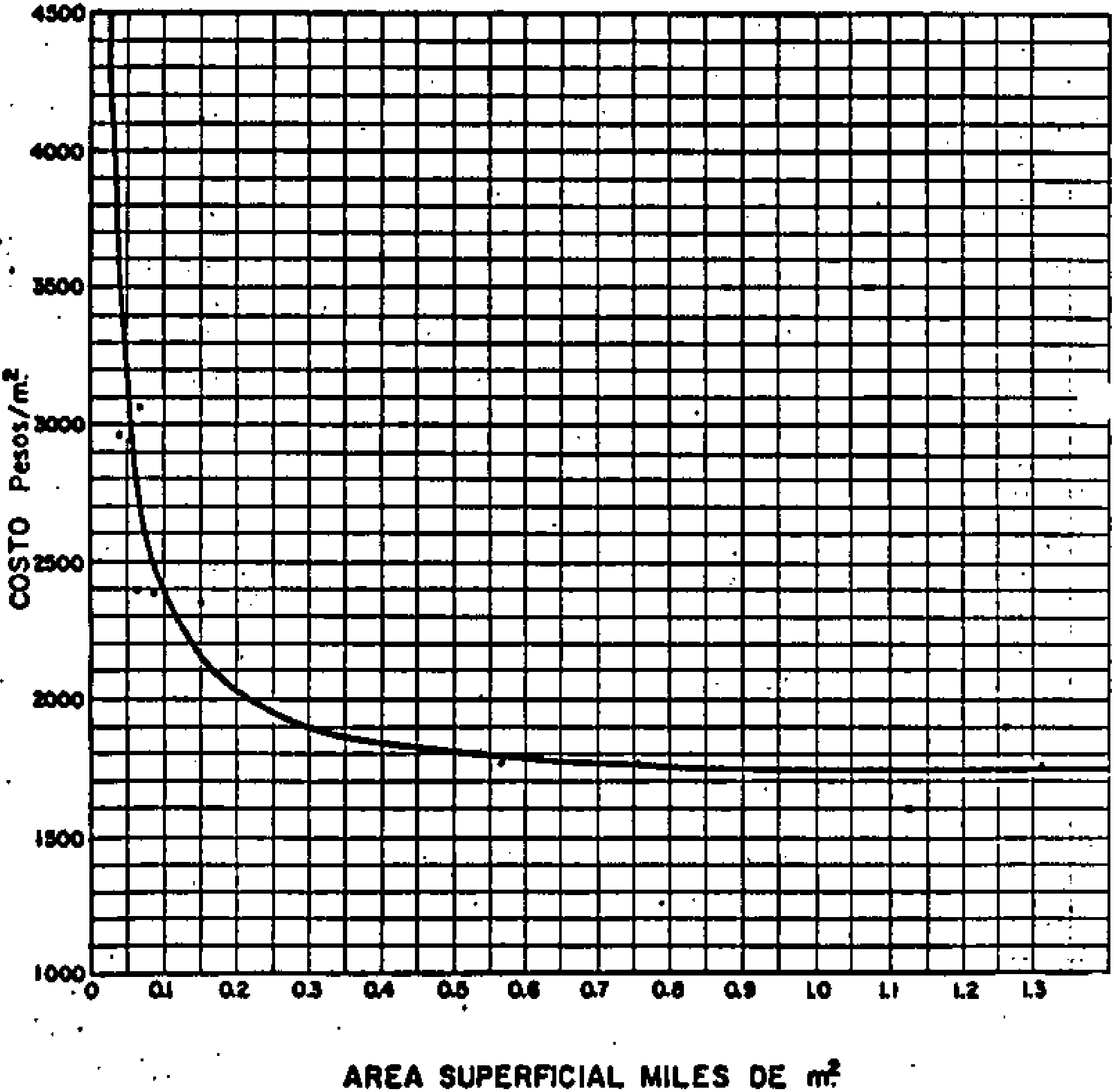
COSTO DE INVERSION DE LAS PLANTAS DE TRATAMIENTO DE AGUAS.

FUENTE: DEPTO. DE TRATAMIENTO DE AGUAS DE ILLINOIS

INDICE 1er. semestre 1977

GRAFICA 6-IX-13

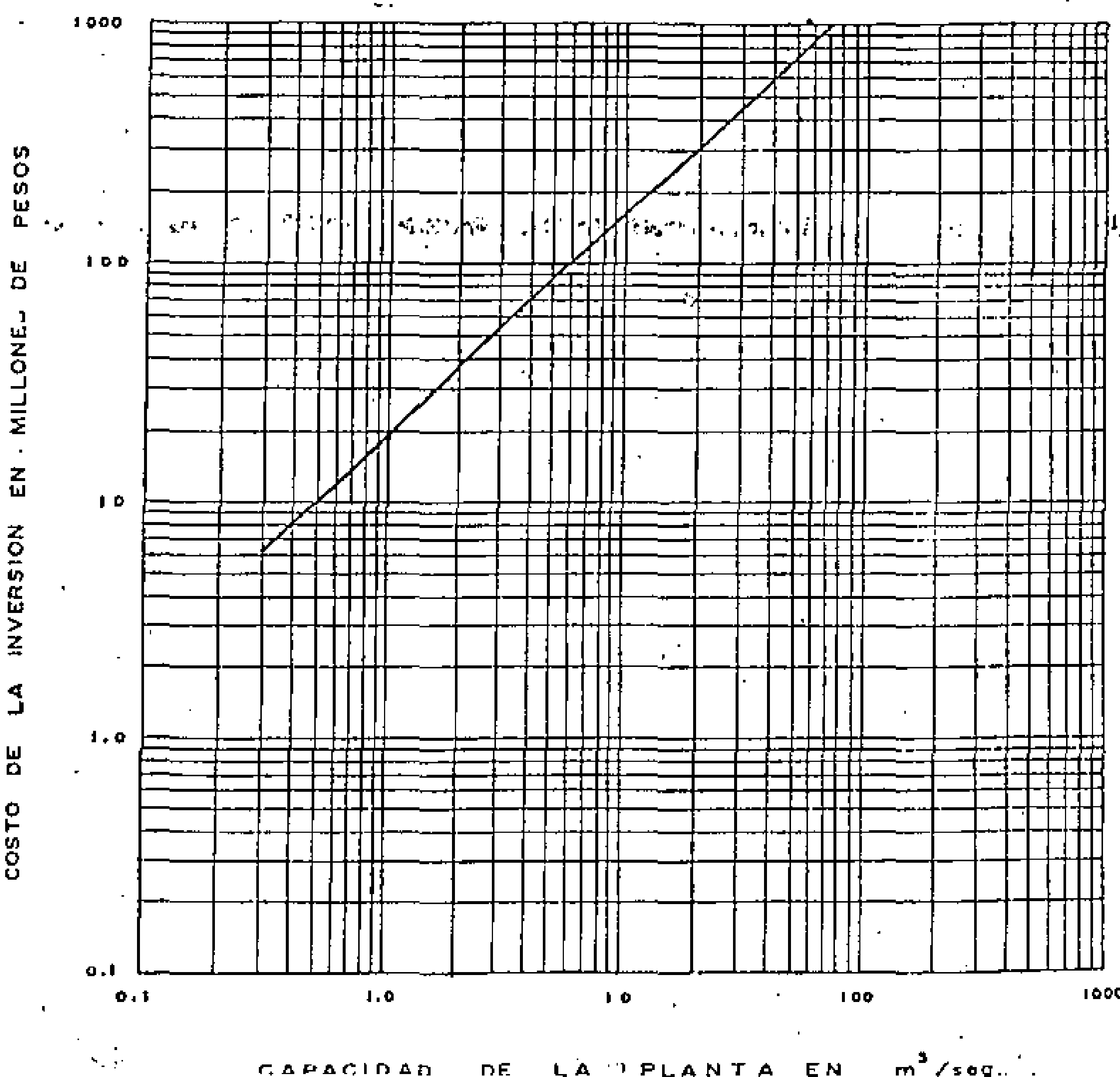
COSTO DE SEDIMENTADORES



GRAFICA

COSTO DE INVERSION DE FILTROS DE MEDIOS MEZCLADOS

FUENTE: ENVIROMENTAL PROTECTION AGENCY (INDICE 1er. semestre 1977).



factors must be considered to the greatest extent possible when preparing a preliminary cost estimate for the pipeline project.

ESTIMATING COSTS OF WATER TREATMENT PLANTS

This section contains construction cost information on water treatment plants designed by Montgomery Engineers. In addition, three plants designed by the Metropolitan Water District of Southern California (MWD) are also listed. The water treatment plant construction costs were adjusted to exclude costs of the following items: land, rights-of-way, raw-water reservoirs, treated-water reservoirs, intake pumping stations, and treated-water pumping stations. These items were excluded from the total actual construction costs to focus on the costs for the portion of the plant directly associated with the water treatment operations, which usually includes operations and administration buildings.

A summary of the adjusted water treatment plant costs is contained in Table VII. Construction cost curves are shown in Figure 8. Although the curves do not show separate costs for major treatment plant components, the construction costs for average conditions can be apportioned as follows:

• Earthwork, general site work and yard piping	15-20%
• Sedimentation and flocculation basins.	20-30%
• Filters and appurtenant system, including wash water tank, pumps and wash water reclamation facilities	20-35%
• Operations and administration building	10-25%
• Electrical and telemetry	10-20%
• Miscellaneous chemical tanks, small structures	10-15%

In determining the above figures, two items normally included in a treatment plant complex were not included because of their highly variable costs: (a) raw water pumping station and high service pumping station, and (b) clear well.

It is to be noted that the cost of pumping stations and clear wells are not included in the cost data tabulated in Table VII and shown in Figure 8.

Conventional Water Treatment Plants

Conventional water treatment plants are defined as full treatment facilities involving flocculation, sedimentation and filtration unit processes. The construction cost curve for conventional plants includes the following plants (refer to Index numbers shown in Table VII): 4, 6, 7, 8, 10, 11, 12, 14, 15, 16, 20, 21, 22, 23, 24, 25, 26, 28, 29 and 31. The cost of

Table VII. Water Treatment Plant Costs

Index No.	Owner	Plant	Maximum Hydraulic Capacity Used as Basis for Unit Cost (mgd)	Construction Cost per mgd of Maximum Hydraulic Capacity for ENR-LA=2500 ($/mgd)	Adjusted Const. Cost for ENR-LA=2500 ($)	Remarks
1	Alameda County Water District	Manual J. Bernardo Water Soft. Plant	18.4	114,000	2,100,000	
2	Azusa Valley Water Co.	Water Filtration Plant	7.5	94,000	704,000	
3	Chino Basin Municipal Water District	Carl B. Masingale Reg. Tertiary Treatment Plant No. 1	20	127,000	2,540,000	
4	Contra Costa County Water District	Ralph D. Bollman Water Treatment Plant	80	116,000	9,280,000	
5	Covina Irrigating Co.	Water Treatment Plant	15	86,000	1,280,000	
6	City of Escondido-Vista Irrigation District	Joint Water Treatment Plant	37.5	224,000	8,400,000	
7	City of Fairfield	Waterman Treatment Plant	15	293,000	4,400,000	
8	Helix Water District	R. M. Levy Filtration Plant (initial)	50	129,000	6,430,000	
9	Helix Water District	R. M. Levy Filtration Plant (expansion)	67	43,000	2,870,000	
10	Helix Water District	R. M. Levy Filtration Plant (composite)	67	139,000	9,300,000	
11	MWD of Southern California	Weymouth Softening & Filtration Plant (composite)	600	138,000	83,000,000	$56,000,000 without softening
2	MWD of Southern California	Diemer Filtration Plant (initial)	400	87,000	34,850,000	
	MWD of Southern California	Diemer Filtration Plant (expansion)	400	63,000	25,000,000	
14	MWD of Southern California	Diemer Filtration Plant (composite)	800	75,000	60,000,000	
15	MWD of Southern California	Jensen Filtration Plant	550	95,000	52,000,000	
16	MWD of Southern California	Skinner Filtration Plant	150	125,000	18,700,000	
17	City of Ontario	Water Purification Plant	7	86,000	603,000	
18	City of Pasadena	John L. Beyner Water Treatment Plant	7.5	186,000	1,390,000	
19	City of Pomona	Canyon Filter Plant	5	109,000	544,000	
20	City of Sacramento	Riverside Water Treatment Plant	20	208,000	4,150,000	
21	City of Sacramento	American River Water Treatment Plant	72	201,000	14,460,000	
22	City of San Diego	Alvarado Water Treatment Plant	100	204,000	20,400,000	$17,340,000 without softening
23	City of San Diego	Miramar Water Filtration Plant	75	121,000	9,070,000	
24	San Dieguito Irrigation District-Santa Fe Irrigation District	Joint Filtration Plant	27	189,000	5,100,000	
25	San Francisco, City & County of	San Andreas Water Filtration Plant	80	155,000	12,370,000	
26	San Francisco, City & County of	Sunol Valley Water Filt. Plant (initial)	80	118,000	9,470,000	

Table VII. Continued

Index No.	Owner	Plant	Maximum Hydraulic Capacity Used as Basis for Unit Cost (mgd)	Construction Cost per mgd of Maximum Hydraulic Capacity for ENR-LA=2500 ($/mgd)	Adjusted Const. Cost for ENR-LA=2500 ($)	Remarks
27	San Francisco, City & County of	Sunol Valley Water Filt. Plant (expansion)	80	71,000	5,660,000	
28	San Francisco, City & County of	Sunol Valley Water Filt. Plant (composite)	160	95,000	15,130,000	
29	City of Santa Barbara	William B. Cater Filtration Plant	15	209,000	3,140,000	
30	City of Santa Monica	Arcadia Water Softening Plant	7.3	123,000	900,000	
31	Stockton-East Water District	Stockton-East Water Treatment Plant	30	239,000	7,170,000	

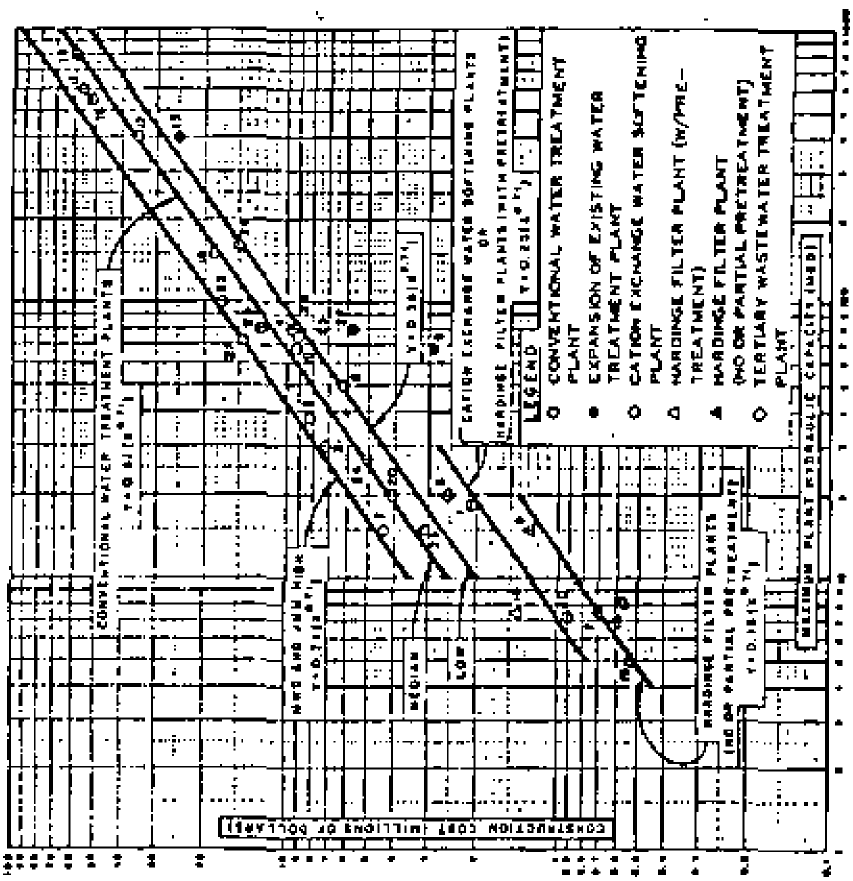


Figure 8. Construction costs of water treatment plants. (ENR-LA = 2500)

the initial Helix Water District plant (8) is included under conventional plants even though the initial construction did not include cost of the sedimentation basins. The costs for cation exchange softening were subtracted from the total costs for the MWD Weymouth plant (11) and the San Diego Alvarado plant (22). The data for conventional water treatment plants were curve-fitted with the resulting best-fit equation:

$$Y = 0.51 (X^{0.71}) \quad (1)$$

where

Y = construction cost (million dollars)

X = maximum plant hydraulic capacity (mgd)

V.- OPERACION

Los problemas de operación de las Plantas Potabilizadoras en - - México se deben a los siguientes factores:

1.- DEFICIENTE DISEÑO

2.- MALA OPERACION

3.- FALTA DE MANTENIMIENTO DE LOS EQUIPOS

4.- EN ALGUNOS CASOS A LA CALIDAD DE LOS PRODUCTOS QUIMICOS.

5.- INSTALACION DE EQUIPOS CON BAJO CONTROL DE CALIDAD.

Los dos primeros son los más importantes.

El diseño deficiente de las instalaciones se debe a :

a) FALTA DE CARACTERIZACION DEL AGUA CRUDA

b) FALTA DE PRUEBAS DE COAGULACION

c) EMPLEO DE TECNICAS OBSOLETAS

d) DESCONOCIMIENTO DE LA TECNOLOGIA MODERNA

Por otra parte los diseños contemplan una medición sofisticada - inoperante en el Pais, o bien no tienen medición adecuada.

En general no se usan polielectrolitos en la coagulación y la mezcla-rápida no se evalua debidamente.

No se cuida la equi-repartición del flujo y se calcula con poco cuida-do la secuencia hidráulica de los procesos.

Existe un monopolio que aplica la misma técnica, con los mismos - - parámetros en todos los diseños.

La mala operación se debe principalmente a la improvisación y falta -

de selección de personal capacitado.

Deberían establecerse en las Universidades del país cursos de Operadores de Plantas, a diferentes niveles y las Dependencias encargadas de la operación de Plantas, exigir como requisito la adecuada preparación de los operadores, dando facilidades y estableciendo estímulos económicos.

Otro aspecto que se descuida en la operación es el valor del Laboratorio en la evaluación del funcionamiento y ayuda para fijar dosificaciones y resolver problemas operativos.

Los problemas principales de operación son la falta de control de la dosificación, mezcla inadecuada y en los filtros el lavado sin la técnica apropiada y carreras demasiado largas que propician cargas negativas y paso de fóculo.

Es importante destacar la falta de actualización de las NORMAS DE CALIDAD de nuestro país y el desconocimiento de aspectos tan importantes como la formación de trihalometanos con la cloración de aguas con contenido orgánico.

Además se destaca la importancia de exigir la fabricación de equipos con mayor control de calidad.

Se sugiere como indispensable, una evaluación realista de las condiciones y operación de las plantas potabilizadoras para eliminar prácticas y equipos defectuosos en los nuevos diseños y poder establecer un plan integral, a nivel nacional, de rehabilitación de las instalaciones y preparación del personal.

Finalmente se considera de vital importancia elaborar un inventario cuidadoso de las facilidades de equipos y accesorios con que se cuenta en México, así como de los de fácil importación, destacando las instalaciones en donde se ha usado, características técnicas y precio para un determinado Indice de Costos.

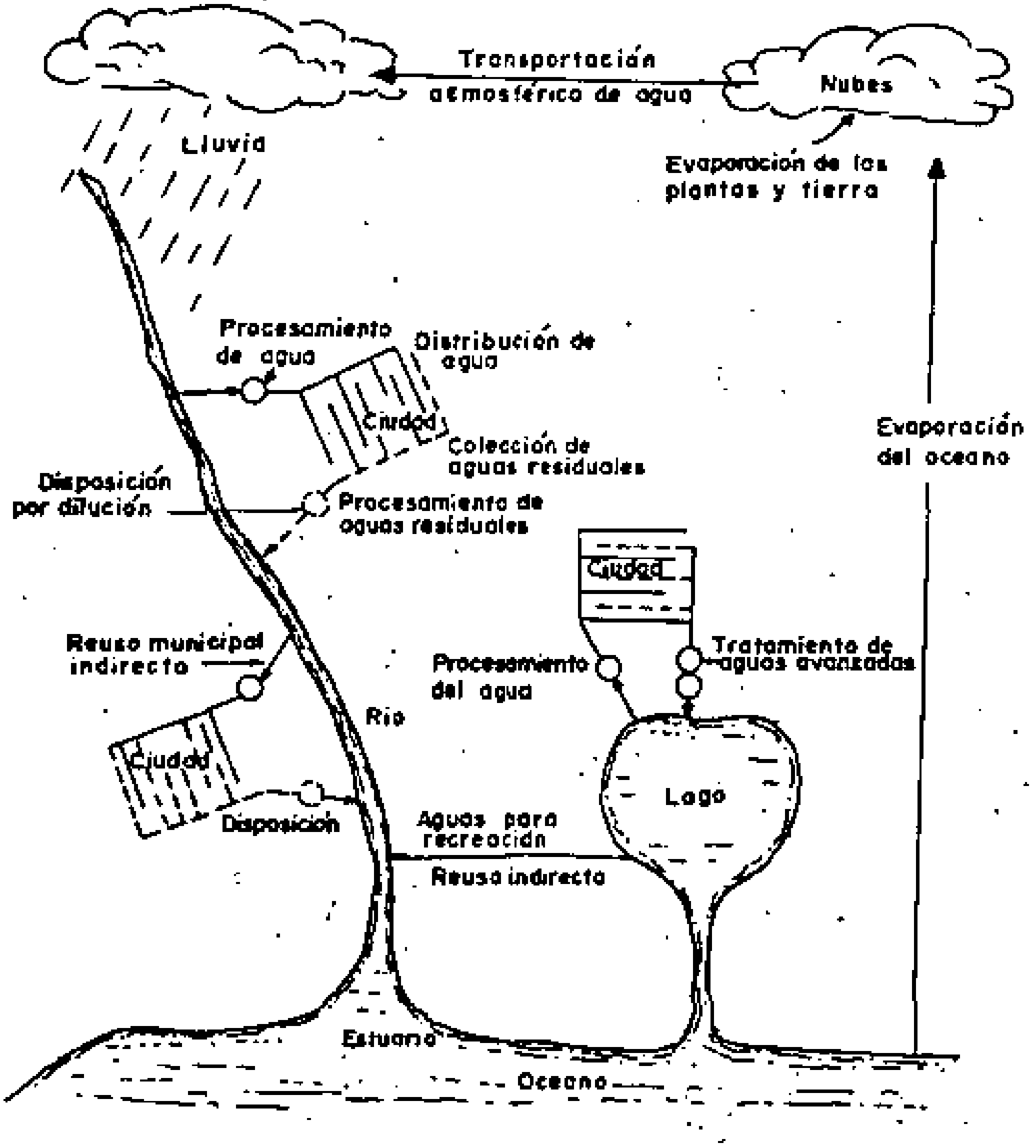


Figura 1

UBICACION DE LAS PLANTAS
POTABILIZADORAS EN EL
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TECNOLOGIA APROPIADA PARA EL TRATAMIENTO DE AGUA Y AGUAS RESIDUALES

LA POTABILIZACION DEL AGUA PARA SERVICIO MUNICIPAL EN LA REPUBLICA MEXICANA

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AGOSTO,1980

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LA POTABILIZACION DEL AGUA PARA SERVICIO MUNICIPAL EN LA REPUBLICA MEXICANA.

En su mayoría las plantas potabilizadoras en la República Mexicana, son copias modificadas o patentes de las que se usan en países más industrializados. Esto se debe a que el gran desarrollo comercial de estos países, impulsa el uso de equipos fabricados por ellos, los cuales exportan conjuntamente con la tecnología que los origina.

Esta situación se ha mantenido inmodificable hasta el presente. Hay que tener en cuenta, no obstante, que una instalación industrial (una planta potabilizadora se considera como tal) no puede operar correctamente, si necesita para su funcionamiento de un nivel tecnológico más elevado del que posee el país donde se construye.

Lo anterior es tanto más cierto cuanto mayor sea el número de trabas impuestas a la importación, tanto de personal como de equipos y piezas de repuesto.

Esta situación se hace aun más crítica en la industria del agua, la cual frente a las apremiantes necesidades de los países en vías de desarrollo, viene a ser una industria debil, trabajosamente soportada por el Estado y con una angustiosa carencia de fondos en la mayoría de los casos.

Es de tomar en cuenta, que no pocas veces las patentes que construyen este tipo de plantas, proporcionan a los operadores locales solamente los conocimientos indispensables como para que controlen su funcionamiento rutinario de las plantas potabilizadoras, sin suministrar mayor información sobre sus principios básicos de diseño por lo que no benefician el nivel tecnológico nacional.

Cualquiera que sea la situación, el problema rádica en las comunicaciones. Muchas veces las plantas de tratamiento de agua se construyen en lugares distantes, de las grandes ciudades donde se encuentran más facilmente las partes de repuesto o el personal capacitado para alguna reparación.

Esto ha producido un serio problema entre el desarrollo tecnológico que originó las ideas básicas del diseño del equipo y el desarrollo tecnológico del país comprador, que tiene que crear la capacitación para la operación y mantenimiento de dichas instalaciones.

Otro de los grandes problemas en la potabilización en México, son debidos a la fálta de operación y mantenimiento en los sistemas de agua potable y alcantarillados, aunados a problemas socio-políticos que estas obras siempre han padecido.

Entre los problemas que se presentan podemos mensionar a continuación algunos.

Inadecuados programas de mantinimiento preventivo y correctivo en las instalaciones electromécanicas.

Desconocimiento de los encargados de las instalaciones de potabilización, de los conceptos básicos conque fueron diseñados en los aspectos electromécanicos, físico-químico, hidráulicos que finalmente proporcionan las direnciones de la obra civil.

Muchas veces no se encuentran las refacciones de servicio a la mano y hasta cierto tipo de reactivos.

Falta de recursos económicos para sufragar los gastos necesarios.

Todo lo anterior hace pensar, que en nuestro país hace falta poner más atención al manejo de la calidad del agua, a la operación y mantenimiento de las obras de abastecimiento de agua y del saneamiento.

Por supuesto que no todo es negativo, pues contamos con algunas instalaciones a las cuales se les ha puesto la atención debida, pues están prestando el servicio de acuerdo para lo que fueron proyectadas y construidas.

Entre ellas podemos mencionar Monterrey, Mochis, Morelia y algunos pocas mas.

Asimismo se han hecho intentos por crear tipos de plantas económicas del tipo convencional,con diseños de ingenieros mexicanos.

Estos técnicos se dieron cuenta que existían en nuestro país,un gran número de poblaciones que se abastecen con aguas superficiales de ríos, lagunas, canales de riego,cuyas características de turbiedad, color y sobre todo bacteriológicas se encuentran fuera de los límites de norma que marca el Reglamento Federal sobre Aprovisionamiento de Agua Potable.

Sobre todo,muchas de estas poblaciones son de escasos recursos económicos y humanos calificados, por lo que se descartaba la posibilidad de construir plantas potabilizadoras muy sofísticadas electro mecanicamente, ya que no estarían en condiciones de pagar la inversión y la adecuada operación y mantenimiento.

Breve descripción de las unidades clarificadoras. La descripción se hará siguiendo el flujo del agua desde la fuente de abastecimiento hasta el tanque de aguas claras.

Estas unidades se construirán para clarificar (30 l p s), y se recomienda un máximo de dos trabajando en paralelo.

La localización se hará a una cota superior al nivel del agua máximo registrado, no es necesario que sea inmediata a la captación, ya que esta deberá supeditarse también al funcionamiento desde el punto de vista de operación y mantenimiento. Sin embargo, en algunos casos los sitios de localización se verán obligados cuando se trata de aprovechar obras existentes.

Las obras principales que constituyen esta planta potabilizadora son:

1.- Dosificador de cal en suspensión.
2.- Dosificador de sulfato de aluminios en solución.
3.- Mezclador rápido.
4.- Floculador
5.- Sedimentador.

El dosificador de cal será un tinaco de asbesto - cemento de 1 100 lts. el cual tiene un área aproximada de un metro cuadrado que facilitará el manejo de la dosificación.

Dentro del tinaco, para mantener la cal en suspensión se instala un motor de un $1/4$ de caballo con su flecha y una élice de 4 cm .

casi en el fondo.

También contiene una maya protectora al flotador para evitar interferencias al dosificador de gasto constante (ver fig. I).

El dosificador de sulfato de alomino es igual que el anterior con esepción de que no necesitá agitador.

Mezclador rápido. Es un tanque de concreto de sección cuadrada de 1.55 m. de lado por 2.50 m. de altura y bordo libre de 0.25 m. que da un volumen de 6.00 m^3 y tiempo de retención de 3 minutos tiempo suficiente para una mezcla adecuada (ver figura 2).

Floculador.- Este tanque también se contruye de concreto de sección cuadrada de 2.85 m. de lado y de 3.35 de altura con bordo libre de 0.30 m. tiene un volumen 27.1 m^3 con un tiempo de retención de 15 minutos aproximademente (ver fig. 3).

Sedimentador.- En esta unidad es donde verdaderamente está la inovación, es un tanque de forma piramidal truncada invertida, de base rectegular de concreto ormado. Su diseño se pensó considerando la facilidad de contrucción y teniendo en cuenta que los taludes de sus muros descansen en la excavación en que se aloje sin resibir empujes.

Las dimenciones de esta estructura son de 18.45 de largo por 12.45 m. de ancho y una profundidad máxima de 4.27m. su volumen total es de 254.13 m^3 con una tolva para todos de 37.85 m^3. tiempo de retención de 2 horas (ver fig. 4).

Concluciones y Recomendaciones.

a) Concluciones:

1.- Se necesitan en nuestro país plantas potabilizadores que esten acorde con tecnología y economía de nuestros sistemas de agua potable.

2.- Existen en nuestro país muchas poblaciones que toman aguas superficiales fuera de las normas físicas y bactereológicas, que pueden potabilizarse con unidades económicas y facil de operarse.

3.- Faltan en nuestro país profesionistas y técnicos sobre tratamiento de agua y los que existen no se les da la oportunidad de trabajar en esa actividad.

4.- En los sistemas de agua potable y saneamiento, los encargados de su administración no le dan la misma importancia al concepto calidad como a la cantidad.

b) Recomendaciones:

1.- En sistemas de abastecimiento de agua superficial a las poblaciones, proyectar y construir plantas potabilizadoras de acuerdo a la realidad técnica y económica de las mismas.

2.- Proyectar y construir plantas potabilizadoras que requieran el mínimo o nada de equipos, partes de repuesto y reactivos del extranjero.

3.- Capacitar recursos humanos a nivel profesional y técnico sobre la actividad de tratamiento de agua, dándoles la oportunidad de colaborar en ello.

4.- Que los Organismos Administradores de los sistemas de agua potable y saneamiento están concientes, que tiene la misma importancia la buena calidad del agua como el buen control del volumen.

5.- En las obras de agua potable y saneamiento, se implanten tarifas por servicio, suficientes para una buena operación y mantenimiento, y asi se pueda entregar un agua en cantidad y calidad adecuada.

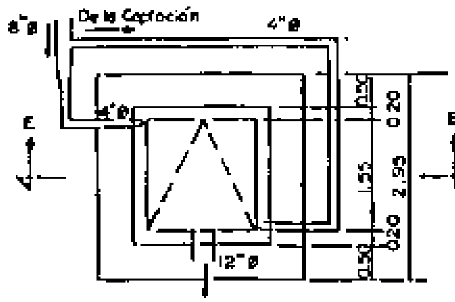
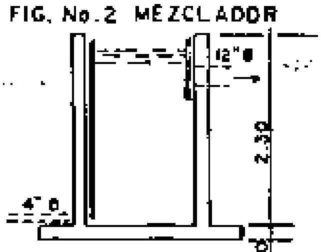
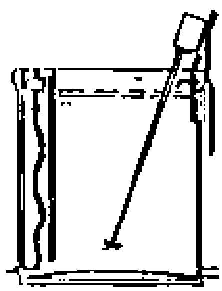


FIG. No. 2 MEZCLADOR



CORTE E-E

FIG. No. 1



DOSIFICADOR

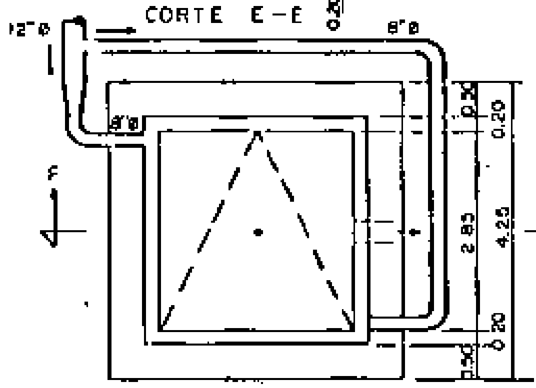
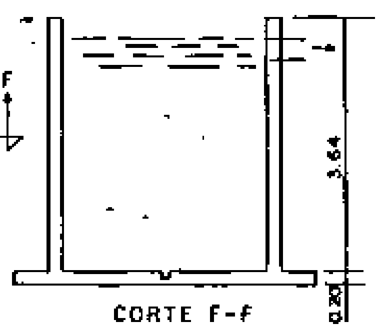
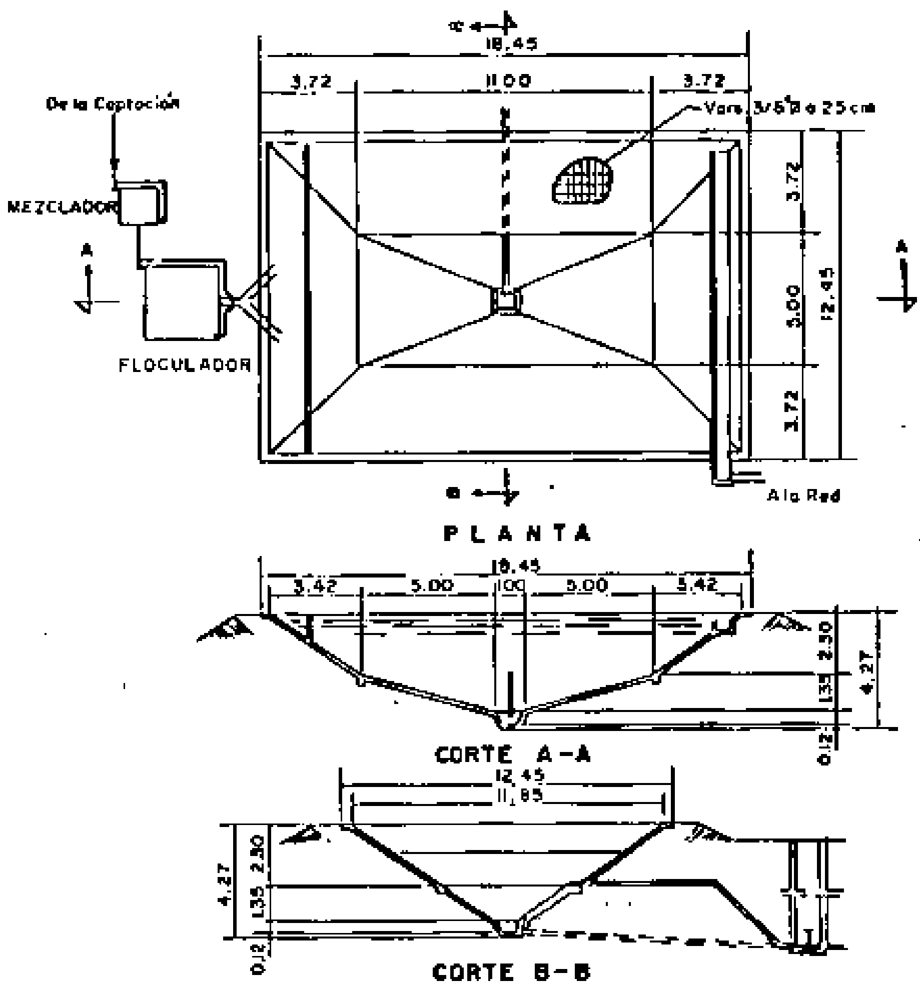


FIG. No. 3 FLOCULADOR



CORTE F-F



18.45
3.72
11.00
3.72
De la Captación
Vars. 3/8" Ø a 25 cm
MEZCLADOR
FLOCULADOR
3.72
5.00
3.72
12.45
A
B
A la Red
PLANTA
18.45
3.42
5.00
1.00
5.00
3.42
2.30
1.35
4.27
0.12
CORTE A-A
12.45
11.85
2.30
1.35
4.27
0.12
CORTE B-B

FIGURA 4

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49. Jorge Sánchez Vázquez
S A H O P
Vallarta 9-1°
México, D.F.

Cumbres de Maltrata 393-9
Col. Narvarte
Z.P. 12
579 84 98

50. Jesus Sereno Orozco
Dubois Mexicana, S.A. de C.V.
Calz. Azcapotzalco la Villa 260
Z.P. 16
561 60 22

51. Jaime Sosa Romero
S A R H
Dir. Gral. de Captaciones y Conducciones
de Agua
Ignacio Ramírez 20-1°
Z.P.4
566 39 11

Sonora 148-404
Hipódromo-Condesa
Z.P. 11

52. León Suárez Gabino
SAHOP
P. de la Reforma 77
Z.P. 4
546 80 16

Av. Jalisco 57
Coyotepec, Edo. de Méx.

53. José Luis Torrescano España
ECCAIV
Jiutepec, Morelos
587 89

Sur 121 A No.342
Col. 201
Z.P. 13
670 37 47

54. Saúl Traconis Ramos
S. A. R. H.
Reforma 107-5°
Z.P. 4
542 27 52

Carlos B. Zetina 161-4
Tacubaya
Z.P. 18
516 90 99

55. Mauricio Trejo Monroy
Av. Constituyentes 947
Z.P. 18
271 30 00 Ext. 458

Liverpool 149
Col. Juárez
Z.P. 6
525 80 08

56. Crescenciano Urióstegui Cardoso
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Av. Insurgentes Sur 465-8°
Z.P. 11
564 76 68

R. Cantos Edif. Guantanamera Depto. 003
Col. Villa Panamericana
Z.P. 21

57. Vicente Vargas N.
SAHOP