U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Study Element 1:

An Appraisal of the Statewide Framework for Stormwater Reclamation and Reuse in Hawaii

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An Appraisal of the Statewide Framework for Stormwater Reclamation and Reuse in Hawaii

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Acronyms

BMPs	Best Management Practices
BWS	Honolulu Board of Water Supply
C	Coefficient
CCH	City and County of Honolulu
cfs	Cubic Feet Per Second
Code	Hawaii’s State Water Code
CWRM	Commission on Water Resource Management
EPA	Environmental Protection Agency
HRS	Hawaii Revised Statutes
DAR	Division of Aquatic Resources
DLNR	Department of Land and Natural Resources
DOH	Department of Health
DWSRF	Drinking Water State Revolving Fund
GIS	Geographical Information System
GWPP	Groundwater Protection Program
GWUDI	Groundwater Under the Direct Influence
I	Intensity
MFL	Million Fibers Per Liter
mgd	Million Gallons Per Day
mg/L	Milligrams per Liter

MRDL	Maximum Residual Disinfectant Level
MRDLG	Maximum Residual Disinfectant Level Goal
NRCS	National Resources Conservation Services
NPDES	National Pollutant Discharge Elimination System
Plan	Hawaii Water Plan
Polychlorinated biphenyls	PCB
Reclamation	U.S. Department of the Interior Bureau of Reclamation
Tc	Time of Concentration
TMDLs	Total Maximum Daily Loads
TT	Treatment Technique
ug/L	Micrograms per Liter
UIC	Underground Injection Control
USDA	U.S. Department of Agriculture
WRF	Water Recycling Facility
WWTP	Wastewater Treatment Plant

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Executive Summary

Groundwater is the principal source of potable water in Hawaii. As sugar cane and pineapple production has declined over the past decade, prime agricultural land is being opened for new residential and commercial development. Over 50,000 new, single-family homes are under construction or planned for Oahu. Development has two impacts on Hawaii's groundwater supply: (1) It increases potable water demand; and (2) it decreases groundwater recharge from rainfall, which is critical for sustaining aquifer levels.

The U.S. Department of the Interior Bureau of Reclamation (Reclamation), in partnership with the Hawaii Commission on Water Resource Management (CWRM) has conducted an appraisal of stormwater reclamation and reuse in Hawaii. Unlike most stormwater management approaches, this appraisal is exploring opportunities to capture and reuse stormwater to augment potable supplies, rather than to simply improve water quality for continued discharge to our streams and near-shore coastal waters.

The appraisal consists of three study elements:

1. Study Element 1 has two components: (1) Develop a statewide framework for identifying and resolving institutional barriers to stormwater reclamation and reuse, and (2) develop a handbook for reclamation and reuse technologies and best management practices for existing and new developments.

2. Study Element 2 consists of an appraisal of opportunities for groundwater recharge of stormwater over a brackish water (caprock) aquifer in a dry, but rapidly developing area on Oahu called the Ewa Plain.

3. Study Element 3 consists of an appraisal of statewide opportunities for augmenting groundwater supplies with stormwater, including groundwater recharge.

This report addresses the statewide framework and identifies potential barriers to stormwater reclamation and reuse, and opportunities for overcoming these barriers. Study Elements 2 and 3 are discussed in *An Appraisal of Stormwater Reclamation and Reuse in the Ewa Plain of Hawaii* and *An Appraisal of Stormwater Reclamation and Reuse in Hawaii*, respectively.

This report appraises the following issues:

- State Water Regulations
- Local Stormwater Management Regulations
- Funding
- Public Issues and Education

A summary of each of these issues is provided below. Table ES-1 summarizes these issues and identifies possible approaches for resolving issues that present barriers to stormwater reclamation and reuse.

State Water Regulations

State water regulations addressed in this appraisal primarily address issues related to water use in the Water Code and water quality requirements in Hawaii Administrative Rules administered by the Clean Water, Safe Drinking Water, and Wastewater Branches of the Department of Health. Two years of discharge monitoring reports were compared with each of the water quality regulations to determine suitability of stormwater for recharge in potable water aquifers, for use with recycled water, and for discharge to receiving waters. For every use, including continued discharge, stormwater might require some level of treatment.

Implementation of total maximum daily loads (TMDLs) to receiving waters by DOH will eventually require stormwater to receive a higher level of treatment than it receives currently for continued discharge to streams and coastal waters. The treatment required to comply with TMDLs will potentially offset the treatment required for other uses, particularly irrigation.

Local Stormwater Management Regulations

Local regulations addressed in this appraisal focus on drainage design standards that control quantity and improve quality of stormwater. A key requirement of these standards is for the volume of post-development runoff to not exceed pre-development runoff for selected storm events. These regulations are potential barriers to stormwater reclamation and reuse since they require developers to size stormwater collection systems and detention facilities the same, regardless of whether reclamation and reuse opportunities are used to reduce the volume of stormwater discharged. There are no provisions, nor incentives, for changing stormwater management practices in new developments.

Funding

Funding for public stormwater management activities occurs currently through the general fund of each County or, for the Department of Transportation, from the State of Hawaii. Though stormwater reclamation and reuse could augment potable water supplies by providing an alternative water supply for some uses (as is done with recycled water), each of the major water supply agencies is planning on rate increases of approximately 40 percent over five years, to fund its own operating needs. Though some financial offset to current management practices could be achieved by the Counties and the State by implementing stormwater reclamation and reuse, an analysis is needed to determine cost versus benefit. As TMDLs are implemented, and the need for stormwater treatment increases for continued discharge, the benefit of stormwater reclamation and reuse might be a more attractive investment. Development of stormwater utilities to fund stormwater management through user fees, would provide a revenue base for stormwater reclamation and reuse opportunities.

Public Issues and Education

Native Hawaiian cultural issues and general public issues relating to water use are discussed in this appraisal. Protection of water resources for Native Hawaiian cultural rights and subsistence agriculture are not only part of the Hawaii Water Code, but are also the subject of legal challenges associated with stream diversions and other activities.

Table ES-1. Summary of Institutional Issues Affecting Stormwater Reclamation and Reuse

Category	Source	Reference	Language / Issue	Comment	Opportunity for Resolution
State Water Regulations	***Hawaii Revised Statutes*** ***State Water Code*** ***Chapter 174C*** Commission on Water Resource Management Department of Land and Natural Resources State of Hawaii (format like the below table)	§174C-2	Groundwater and surface water are held as public trusts for the benefit of all people. The CWRM has considerable authority to protect surface and groundwater quantity and quality.	Issues such as stream flow standards, in-stream diversions, and Native Hawaiian Water Rights can potentially promote and hinder stormwater reclamation and reuse.	Diversion of water from streams is the major area of controversy for maintaining minimum stream flow, protecting habitat, and protecting cultural activities. These concerns can be mitigated by reclaiming and reusing stormwater in the area in which it falls or flows through normally dry gulches. Whereas human activity has diverted water from streams for use in other areas, human activity has also increased the amount of stormwater runoff through gulches due to the increase in impervious surface area from developments.
		§174C-51.5	The CWRM, as a condition for issuing permits pursuant to this part, may require the use of dual line water supply systems in new industrial and commercial developments located in designated water management areas.	Though the intent of the language was to promote the use of recycled wastewater, its use of the term *nonpotable water* could apply equally to reclaimed stormwater. Though there is no requirement for developers to develop nonpotable water sources, the language could promote the use of reclaimed stormwater if a source is made available.	Require new developments to incorporate stormwater reclamation and reuse into their designs. Require zero net loss of groundwater recharge in water supply rules and regulations for new developments.
	Hawaii Administrative Rules ***Title 11, Chapter 23 - Underground Injection Control*** Clean Water Branch Department of Health State of Hawaii	§11-23-09 (A)	Any new injection well, other than subclass D injection wells, shall be sited beyond an area which extends at least one-quarter mile from any part of a drinking water source. This includes not only the surface expression of the water supply well, tunnel or spring, but also all portions of the subsurface collection system which may extend laterally, either at right or inclined angles to the ground surface. The area of protection shall be delineated by a reasonably smooth curve drawn to connect the points extending one-quarter mile beyond the most extensive portions of the drinking water source and its collection system.	An injection well for stormwater is considered a subclass C injection well, so this regulation applies. Location of any stormwater recharge facility above the Underground Injection Control (UIC) line will require careful delineation of zones of influence for potable water wells. The location of any stormwater injection well for direct recharge would be limited by the spatial dimensions of this regulation. An entire aquifer could be considered the drinking water source, further limiting direct injection.	Provide the level of treatment necessary for groundwater recharge. All groundwater recharge of stormwater will require some level of treatment. Non-potable water aquifers will require less than potable water aquifers. This is a potentially expensive resolution, but might be attractive financially as aquifer levels decrease due to decrease in recharge.
	Hawaii Administrative Rules ***Title 11, Chapter 20 - Rules Pertaining to Potable Water Systems*** Safe Drinking Water Branch Department of Health State of Hawaii	HAR 11-20	Direct connections between surface and groundwater can result in a groundwater drinking water source being designated as Groundwater Under the Direct Influence (GWUDI) of surface water.	GWUDI designation would require that groundwater be treated in the same manner as surface water, which would be costly. Situations that would result potentially in a GWUDI designation would be resisted by public (and private) water supply agencies. An analysis of stormwater discharge monitoring reports show that some stormwater quality exceeds drinking water numerical limits. There are insufficient data available in discharge monitoring reports (DMR) to determine if untreated stormwater will comply with all drinking water quality requirements. There are no microbiological data reported for stormwater, yet this is a critical parameter for determining compliance with all water quality standards.	Provide the level of treatment necessary for groundwater recharge.

Table ES-1. Summary of Institutional Issues Affecting Stormwater Reclamation and Reuse

Category	Source	Reference	Language / Issue	Comment	Opportunity for Resolution
State Water Regulations **(continued)**	***Hawaii Administrative Rules*** ***Title 11, Chapter 54 – Water Quality Standards*** Clean Water Branch Department of Health State of Hawaii	HAR 11-54	Total maximum daily loads (TMDL) will limit discharge of certain pollutants (receiving water dependent) from point sources, such as stormwater system outfalls	TMDLs might require that stormwater be treated to meet specific waste load allocations. Such treatment would be expensive and encourage developers to seek alternatives to direct discharge of stormwater to surface waters. This could promote technologies and best management practices for stormwater reclamation and reuse.	Require existing and new developments to reduce stormwater runoff rather than just mitigate peak runoff events.
	Hawaii Administrative Rules ***Title 11, Chapter 62 – Guidelines for Treatment and Use of Recycled Water*** Wastewater Branch Department of Health State of Hawaii	HAR 11-62	There are three classes of recycled water. Each class is determined by the level of treatment. The two highest levels of recycled water must meet specific microbiological quality requirements, and, in the case of the highest level of recycled water, turbidity requirements. Compliance with quality requirements for recycled water is determined at the end of the treatment process, not at the point of reuse.	The DOH has verbally said that integration of recycled water and stormwater would require that stormwater meet recycled water quality. An analysis of stormwater discharge monitoring reports (DMRs) show that some stormwater quality exceeds recycled water numerical limits. There are insufficient data available in DMRs to determine if untreated stormwater will comply with all recycled water quality requirements. There are no microbiological data reported for stormwater, yet this is a critical parameter for determining compliance with all water quality standards.	Compliance with recycled water guidelines is determined at the end of the treatment required for a given class of recycled water. Since there are no DOH regulations for stormwater reuse, combining stormwater with post-treatment recycled water should not require stormwater to meet any specific quality. Develop quality requirements for specific end-uses of reclaimed stormwater, similar to recycled water.
	Hawaii Administrative Rules ***Title 11, Chapter 55 – Water Pollution Control*** ***(Appendix B – NPDES General Permit Authorizing Discharges Of Storm Water Associated With Industrial Activities)*** Clean Water Branch Department of Health State of Hawaii	Discharge Monitoring Report Review	The small number of existing stormwater monitoring points might not adequately characterize stormwater quality from all sources.	Additional characterization of stormwater quality is necessary to determine if it can be used effectively for recharge to drinking water and non-potable aquifers, or integration with recycled water. Treatment of stormwater to meet applicable water quality standards might be necessary in cases where clean catchment cannot be achieved.	Characterize stormwater from a given service area prior to implementation of reclamation and reuse to determine the degree of treatment needed, if any. Develop quality requirements for specific end-uses of reclaimed stormwater, similar to recycled water.
Local Regulatory	***Rules Pertaining to Storm Drainage*** Department of Planning City and County of Honolulu, January 2000 ***Storm Drainage Standard*** Department of Public Works County of Hawaii October 1970 ***Storm Water Runoff System*** Department of Public Works County of Kauai July 2001 ***Rules for Design of storm drainage facilities*** Department of Public Works & Waste Management County of Maui July 1995	Reference from City and County of Honolulu (similar language is in all County design standards) §1-5.1 D.2.a-d Section 5.8	Specific treatment levels (i.e., infiltration, vegetated swales, bioretention filters, and other filters) are required for stormwater flow-through treatment (little or no storage).	Some level of treatment is required for stormwater injection into potable and non-potable water aquifers irrespective of water quality.	These same treatment requirements could equally enhance or mitigate the degree of additional treatment for stormwater reuse.

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Public Issues	Hawaii Supreme Court Waiahole Ditch Decision	Hawaii's Thousand Friends http://hawaiis1000friends.org/	When the sugar industry reduced its use of water from the Waiahole Ditch, the CWRM allocated the water in a manner that resulted in a law suit by Windward parties that wanted to protect in-stream and cultural uses of the watershed that supplied the water. The Supreme Court ruled in the favor of the Windward parties affirming that water resources are part of the public trust. As such, CWRM must protect, control and regulate water resources for the benefit of the people.	These issues are not necessarily barriers to stormwater reclamation and reuse. If inter-watershed movement of water and stream diversions can be reduced by using stormwater that falls locally, the issues will be addressed in total or in part.	Implement stormwater reclamation and reuse opportunities that help reduce reliance of stream diversions and inter-watershed transfers of water.
	Star Bulletin "Big Isle Group Wants Ditch Water for Waipio"	October 24, 1997 http://starbulletin.com/97/10/24/news/story5.html	Similar to Waiahole Ditch, once the sugar industry stopped using water that had previously been diverted from Waipio Stream, an effort by local groups was made to re-establish the natural flow to Waipio Stream for cultural, agricultural, and environmental reasons.		
	Earth Justice Website	http://www.earthjustice.org/our_work/campaigns/restore-stream-flow.html	Similar to Waiahole Ditch and Waipio Stream, diversions from Waihe`e, North & South Waiehu, `Iao, and Waikapu Streams on Maui have been challenged by public/environmental groups. These diversions have affected stream flow, cultural activities, and groundwater recharge.		
	Maui County Code	14.01.010	On Maui, due to public concerns about contaminants in drinking water, the City Council proposed an ordinance that would prohibit the use of any groundwater under active agriculture as a drinking water source. The final ordinance was limited to Hamakuapoko Wells 1 and 2 only. These wells had small concentrations of contaminants from agricultural chemical use. Even though development of the wells would have incorporated treatment to address the contaminants, public opposition was strong. The implications for stormwater reclamation and reuse are the potential introduction of contaminants during recharge.	Indirect groundwater recharge of potable water aquifers with stormwater might cause a temporary increase in contaminants due to movement through the soil. Stormwater could be perceived to add pollutants to the groundwater.	These issues are extremely difficult to resolve, even with public education efforts.
Public Education	City and County of Honolulu Department of Environmental Services State of Hawaii Department of Transportation	http://www.cleanwaterhonolulu.com/storm/index.php http://stormwaterhawaii.com/	Public education relating to stormwater issues focuses on best management practices to minimize pollutant discharge.	These same issues will be important for stormwater reclamation and reuse, and may be even more important for some types of reuse.	Develop a public education program for stormwater reclamation and reuse. Such an education program will depend on specific opportunities, but improved urban watershed management will be a key consideration. Public education programs relating to stormwater reclamation and reuse should be developed for multiple interests, including homeowners, and residential/commercial developers.

An Appraisal of the Statewide Framework for Stormwater Reclamation and Reuse in Hawaii

Introduction

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Current Approach to Stormwater Management

As with many public agencies throughout the U.S. Mainland, stormwater regulations in Hawaii consist primarily of best management practices to reduce pollutants in stormwater runoff and to ensure that stormwater discharges from new developments do not exceed pre-development peak flow rates. The latter approach is effective for reducing peak pollutant loads, but not effective for reducing total pollutant loads unless the flow mitigation measures remove pollutants physically (e.g. settling in a detention basin) or biologically (e.g. wetlands treatment).

The number of green and low impact development approaches to stormwater management is increasing. Some, such as pervious paving, green roofs, and rainwater harvesting for toilet flushing have been implemented on a small scale in Hawaii. Large-scale capture and reuse of stormwater is a new concept in Hawaii, but one that can help replace some potable water being used currently for non-potable uses, such as irrigation.

Hawaii Water Regulations

The current regulatory focus for Hawaii's stormwater occurs at both a state and local level. State regulations are often based on federal regulations, which have primacy over the state regulations. The State of Hawaii is delegated by the Environmental Protection Agency (EPA) to enforce federal regulations. In addition, the State of Hawaii has other regulations that potentially impact stormwater. The purpose of this section is to outline and discuss the current regulatory framework that might affect stormwater reclamation and reuse in Hawaii. These regulations and their potential impacts are summarized in Table 3.

State Water Code

Hawaii Revised Statutes (HRS) Chapter 174C establishes Hawaii's State Water Code (Code). The Code is the basis for regulating and protecting all waters of the State, except coastal waters, for the benefit of the people. The Code establishes the CWRM to oversee surface water and groundwater as public trusts.

The Code establishes a requirement for a Hawaii Water Plan (Plan) that includes a water resource protection plan prepared by the CWRM, water use and development plans prepared by the Department of Agriculture and each of Hawaii's four counties, and a State water projects plan that identifies projects that potentially affect groundwater and surface water resources. The Plan also requires the Hawaii Department of Health (DOH) to develop a water quality plan.

The CWRM can designate water management areas for administrative control over withdrawals and diversions of groundwater and surface waters. The purpose is to ensure reasonable beneficial use of water resources in the public trust. The CWRM is also responsible for establishing in-stream flow standards (including minimum flow) on a stream-by-stream basis; for overseeing the registration, permit issuance, and oversight of wells for groundwater withdrawal or long-term monitoring; for registration and permitting of stream alterations and diversion works relating to surface water; and for establishing aquifer sustainable yields.

The CWRM can require dual water supply systems for new commercial and industrial developments in designated water management areas if a non-potable source of water is available. The purpose of this requirement is to further protect the quantity and quality of potable water supplies. Stormwater could potentially serve as a non-potable water source in a dual water system.

The Code also includes provisions to protect Native Hawaiian Water Rights. These rights extend to ensuring adequate water reserves for current and foreseeable development and use of Hawaiian homelands, and for traditional and customary rights associated with cultural and subsistence agricultural practices.

State Water Quality Regulations

As indicated previously, Part V of the State Water Code establishes the Hawaii DOH as the administrator of the State's water quality control program. The DOH is responsible for developing a water quality plan for all existing and potential sources of drinking water. Though the Code provides for it, the current plan does not include any water quality criteria for the designation of ground water management areas and surface water management areas.

Though not all potential uses of reclaimed stormwater have been established, integration with recycled wastewater, recharge of drinking water aquifers, direct irrigation, and recharge of non-potable water aquifers have been identified. The following water quality regulations are discussed in this section:

- **Surface Water Standards** – discusses water quality standards for stream, river, coastal, and ocean discharges.
- **Drinking Water Standards** – discusses water quality standards for potable water.
- **Recycled Water Standards** – discusses water quality standards for three class of recycled wastewater.
- **Underground Injection Regulations** – discusses rules for locating underground stormwater injection wells.
- **Honolulu Board of Water Supply Underground Injection Rules** – discusses "no Pass Zones" established on Oahu that further restrict the location of underground injection wells.
- **Good Manufacturing Practice In Manufacturing, Packing, Or Holding Human Food** – discusses the Hawaii Department of Health's guidelines for washing fresh fruits and vegetables.
- **Summary and Conclusions** – provides a summary of key points and conclusions relating to stormwater reclamation and reuse.

Surface Water

The DOH Clean Water Branch administers Hawaii Administrative Rule (HAR) 11-54, *Water Quality Standards*, which pertain to surface discharges to inland lakes and streams, as well as coastal and ocean discharges. These rules establish narrative and numeric criteria that must be met in surface receiving waters to prevent toxicity and water quality degradation.

The Stormwater NPDES program is administered by the DOH Clean Water Branch under HAR 11-55, *Water Pollution Control and National Pollutant Discharge Eliminations System (NPDES) General Permits, Appendices B and C*. The basic purpose of regulating stormwater discharges through the NPDES permit program is to protect surface water quality. These discharges are considered point sources that can be readily monitored and controlled. Though stormwater discharges can have a direct impact on the water quality standards in HAR 11-54, the stormwater NPDES discharge permits do not typically include numeric limits, only monitoring of pollutants. Permittees are required to implement plans that include best management practices (BMPs) to reduce the discharge of stormwater pollutants.

Most permits require the following parameters to be monitored during storm events and when there is stormwater-associated runoff:

- Biochemical oxygen demand (BOD)

- Chemical oxygen demand (COD)
- Total suspended solids (TSS)
- Phosphorus
- Nitrogen
- Nitrate + Nitrite Nitrogen
- Oil & Grease
- pH

Permittees are often required to monitor other parameters. These additional parameters are based on pollutants the permittee believes might be present in a stormwater-related discharge from its system. The permittee identifies the possible pollutants when completing an application for a stormwater NPDES permit through the DOH Clean Water Branch. Appendix A provides the list of pollutants that are included in the NPDES permit application.

Though a permittee does not have to meet specific numeric criteria in its stormwater discharge, this might change with the implementation of total maximum daily loads (TMDL) for impaired waters. Under section 303(d) of the 1972 Clean Water Act, states are required to develop lists of impaired waters that do not meet water quality standards. A TMDL specifies the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. Once established, TMDLs allocate pollutant loadings to point sources (waste load allocation) and nonpoint sources (load allocations).

The State of Hawaii has identified 241 impaired water bodies that do not meet the water quality standards in HAR 11-54. Table 1 identifies the causes of impairment and the number of waters with the specific impairment (Note that all tables are presented at the end of the report). Some water bodies exceed more than one water quality standard, which accounts for the total number of impaired water bodies being greater than the number of impaired water bodies.

The number of impaired marine water bodies by island is provided in Table 2. Hawaii DOH has only received approval for 17 TMDLs.

Recycled Water

The DOH Wastewater Branch administers HAR 11-62, *Wastewater Systems* and *Guidelines for the Treatment and Use of Recycled Water*. There are three classifications of recycled water: R-1, R-2, and R-3. These classifications are based on the degree of treatment, which in turn governs applicable use. Definitions for each classification of recycled water are provided below:

- R-1 Water means recycled water that is at all times oxidized, then filtered, and then exposed, after the filtration process, to:
  - A disinfection process that, when combined with the filtration process, has been demonstrated to inactivate and/or remove 99.999 percent of the plaque-forming units of F-specific bacteriophage MS2, or polio virus in the wastewater. A virus that is at least resistant to disinfection as polio virus may be used for purposes of demonstration; and
  - A disinfection process that limits the concentration of fecal coliform bacteria to the following criteria:

        - The median density measured in the disinfected effluent does not exceed 2.2 per 100 milliliters utilizing the bacteriological results of the last seven days for which analyses have been compiled; and
        - The density does not exceed 23 per 100 milliliters in more than one sample in any 30-day period; and
        - No sample shall exceed 200 per 100 milliliters.
- R-2 Water means recycled water that has been oxidized, and disinfected to meet the following criteria:
    - The median density measured in the disinfected effluent does not exceed 23 per 100 milliliters utilizing the bacteriological results of the last seven days for which analyses have been completed; and
    - The density does not exceed 200 per 100 milliliters in more than one sample in any 30-day period.
- R-3 Water means oxidized wastewater, and does not include any disinfection requirement.

The definitions outlined above clearly show that microbiological quality is the main emphasis of recycled water classification. Since the most common use of recycled water is irrigation, human exposure to potential pathogenic organisms is a concern. This is further emphasized by the use of turbidity as a required monitoring parameter for R-1 water. If the effluent from an R-1 water facility exceeds a turbidity of 5 Nephelometric turbidity units (NTU) for more than 15 minutes, chemical coagulants must be added automatically or the effluent is diverted from its intended use.

As the quality of recycled water increases, the restrictions on its use decrease. R-1 water is approved for a broad range of uses including irrigation of food crops, fire fighting, and elementary school irrigation.

Drinking Water

The DOH Safe Drinking Water Branch administers HAR 11-20, *Rules Pertaining to Potable Water Systems*. The DOH has authority delegated from the EPA to enforce applicable federal rules (40 CFR Parts 141 through 143) and to adopt more stringent rules if necessary.

There are 88 numeric primary drinking water standards for microbiological and chemical parameters. These are enforceable as violations if they are exceeded. There are 15 secondary drinking water standards, which are not enforceable, but are intended to improve the aesthetics of drinking water.

The majority of Hawaii’s drinking water is from groundwater. The water is of sufficient quality that treatment is minimal. Most treatment of groundwater is limited to disinfection. Some groundwater sources are known to contain pesticides and other chemicals as the result of historical agricultural practices. Granular activated carbon (GAC) is used typically as a treatment system for removing these types of organic contaminants. There are several GAC treatment systems in Central Oahu.

Surface water sources of drinking water require a higher level of treatment, including chemical coagulation, sedimentation, chemical flocculation, filtration, and disinfection. These treatment processes significantly increase the cost to meet drinking water regulations to provide safe drinking water. Consequently, groundwater sources are preferred, and in some cases selected over surface water sources. As an example, the Honolulu Board of Water Supply (BWS) owns a treatment plant at

Nu'uanu Reservoir that treats spring water potentially influenced by surface water. BWS chooses not to operate it. This decision is based not only on cost, but other water quality considerations (e.g., taste) as well.

Though groundwater in Hawaii does not require the stringent treatment required of surface water, it could be subject to surface water treatment rules if there is a direct connection between surface water and groundwater. Such a connection would classify the drinking water source as Groundwater Under the Direct Influence (GWUDI) of surface water. This designation is determined primarily by observations including groundwater exhibiting characteristics of surface water (e.g., insect parts) and fluctuations in groundwater levels in response to surface-related events (e.g., rainfall). Direct injection of untreated or partially treated stormwater into a potable water aquifer could be a basis for designating an aquifer as GWUDI. This would possibly require that groundwater extracted from the aquifer be treated by the same processes and fall under the same regulations as surface water. Direct injection of stormwater into a potable water aquifer would be a concern to water supply agencies.

Underground Injection

The DOH Safe Drinking Water Branch administers HAR 11-23, *Underground Injection Control (UIC)*. These regulations do not regulate water quality directly, but indirectly, by regulating where underground injection wells can be located in relation to potable water sources.

Underground injection well classification is based on the source water. Stormwater injection wells are classified as a Class V Subclass C injection wells. They are permitted to be constructed but must be sited beyond an area extending at least one-quarter mile from any part of a drinking water source. This includes not only the surface water expression of the water supply well, tunnel, or spring, but also all portions of the subsurface collection system, which may extend laterally, either at right or inclined angles to the ground surface. The area of protection is delineated by a reasonably smooth curve drawn to connect the points extending one-quarter mile beyond the most extensive portions of the drinking water source and its collection system.

Each island has a UIC line that delineates areas of control. Areas below the UIC line are not considered drinking water sources and a wider variety of wells is permitted. Areas above the UIC line are considered drinking water sources. The types of injection wells permitted in these areas are limited. Permits for injection wells are required in both areas, and permit limitations will be more restrictive in the area of drinking water sources.

Oahu "No Pass Zones"

The Honolulu Board of Water Supply's (BWS), *Rules and Regulations, Chapter III, Protection, Development and Conservation of Water Resources*, establishes "No Pass Zones" on Oahu that further limit location of waste disposal facilities that may "affect the quality and/or quantity of water resources used or expected to be used for domestic water." The "No Pass Zones" established by BWS are more restrictive than UIC lines. Waste disposal facilities are defined as the following:

- Sewage disposal systems (cesspools, septic tank systems, and individual household aerobic treatment systems)
- Disposal wells
- Sanitary landfills
- Refuse disposal dumps

- Sewage treatment plants
- Stabilization ponds
- Any other wastewater disposal facilities

In the absence of water quality data, direct injection of stormwater above the “No Pass Zones” would likely be considered a waste disposal facility.

Good Manufacturing Practice in Manufacturing, Packing, or Holding Human Food

The Food and Drug Branch of the DOH regulates food handling safety. Regulations can be found in HAR 11-20, but generally reference U.S. Food and Drug Administration regulations in 21 CFR. Though reclaimed stormwater would not be used for food processing, growing crops in which edible portions come in contact with the stormwater is a concern to agricultural users. The primary concern is microbial contamination. The U.S. Food and Drug Administration issues *The Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables*, which states: “Whenever water comes into contact with fresh produce, its quality dictates the potential for pathogen contamination.” Though a specific water source or quality is not required, the guidance includes the following considerations for agricultural water:

- Identify the source and distribution of water used and be aware of its relative potential for being a source of pathogens.
- Maintain wells in good working conditions.
- Review existing practices and conditions to identify potential sources of contamination.
- Be aware of current and historical use of land.
- Consider practices that will protect water quality.
- Consider irrigation water quality and use.

Opportunities for stormwater reclamation and reuse that include direct irrigation will need to be of a quality similar to that currently used. Water quality will be a key issue for agricultural users of stormwater, as well as their commercial customers.

Regulatory Impacts

The previous discussion described water-related regulations and their potential impact on stormwater reclamation and reuse. This section focuses on stormwater quality and compares two years of existing stormwater quality data with applicable water quality standards that could be pertinent to stormwater reclamation and reuse. The stormwater data are compared with drinking water, recycled water, and surface water numeric standards.

The DOH regulates the quality of three types of water: drinking water, recycled water, and surface water. The Safe Drinking Water Branch administers federal and state safe drinking water regulations. The Wastewater Branch administers and enforces regulations and guidelines for use of recycled water. The Clean Water Branch administers and enforces statewide water pollution laws and rules affecting surface water.

The following subjects are discussed in this section:

- **Stormwater NPDES Permits** – provides background on Hawaii's stormwater NPDES permits and their occurrence.
- **Stormwater Quality Data Review** – describes the stormwater quality data that were available and the process used to compare the data with other pertinent water quality standards.
- **Drinking Water Standards** – compares the stormwater quality data with drinking water standards.
- **Recycled Water Standards** – compares the stormwater quality data with recycled water standards.
- **Surface Water Standards** – compares the stormwater quality data with surface water standards.
- **Microbiological Parameters** – addresses the issue of microbiological quality of stormwater.
- **Summary and Conclusions** – provides a summary of key points and conclusions relating to stormwater reclamation and reuse.

Stormwater NPDES Permits

The EPA delegates responsibility to DOH for administration of the NPDES permit program. The permitting program is administered through HAR 11-55, *Water Pollution Control*.

The DOH Clean Water Branch issues two types of NPDES permits (General and Individual), which allow discharge to inland and marine waters. The distinction between a General Permit and an Individual Permit is based on the classification of the receiving water. General Permits are intended for discharges to Class A and Class II waters, while Individual Permits are intended for discharges to more restrictive Class AA and Class I waters. HAR 11-54, *Water Quality Standards*, describes the classifications of marine waters. Condensed descriptions are provided below.

- **Class AA waters:** It is the objective that these waters remain in their natural pristine state as nearly as possible with an absolute minimum of pollution or alteration of water quality from any human-caused source or actions.
- **Class A waters:** It is the objective that the use of these waters for recreational purposes and aesthetic enjoyment be protected. Any other use shall be permitted as long as it is compatible with the protection and propagation of fish, shellfish, and wildlife, and with recreation in and on these waters. These waters shall not act as receiving water for any discharge that has not received the best degree of treatment or control compatible with the criteria established for this class.
- **Class I waters:** It is the objective that the marine bottom ecosystems of these waters remain as nearly as possible in their natural pristine state with an absolute minimum of pollution from any human-induced source.
- **Class II waters:** It is the objective that the marine bottom ecosystems of these waters, including propagation of fish, shellfish, and wildlife; and for recreational purposes not be limited in any way.

Figure 1 contains a summary of the NPDES permit structure for stormwater discharges. There are multiple types of discharges authorized for General and Individual Permits. The types of authorized stormwater discharges can be found in HAR 11-55, as outlined below:

- HAR, Chapter 11-55: Large Municipal Separate Storm Sewer Systems
- Appendix B: Stormwater associated with industrial activities
- Appendix C: Stormwater associated with construction activity
- Appendix K: Discharges of stormwater and certain non-stormwater discharges from Small Municipal Separate Storm Sewer Systems (MS4s).

In addition to the issuance of an Individual Permit for the water classes described above, an Individual Permit can also be granted to consolidate multiple General Permits for a given site.

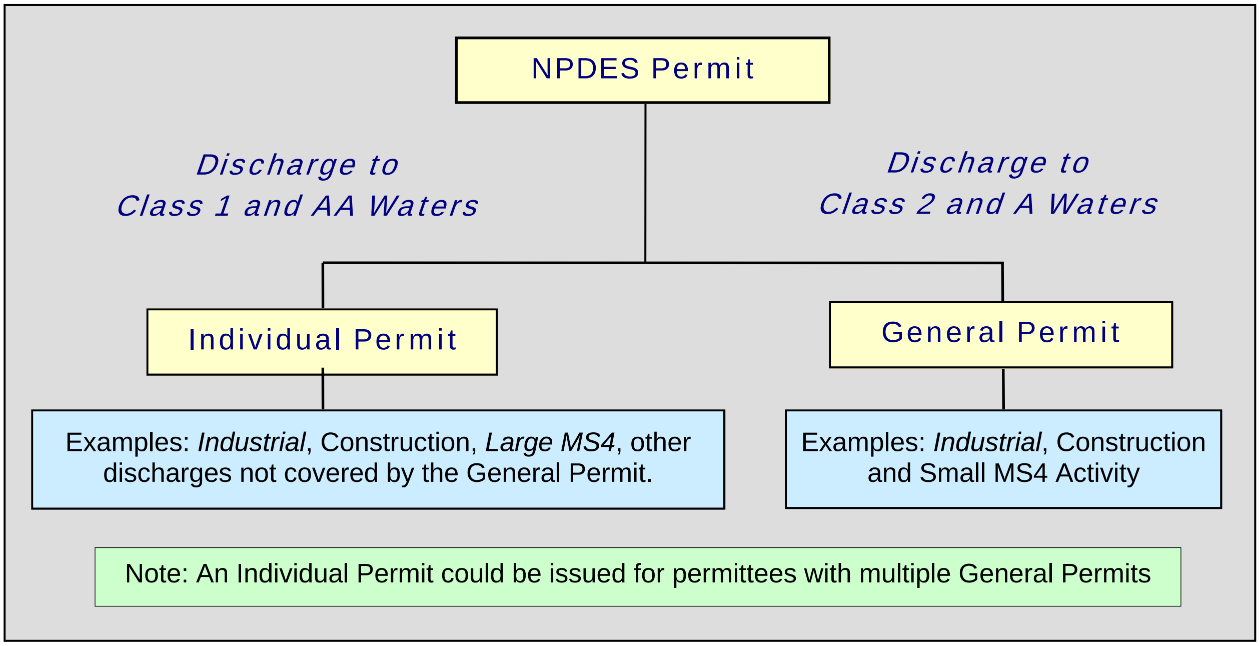

Figure 1. Summary of the NPDES Permit for Stormwater Discharge

Stormwater NPDES discharge monitoring reports meeting the following criteria were reviewed as part of this appraisal:

- Permits with stormwater monitoring data between 2004 and 2006
- Permits for Industrial and MS4 types of discharge

Stormwater discharges associated with construction activities were not reviewed due to the transitory nature and diversity of construction activity.

A total of 225 stormwater-related NPDES permits with the characteristics noted above were identified, including 182 General Permits and 43 Individual Permits. The General Permits included 173 industrial permits and 9 small MS4 permits. The Individual Permits included 26 industrial permits and 17 large MS4 permits. Table 4 shows the number of permits per island.

Stormwater Quality Data Review

Stormwater quality data must be reported in annual discharge monitoring reports (DMRs) by a permittee. Available DMRs were reviewed at the DOH to collect water quality data and other information pertinent to the water quality analysis for this appraisal.

As discussed previously, most DMRs require that the following parameters be monitored during storm events and when there is stormwater-associated runoff:

- Biochemical oxygen demand (BOD)
- Chemical oxygen demand (COD)
- Total suspended solids (TSS)
- Phosphorus
- Nitrogen
- Nitrate + Nitrite Nitrogen
- Oil & Grease
- pH

Permittees are often required to monitor other parameters, which are based on pollutants the permittee believes might be present in a stormwater-related discharge due to activities in the stormwater collection area.

The duration of the storm event typically determines the type of sample collected. A grab sample is typically collected during the first 15 minutes of discharge. If the discharge lasts longer, additional grab samples are collected at 15-minute intervals for a maximum of one hour to develop a composite sample. The following sections present comparisons of available DMR stormwater quality data with pertinent drinking water, recycled water, and surface water standards.

Drinking Water Standards

The mission of the DOH Safe Drinking Water Branch is to safeguard public health by protecting Hawaii’s drinking water sources (surface water and groundwater) from contamination and assure that owners and operators of public water systems provide safe drinking water to the community. This mission is accomplished through the administration of the Safe Drinking Water Program, UIC Program, Groundwater Protection Program (GWPP) and the Drinking Water State Revolving Fund (DWSRF).

Numerical standards are principally included in the Safe Drinking Water Program and include primary and secondary standards. Primary drinking water standards are specific numerical limits that are enforceable. Secondary drinking water standards are associated with aesthetic quality (e.g., taste) but are not enforceable.

A comparison of primary drinking water standards and DMR stormwater quality data are presented in Tables 5 through 11.

- Table 5 provides the standards and monitoring results for microorganisms
- Table 6 provides the standards and monitoring results for disinfection byproducts

- Table 7 provides the standards and monitoring results for disinfectants
- Table 8 provides the standards and monitoring results for inorganic chemicals
- Table 9 provides the standards and monitoring results for organic chemicals
- Table 10 provides the standards and monitoring results for radionuclides
- Table 11 provides the secondary drinking water standards and monitoring results.

Definitions for the parameters in the tables include:

- **Maximum Contaminant Level (MCL)** – The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the maximum contaminant level goal (defined below) as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.
- **Maximum Contaminant Level Goal (MCLG)** – The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.
- **Maximum Residual Disinfectant Level (MRDL)** – The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants. (Note: This definition was added as part of the 1996 amendments to the Safe Drinking Water Act.)
- **Maximum Residual Disinfectant Level Goal (MRDLG)** – The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants. (Note: This definition was added as part of the 1996 amendments to the Safe Drinking Water Act.)
- **Treatment Technique (TT)** – A required treatment process intended to reduce the level of a contaminant in drinking water (Note that equivalent treatment is not required for stormwater).
- **Micrograms per Liter (ug/L)** **–** The equivalent of parts per billion.
- **Milligrams per Liter (mg/L)** – The equivalent of parts per million.

The comparisons in Tables 5 through 11 show two important points:

- Not all primary and secondary drinking water standards are monitored routinely in stormwater discharges; and
- Some pollutants in stormwater discharges exceed the primary and secondary drinking water standards (e.g., lead in Table 8 and iron in Table 11).

This comparison of stormwater quality data with drinking water standards suggests direct recharge of stormwater into a potable water aquifer should not be considered unless the stormwater is treated to a level to ensure drinking water standards are not exceeded.

Recycled Water

The DOH Wastewater Branch administers HAR 11-62 *Wastewater Treatment Systems* and *Guidelines for the Treatment and Use of Recycled Water.* There are three classifications of recycled water: R-1, R-2, and R-3. These classifications are based on the degree of treatment, which in turn governs applicable use. The definitions of these classes were presented previously. Turbidity and fecal coliform bacteria are the two water quality parameters used to assess the quality of recycled water. The emphasis is on microbiological quality. The DMRs do not contain any data for fecal coliform bacteria. Despite this lack of data, DOH's Clean Water Branch routinely issues beach warnings, advisories, and closures due to bacterial contamination attributed to rainfall and subsequent stormwater runoff. Consequently, stormwater will likely pick up microbial contamination as it flows across land surfaces.

The DMRs do contain some data for turbidity. Table 5 shows 20 reported turbidity values. Nineteen of the 20 values exceeded the recycled water turbidity limit of 5 NTU.

Surface Water Standards

The DOH Clean Water Branch administers HAR 11-54, *Water Quality Standards*. These standards pertain to surface discharges to inland lakes and streams, as well as coastal and ocean discharges. These rules establish narrative and numeric criteria that must be met in surface receiving waters to prevent toxicity and water quality degradation.

The water quality standards are segregated into numeric limits for freshwater and saltwater. They are further classified as acute and chronic toxicity standards for each type of water. Acute toxicity is the degree to which a pollutant causes a rapid adverse impact to aquatic organisms (e.g., death). Chronic toxicity is the degree to which a pollutant causes a long-term adverse impact to aquatic organisms, such as a reduction in growth and reproduction.

Water quality standards are also established for total nitrogen, ammonia nitrogen, nitrate + nitrite nitrogen, total phosphorus, and turbidity. These standards differ based on the class of the receiving water and statistical frequency of occurrence. For inland waters, these criteria are higher during the wet season and lower during the dry season.

A comparison of water quality standards with DMR data is presented in Table 12. This comparison shows two important points:

1. There is stormwater quality data for only 33 of the water quality standards, and

2. Eight of the stormwater quality parameters exceed water quality standards.

The latter point does not mean necessarily that there was a violation of water quality standards. Initial mixing of the stormwater discharge into the receiving water might have provided sufficient dilution to prevent a violation.

Microbiological Parameters

The stormwater data in the DMRs do not include any microbiological data, yet each of the water quality regulations administered by DOH includes various microbiological limits. The microbiological parameters associated with each water quality regulation are presented in Table 13.

Understanding the microbiological content of stormwater is essential because microbiological data are required to determine compliance with the water quality regulations that could potentially impact stormwater reclamation and reuse. In 2002, BWS conducted a characterization study of various water sources (Brown and Caldwell, 2002), including:

- **Honouliuli Water Reclamation Facility (WRF)** – This water source is R-1 recycled water
- **Impacted Well** – This water source is a deep groundwater well that is known to be impacted by human activity on the ground surface. This impact is characterized by some known contaminant, usually a chemical associated with agricultural activity.
- **Pristine Well** – This water source is a deep groundwater well that is not suspected of being impacted by human activity on the ground surface.
- **Waiahole Ditch** – This water source is an agricultural water source that conveys water from the windward side of Oahu through a tunnel in the Ko’olau Mountains to the Kunia area of Oahu. It is primarily surface water, which includes stormwater.

Table 14 compares 12 months of microbiological data for each of these water sources.

Table 14 also includes suspended solids data for each of the water sources. The suspended solids data emphasize an important point about the potential microbiological quality of stormwater. Turbidity is closely related to suspended solids in water. Stormwater was shown in Table 5 to be high in turbidity. Microbiological parameters are often associated with high turbidity since solids can contain and shield bacteria, viruses, and other microorganisms. Waiahole Ditch has significantly higher concentrations of microbiological parameters than the recycled water from the Honouliuli WRF, yet the water from Waiahole Ditch, which is surface water, is low in suspended solids. Consequently, stormwater, which is surface water and has high turbidity, is likely to contain microbial contamination.

Conclusions

A summary of the constituents in the DMRs that exceeded drinking water, recycled water, and surface water standards is provided in Table 15.

The following conclusions can be drawn from this comparison of stormwater monitoring data with various water quality standards:

- The small number of existing stormwater monitoring points might not adequately characterize stormwater quality from all sources.
- There are insufficient data available in DMRs to determine if untreated stormwater will comply with all drinking water and recycled water quality requirements.
- Some data show that drinking water and recycled water numeric requirements would be exceeded.
- There are no microbiological data reported for regulated stormwater discharges, yet microbial parameters are critical for determining compliance with all water quality standards.
- Additional characterization of stormwater quality is necessary to determine if it can be used effectively for recharge to drinking water and non-potable aquifers, or integration with recycled water.

Table ES-1 in the Executive Summary highlights key issues relating to State water regulations and possible opportunities for resolution.

- Treatment of stormwater to meet applicable water quality standards might be necessary in cases where clean catchment cannot be achieved.

Local Stormwater Regulations

This section describes stormwater system design requirements of the City and County of Honolulu, County of Maui, County of Hawaii, and County of Kauai. Flood control and water quality improvement are the focus of these requirements

The following subjects are discussed in this section:

- **Rational Method Hydrologic Criteria** – provides information and step-by-step instructions for obtaining the desired runoff flow (Q) using the Rational method formula.
- **Detention for Water Quality** – provides information about sizing detention basins for improving stormwater quality prior to discharge.

Rational Method

The volume of runoff is critical to sizing stormwater infrastructure, including pipes, drainage channels, and retention basins. All Counties require that post-development runoff for selected storm events not exceed pre-development conditions. The Rational Method is used to determine the runoff for uniform comparison from pre- and post developments.

The Rational Method is an empirical equation that relates the peak discharge from a watershed to the product of a runoff coefficient that is estimated from basin hydrologic characteristics, the watershed area, and rainfall intensity. It is used to determine quantities of flow rate for drainage areas of 100 acres or less. The formula is:

$$\mathbf{Q = C\ I\ A}, \text{ in which}$$

Q = flow rate in cubic feet per second (cfs)

C = runoff coefficient

I = rainfall intensity in inches per hour (in/hr), for a duration equal to the time of concentration

A = drainage area in acres (ac)

There are three variables for the Rational Method: drainage area, runoff coefficient, and rainfall intensity. These are discussed in more detail in the following sections.

Area

Area is the drainage area for the site under consideration in acres (ac).

Runoff Coefficient

The Runoff Coefficient (C) is a critical element that determines the relationship between the average rainfall rate of a particular rainfall recurrence, to the peak runoff intensity of the same frequency. The runoff coefficient considers infiltration, relief of terrain, vegetative cover, and development type. A weighted value of C is used for drainage areas of multiple types.

Figure 2 shows the step-by-step method for determining C. The referenced tables are provided in Appendix B. As the figure shows, the process for some Counties includes multiple steps.

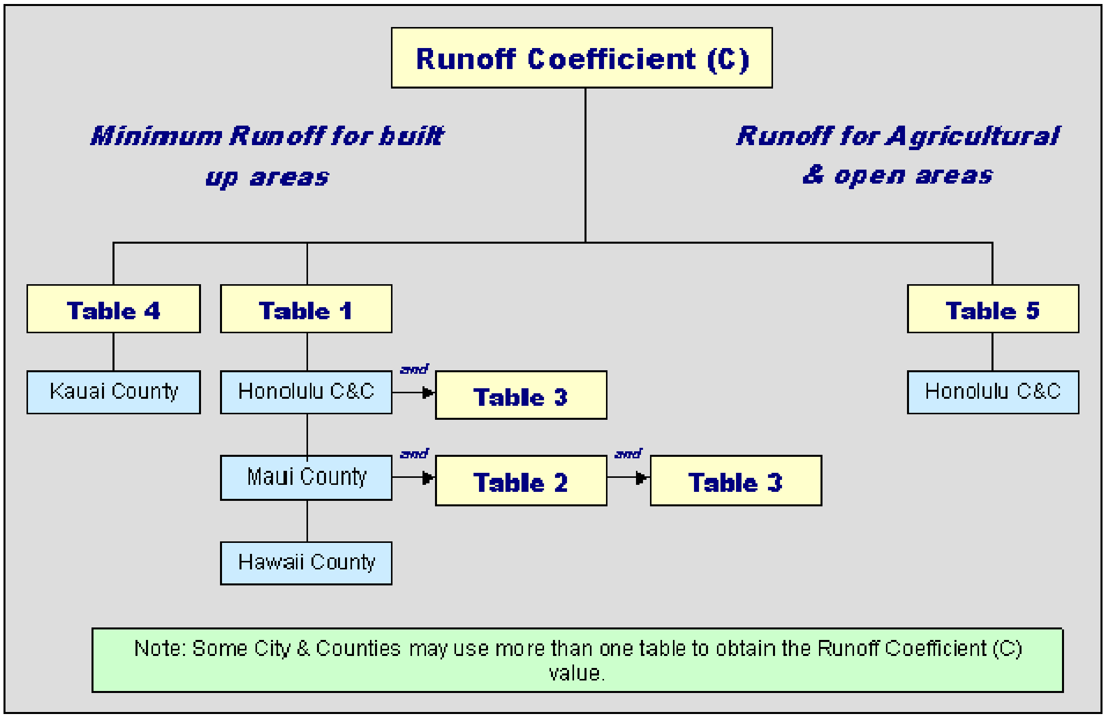

Figure 2. Process for Determining Runoff Coefficient (C)

Intensity

Intensity (I) is the rate of the total quantity of precipitation and is dependent on the time of concentration and the storm frequency or recurrence interval. Short-duration storms and less frequent storms are more intense.

Time of Concentration

Time of Concentration (Tc) is defined as the time required for a drop of water to travel from the most hydrologically remote point in the watershed to the point of collection. Figure 2 shows the process for determining Tc. The referenced plates are provided in Appendix C.

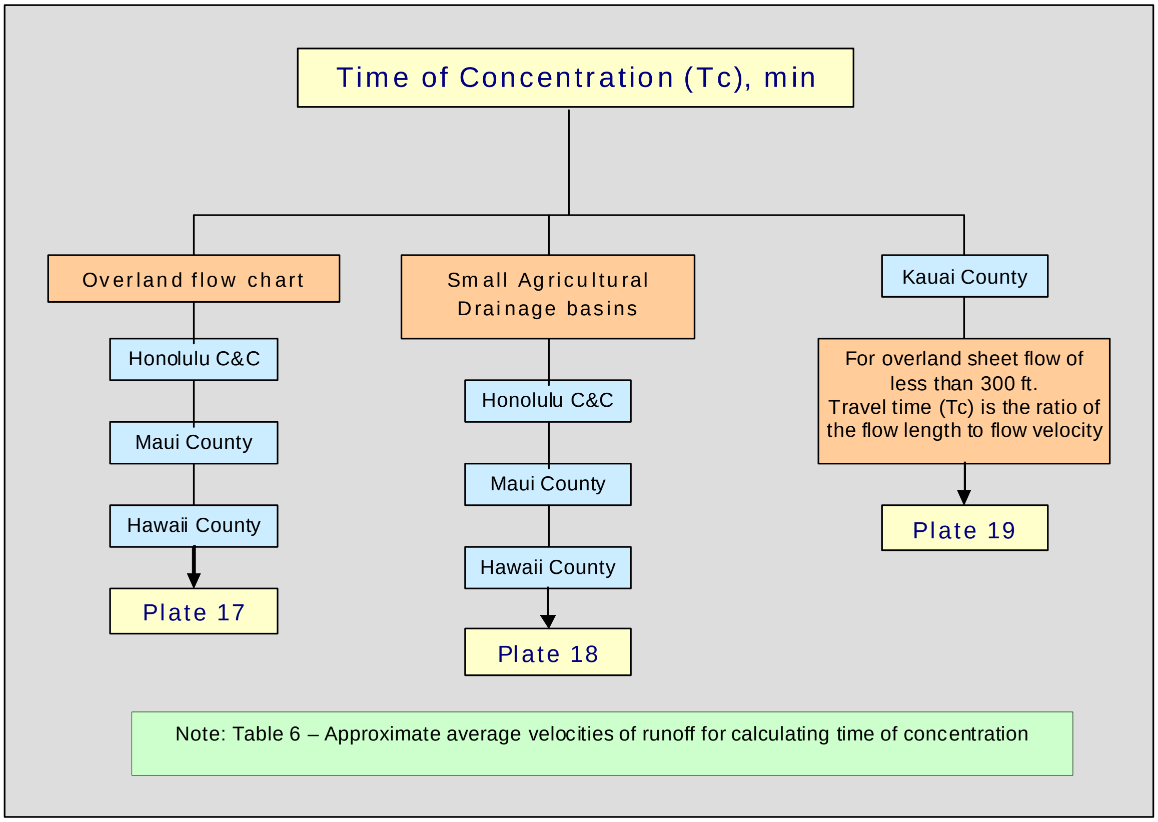

Figure 3. Process for Determining Time of Concentration (Tc)

As the figure shows, the process for some Counties includes multiple steps. Differences for determining Tc among the Counties are discussed below.

- **City and County of Honolulu, County of Maui, & County of Hawaii**
  1. Determine overland flow time from *Plate 17* for paved, bare soil, & grassed areas.
  2. Determine overland flow time from small agricultural areas with well-defined divided and drainage channels from *Plate 18*.
     a. Use upper curve for well-forested areas, representing

     $$\mathbf{Tc = 0.0136K^{0.77}}$$

     b. Use lower curve for areas with little or no cover, representing

     $$\mathbf{Tc = 0.0078K^{0.77}}$$

  3. In case of uncertainty, the time of concentration is checked by dividing the estimated longest route of runoff by the appropriate runoff velocity from *Table 6*.
- **County of Kauai**
  1. For overland sheetflow of less than 300 feet, Tc is determined using Plate 19 in conjunction with the travel velocity for overland flow.
  2. Travel time is the ratio of the flow length to flow velocity.
  3. Overland sheet flow of greater than 300 feet is considered shallow concentrated flow, and the grassed waterway line is used to estimate travel velocity.

Recurrence Interval

A specific flood value recurs over a period of time, since the magnitude of the flows recorded in the past will be repeated. The actual time between exceedances is called the recurrence interval (Tm). Recurrence intervals of 2, 10, 50, and 100 years are typically used for calculating rainfall intensity. Figure 3 shows how Tm is used to determine rainfall intensity.

Differences in the approach for each County are discussed below.

- **City and County of Honolulu, County of Maui, & County of Hawaii**
  1. For drainage areas of 100 acres or less, Tm = 10 years, unless otherwise specified.
  2. For drainage areas of 100 acres or greater with sump, or tailwater effect, and for the design of roadway culverts and bridges, Tm = 50 years.
  3. For drainage areas greater than 100 acres and all streams, design curves from the Natural Resources Conservation Services (NRCS) hydrograph shall be used, Tm = 100 years based on a 24-hr storm.
- **County of Kauai**
  1. For local drainage systems with drainage areas less than 100 acres with sump, or tailwater effect, and for the design of roadway culverts and bridges utilizing static head entrance, Tm = 2 years.
  2. For local drainage systems with drainage areas greater than 100 acres and major drainage systems, Tm = 100 years.

Determining Rainfall Intensity – Step 1

The first step in determining a 1-hour rainfall intensity (I) is common to all Counties (Figure 4). The appropriate intensity of 1 hour rainfall (in) is selected from *Plate 1-14*, depending on the Tm for the design recurrence interval.

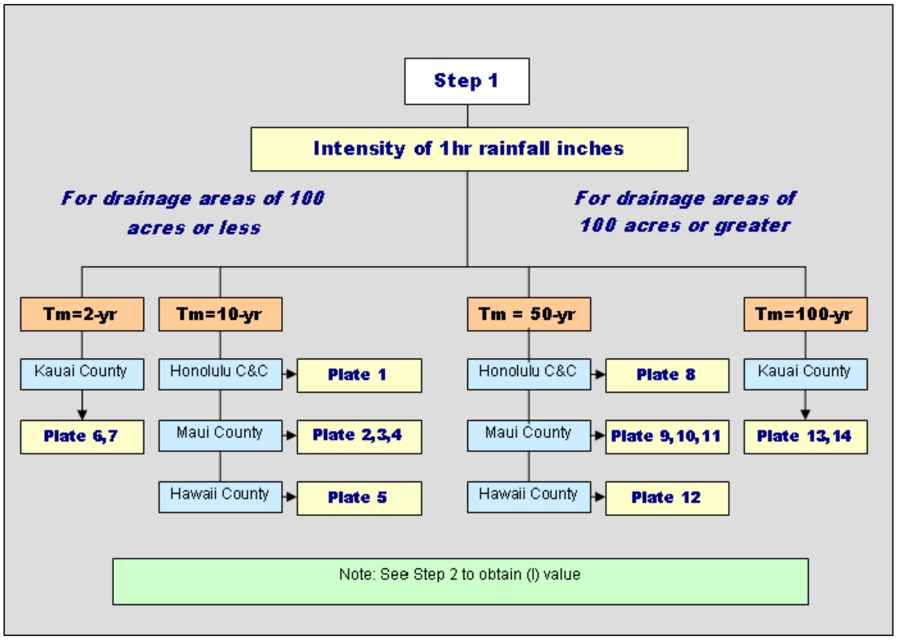

Figure 4. Step 1 Process for Determining Rainfall Intensity (I)

Determining Rainfall Intensity – Step 2

The second step for determining I differs among some of the Counties (Figure 5). These differences are discussed below.

- **City and County of Honolulu and County of Kauai**

  The Tc is used to select the corresponding correction factor (R) from *Plate 15*, and the 1-hour rainfall (in) is multiplied by the correction factor (R) to obtain the design I.

- **County of Maui and County of Hawaii**

  The intensity of a 1-hour rainfall (in) from *Plate 2-5, 9-12* and the required Tc (min), are used to determine the intensity of a 1-hour rainfall from *Plate 16*.

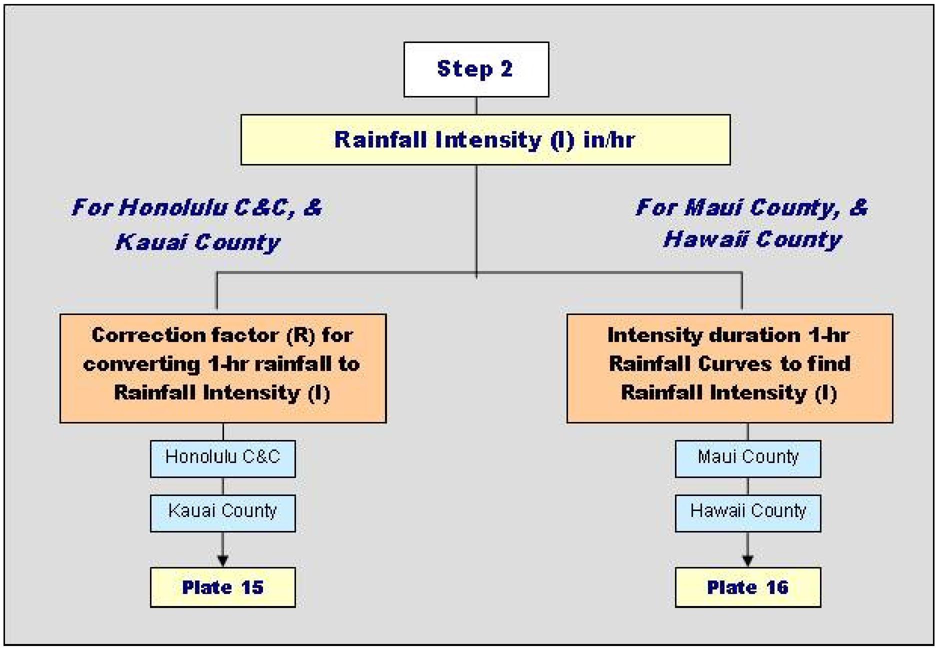

Figure 5. Step 2 Process for Determining Rainfall intensity (I)

Hydraulics

In addition to the requirements for determining the quantity of flow, each agency also has narrative design standards.

- On the basis of the runoff resulting from the selected design storm, the system shall dispose of surface runoff and subsurface water without damage to street facilities, structures or ground, and cause no serious interruption of normal vehicular traffic.
- Runoff exceeding the design storm must be disposed of with the least amount of interruption to normal traffic and minimum amount of damage to surrounding property.
- Systems must have maximum reliability of operation with minimum maintenance and upkeep requirements.
- Systems must be adaptable to future expansion, if necessary, with minimum additional cost.
- In general, natural gullies, waterways, streams and tributaries shall not be replaced with a closed system except at roadway crossings.

- Outlets for enclosed drains emptying into open channels shall be designed to point downstream at an angle of 45 degrees.
- Where groundwater is encountered, or may be present during wet weather, subsurface drains shall be installed wherever recommended by the agency.
- When downstream drainage systems cannot accommodate peak runoff rates from design storms, runoff rates discharged downstream from new developments will be limited to pre-development values unless improvements to the downstream system are made.

Detention for Water Quality

Detention times for water quality control are typically much longer than those required for flood control to allow for settling of fine particles and pollutants. While a detention system for water quality control could be combined with a flood control system, the volume assigned for water quality control must meet minimum detention times. The volume required for flood control only, is generally less than the volume required for water quality improvement.

The required design volume for detention-based control is equal to the entire runoff volume that would occur from the area during a 1-inch rain storm.

The Runoff Coefficient (used previously in the Rational Method) is determined from the following equation as developed by EPA for smaller storms in urban areas:

$C = 0.05 + (0.009) \times (IMP)$, in which

C = Runoff Coefficient
IMP = Impervious Area (surface areas which allow little or no infiltration, including pavements, roofs, etc.) for the tributary watershed, expressed as a percentage

The runoff coefficient is based upon the ultimate use of the drainage area, unless the water quality feature will be re-built/sized during subsequent phases of construction.

For water quality treatment to be effective, longer detention times are required. The draw-down (or draining) time for the detention volume is required to be greater than or equal to 48 hours. For the bottom half of the detention volume, the draw-down time is required to be greater than or equal to 36 hours.

For water quality control with detention times less than or equal to 20 acres of drainage area, the total draw-down time can be reduced to 36 hours, with the bottom half of the detention volume draw-down time reduced to 24 hours.

The detention system is designed to maximize the distance between the inlet and the outlet, and to minimize “dead spaces” (areas where little or no exchange occurs during a storm event), there-by limiting short-circuiting. A minimum flowpath length to width ratio of 3 is required.

The outlet is sized to achieve the above required detention times including any potential for clogging. The outlet should be 4 inches or larger in diameter. If it is not possible, measures based on flow-through are considered.

The volume is calculated using the following equation:

WQDV = C x 1 x A x 3630, in which

WQDV = Water Quality Detention Volume, in cubic feet
C = Runoff Coefficient
A = Area of site, in acres
3630 = Conversion Factor

Conclusions

The following conclusions can be drawn from an analysis of design standards for stormwater management systems:

- Each public entity has a defined, methodical process for determining the stormwater rate of flow and sizing of stormwater collection systems. The process differs somewhat among the Counties.
- The design requirements are intended to ensure the post-development runoff does not exceed the pre-development runoff for selected storm events.
- A similar approach could be used to require that post-development groundwater recharge is not less than pre-development recharge, but would likely require more extensive stormwater management facilities.
- The process used by each County to size the stormwater collection system does not include provisions for reclaiming and using stormwater on-site (i.e., that would not otherwise be discharged to the stormwater collection system and to surface waters of the State).
- The design standards do not provide any cost-saving incentives for developers to implement stormwater reclamation and reuse in their designs.
- Developers want to turn public utility infrastructure over to the respective counties upon completion. Since stormwater reclamation and reuse infrastructure is not included in drainage standards, developers will be reluctant to incorporate it into designs.

Table ES-1 in the Executive Summary highlights key issues relating to local regulations and possible opportunities for resolution.

Funding

This section provides an overview of the cost of various categories of water service throughout Hawaii. These services include potable water, non-potable water (other than recycled water), and recycled water. Stormwater reclamation and reuse will require infrastructure for implementation. Funding of infrastructure is a key consideration, particularly since water purveyors are experiencing increasing operation, maintenance, and capital costs due to aging infrastructure.

Groundwater and surface water from streams are considered public trusts in Hawaii. Water “utilities” cannot charge for the water per se, but can charge for the cost of providing the service, including capital improvements, debt service, and operation and maintenance of the water system.

Public stormwater collection and conveyance systems are funded through the general funds and transportation-related revenues of each County, and through the Hawaii Department of Transportation

(HDOT) for statewide transportation-related stormwater. Though stormwater management programs are mandated by State and Federal law, funding for them currently must compete with other, higher profile needs such as police, fire, and parks and recreation.

The following subjects are discussed in this section:

- **Public Water Supply Agencies** – identification of public agencies that supply water for potable and non-potable use.
- **Water Rate Structures** – summary of the rate structures of each public water supply agency for operation and maintenance of potable, non-potable, irrigation, and recycled water systems.
- **Facility Charges** – summary of new development charges assessed by public water supply agencies.
- **Stormwater Utility Development** – overview of the concept of stormwater utilities for managing and funding stormwater programs.

Public Water Supply Agencies

There are four public water supply agencies in Hawaii including the BWS, the County of Hawaii Department of Water Supply (HDWS), the Kauai Department of Water (KDOW), and the Maui Department of Water Supply (MDWS). Each of these agencies provides potable and non-potable water to customers. The function, power, and duties of each of these departments or boards are defined in the respective County's charter. In addition to each of these public water supply agencies, the Hawaii Department of Agriculture (HDOA) sets rates for state-operated agricultural irrigation systems.

The HDOA manages five irrigation systems on three islands: Oahu, Hawaii, and Molokai. These systems are used to irrigate over 10,100 acres and transport approximately 1.7 billion gallons of water a year. Hawaii Revised Statures (HRS) 167-11 gives HDOA the power to fix and adjust rates and charges for the furnishing of irrigation or domestic water service so that the revenues derived from the rates are sufficient to cover the cost of operation, maintenance, and replacement of the systems.

Water Rate Structures

Water rate structures for each of four County water supply agencies and the HDOA are provided in Tables 16 through 18. The dates of the rate structures are provided below:

- BWS – Effective July 1, 2008
- HDWS – Effective July 1, 2008
- KDOW – Effective January 1, 2008
- MDWS – Effective July 1, 2008
- HDOA – Effective July 1, 2008

Each of the agencies is planning rate increases of approximately 40 percent for the 5-year period following the effective date shown above. The basis for these increases is two-fold:

1. Cost for providing service has increased dramatically, particularly for electricity, construction materials, and labor.

2. Aging infrastructure needs capital infusion to ensure reliability.

Recycled Water

Only one public water supply agency, BWS, is a supplier of recycled water. The other suppliers are wastewater agencies of the Counties of Hawaii, Kauai, and Maui, or private companies that treat and distribute recycled water. The rates for recycled water use are shown in Table 19.

Facilities Charges

Each of the four Counties' public water supply agencies levy water system facilities charges or development fees. These fees are for new developments that require new or additional water connections from existing water services. The purpose of these charges is to establish reserves for capital improvements to the water system including resource development, transmission, and storage. These fees are shown in Table 20.

Stormwater Utilities

Public agencies throughout the U.S. are shifting to fee-based enterprise funds as an alternative to tax-based funding, as a means of complying with stormwater management permits and regulations. The City of Eugene, Oregon; Metropolitan Saint Louis Sewer District; and the City of Durham, North Carolina are examples of the estimated 600 stormwater utilities (Hoskins, 2006) in the U.S. Funding for these utilities is based on the amount of impervious surface area for a given property. A 2007 survey (Black & Veatch, 2007) showed average monthly residential stormwater service rates ranged from $0.75 to $16.82 per month.

A key advantage of fee-based funding is the equity of charges. Tax-exempt organizations do not pay for stormwater management under tax-based systems. Many of these organizations, such as churches and schools, have large areas of impervious surface area including buildings and parking lots. Fee-based utilities include these organizations in their rate structure.

There are five important issues relating to the development of a stormwater utility:

1. Hawaii's regulatory framework must allow development of the utility.
2. Hawaii's regulatory framework must allow the utility to develop a rate structure and collect fees.
3. The concept must be promoted to the public.
4. User fees must be developed.
5. Supplemental funding sources might be necessary.

Establishing stormwater utilities in Hawaii as a means funding stormwater management could provide a revenue source for alternative means of management, including reclamation and reuse.

Conclusions

The following conclusions can be drawn from an analysis of water supply funding:

- Water service providers assess charges for water use and for system development, including pumping, capture, conveyance, storage and treatment. The charges help finance capital improvement projects as well as the day-to-day operation of the agency.

- Charges for water use and system development are intended to derive revenues to make water supply agencies self-supporting.
- Three of the four public water utilities in Hawaii, as well as HDOA for irrigation water, are planning on increases of approximately 40 percent over the next five years.
- Stormwater management is funded currently out of general funds of the Counties and the State.
- A stormwater utility approach that assesses fees based on impervious surface area could provide a funding source for stormwater reclamation and reuse, as well as stormwater management in general.

Table ES-1 in the Executive Summary highlights key issues relating to funding stormwater reclamation and reuse, and possible opportunities for resolution.

Public Issues

Water is an integral part of Hawaiian culture. Though Hawaii is surrounded by water, freshwater has always been the key to sustainability. Prior to Western contact, surface water was the sole source of potable water for Native Hawaiians. As agriculture and development expanded in the 1900s, surface water use yielded to groundwater. Though alternative water sources have been studied and developed, including desalination and recycled water, groundwater remains the principle source of potable water today.

Cultural Issues

The Hawaiian word for law – *kanawai*- incorporates the word *wai*, or water. Water was so integral to land management, that ancient Hawaiian laws included issues involving water rights. *Wai* is also associated with many place names including *Waikiki* (spouting waters), *Waimea* (reddish water), and *Waimanalo* (potable water). The importance of water in the Hawaiian culture is reinforced through themes by prominent native Hawaiian organizations and public agencies, including:

Honolulu Board of Water Supply – ***Ka Wai Ola*** (Water for Life)

Office of Hawaiian Affairs Newsletter – ***Ka Wai Ola*** (The Living Water)

Cultural recognition of the importance of rainfall can be found in two Hawaiian expressions, the first of which is prominently displayed at the entrance to the Honolulu Board of Water Supply:

Uwe ka lani, ola ka honua – When the Heavens weep, the earth lives

Ola i ka wai a ka `opua – There is life in the water from the clouds.

As stated previously, the State Water Code extends water rights to ensuring adequate water reserves for current and foreseeable development and use of Hawaiian homelands, and for traditional and customary rights associated with cultural and subsistence agricultural practices. Stream diversions resulting from historic sugar cane and pineapple production have been a central focus of legal challenges to ensure protection of these traditional and customary rights. These legal challenges often include alliances with environmental groups since reduced stream flow also has environmental impacts. Examples of these challenges are provided below:

- **Waiahole Ditch, Oahu** – When the sugar industry reduced its use of water from the Waiahole Ditch, the CWRM allocated the water in a manner that resulted in a lawsuit by Windward parties that wanted to protect in-stream and cultural uses of the watershed that supplied the water. The Supreme Court ruled in the favor of the Windward parties affirming that water resources are part of the public trust. As such, CWRM must protect, control and regulate water resources for the benefit of the people (Hawaii Supreme Court, Waiahole Ditch Decision).

- **Hamakua Ditches, Hawaii** – Similar to Waiahole Ditch, once the sugar industry stopped using water that had previously been diverted from Waipio Stream, an effort by local groups was made to re-establish the natural flow to Waipio Stream for cultural, agricultural, and environmental reasons (Star Bulletin, October 24, 1997).

- **Stream Diversions, Maui** – Similar to Waiahole Ditch and Waipio Stream, diversions from Waihe`e, North & South Waiehu, `Iao, and Waikapu Streams on Maui have been challenged by public/environmental groups - *Hui o Na Wai Eha*. These diversions have affected stream flow, cultural activities, and groundwater recharge.

Since stormwater is integral to perennial and intermittent streams, stormwater reclamation and reuse that affect streamflow could be met with similar challenges. At the same time, stormwater is recognized as a major contributor of pollution to nearshore coastal waters, and to some, a waste of a water resource (Taum, February 2006).

Another legal challenge was recently initiated based on the impact that stormwater runoff from a large development could have on cultural practices. The Native Hawaiian Legal Corporation recently challenged an application for a large storm drain channel in a development in the Ewa Plain. Protection of *limu* – seaweed used for medicinal purposes – is at the center of the challenge. The concern is that an increase in the amount of stormwater will add to the growth of invasive species that will out-compete the *limu* (*Honolulu Advertiser*, Monday, June 16, 2008).

General Public Issues

The Public Works Departments of the Counties of Hawaii, Kauai, and Maui are responsible for stormwater management, whereas the Department of Environmental Services is responsible for the City and County of Honolulu. The City and County of Honolulu has the most extensive public education campaign about stormwater management (http://www.cleanwaterhonolulu.com/storm/index.php), including videos, fact sheets, and best management practices guidance for residences and businesses. The program also includes community activities such as storm drain stenciling and stream clean-up. Short-term benefits are likely achieved as a result of these activities, but the long-term effectiveness is uncertain. The greatest long-term benefit is likely educating school children as a means of changing behavior about proper disposal of trash.

The HDOT is another public agency responsible for stormwater management in Hawaii. On Oahu alone, HDOT operates and maintains more than 320 miles of roadways with 9,000 storm drain inlets to over 2,200 outfall locations. HDOT has negotiated a consent decree with EPA to implement a range of stormwater management activities to improve the quality of stormwater discharges. HDOT has developed extensive educational, management, and program plans for meeting the requirements of the consent decree. This information is posted on their website http://stormwaterhawaii.com. As with the CCH program, the long-term effectiveness is uncertain.

Both CCH and HDOT have common needs to reduce pollutants associated with stormwater. A TMDL has been established for the Ala Wai Canal on Oahu, and requires an estimated reduction in nitrogen and phosphorus of 65 percent and 50 percent, respectively. Public education and involvement will be critical elements for achieving these goals.

Stormwater-related events likely drive public awareness more than public education. Recent events such as the Manoa Flood on Oahu (2004), the Kaloko Dam collapse on Kauai (2006), and the Ala Wai wastewater spill (2006) were all directly or indirectly related to stormwater, and received significant press coverage.

Despite general awareness and public education programs, direct public attitudes regarding stormwater reclamation and reuse are not known. Public attitudes about potable water supplies and quality of all water resources have been surveyed:

- A 2001 survey showed that only two-fifths of Leeward and Central Oahu's residents felt there was a possible scarcity issue with Oahu's water supply, indicating a need to improve education about limited potable water resources. Almost 90 percent of the respondents believe their drinking water is safe to drink and over 70 percent believe water is sacred (OmniTrak, September 2001).
- A 2005 statewide survey showed that clean drinking water, groundwater, and rivers were extremely to very important to over 90 percent of respondents. Almost 90 percent of the respondents also believe their potable water at home is safe to drink, yet showed that groundwater and surface water deterioration is a concern. (*Water Issues*, August 2005).

Public concerns about safe drinking water also potentially affect stormwater reclamation and reuse, whether used for direct or indirect recharge. On Maui, the City Council proposed an ordinance that would prohibit the use of any groundwater under active agriculture as a drinking water source, due to public concerns about contaminants in drinking water. The final ordinance was limited to Hamakuapoko Wells only. These wells had small concentrations of contaminants from agricultural chemical use. Even though development of the wells would have incorporated treatment to address the contaminants, public opposition was strong. The implications for stormwater reclamation and reuse are the perception of introducing contaminants during recharge (*MauiTime Weekly*, January 4, 2007).

The expansion of recycled water use in Hawaii might be the model for promoting stormwater reclamation and reuse. The public has generally accepted recycled water (from wastewater treatment plants) as an alternative to potable water supplies for irrigation. There are over 70 recycled water users statewide, using over 22 million gallons per day (State of Hawaii, November 2006). Uses include irrigation for golf courses, parks, median strips, and agriculture. The largest number of users is on Maui, whereas the largest volume of use is on Oahu. Both Maui and Oahu have extensive public relations campaigns to promote recycled water use.

Despite the public acceptance of recycled water, the agricultural industry is not receptive to its use due to their customers' acceptance. Some farmers have stated that they believe recycled water is safe for use, but the stores to which they provide produce have stated that they will not accept produce grown with recycled water. The same concerns have been expressed about stormwater use on agricultural products for direct human consumption (not other agricultural products that are not consumed or that have protective skins that are not consumed such as bananas, papayas, and turf grass). The primary concern is microbial contamination.

Conclusions

The following conclusions can be drawn from an assessment of public issues:

- Residents of Hawaii have a general awareness of limitations of fresh water in the island environment.
- Stream diversions that convey water from one part of an island to another have faced legal challenges with the decline of the pineapple and sugarcane production.
- Any transfer of stormwater from one watershed to another could be perceived negatively.
- Public education about stormwater focuses on discharges to storm drains, and subsequent coastal pollution.
- Recycled water use has been expanded with minimal public issues through effective public education programs.
- Development of stormwater reclamation and reuse opportunities would likely benefit from public education similar to that used for recycled water.
- Characterization of stormwater quality (and possible treatment) will be necessary to alleviate concerns from agricultural users about the impact of stormwater on products grown for direct consumption.

Table ES-1 in the Executive Summary highlights key issues relating to public issues and possible opportunities for resolution.

Table 1. Causes of Impaired Water Bodies[1]

Water Quality Standard	Number of Impaired Water Bodies
Turbidity	197
Nutrients	177
Algal Growth	90
Pathogens	52
Floatables	17
Ammonia	13
Pesticides	6
Metals (other than mercury)	4
Polychlorinated biphenyls (PCB)	1

[1] Environmental Planning Office, *Final 2004 List of Impaired Waters in Hawaii*, Hawaii State Department of Health, (June 16, 2004).

Table 2. Impaired Marine Water Bodies by Island[1]

Island	Number of Impaired Water Bodies
Hawaii	31
Kauai	28
Lanai	6
Maui	72
Molokai	3
Oahu	71

[1] Hawaii Department of Health Clean Water Branch, 2006 State of Hawaii Water Quality Monitoring and Assessment Report, January 2008

Table 3. Potential Impact of Current Water Regulations on Stormwater Reclamation and Reuse

Applicable Regulation	Applicable Language	Potential Impact
State Water Code Hawaii Revised Statutes 174C-51.5	Groundwater and surface water are held as public trusts for the benefit of all people. The CWRM has considerable authority to protect surface and groundwater quantity and quality.	Issues such as stream flow standards, instream diversions, and Native Hawaiian Water Rights can potentially promote and detract from stormwater reclamation and reuse.
	The CWRM can require dual water line systems in new industrial and commercial developments when located in designated water management areas. This requirement is contingent on an available source of *nonpotable water.* Though the intent of the language was to promote the use of recycled wastewater, its use of the term *nonpotable water* could apply equally to reclaimed stormwater.	Though there is no requirement for developers to develop nonpotable water sources, the language could promote the use of reclaimed stormwater if a source is made available.
HAR 11-20 *Rules Pertaining to Potable Water Systems*	Direct connections between surface and groundwater can result in a groundwater drinking water source being designated as GWUDI of surface water.	GWUDI designation would require that groundwater be treated in the same manner as surface water, which would be costly. Situations that would result potentially in a GWUDI designation would be resisted by public (and private) water supply agencies.
HAR 11-23 *UIC*	Any new injection well cannot be sited closer than ¼-mile from any part of a drinking water source.	The location of any stormwater injection well for direct recharge would be limited by the spatial dimensions of this regulation. An entire aquifer could be considered the drinking water source, further limiting direct injection.
HAR 11-54 *Water Quality Standards*	TMDL will limit discharge of certain pollutants (receiving water dependent) from point sources, such as stormwater system outfalls.	TMDLs might require that stormwater be treated to meet specific waste load allocations. Such treatment would be expensive and encourage developers to seek alternatives to direct discharge of stormwater to surface waters. This could promote technologies and best management practices for stormwater reclamation and reuse.
HAR 11-62 *Water Systems* *Guidelines for Treatment and Use of Recycled Water*	There are three classes of recycled water. Each class is determined by the level of treatment. The two highest levels of recycled water must meet specific microbiological quality requirements, and, in the case of the highest level of recycled water, turbidity requirements. Compliance with quality requirements for recycled water are determined at the end of the treatment process, not at the point of reuse.	The DOH has verbally said that integration of recycled water and stormwater would require that stormwater meet recycled water quality.

Table 4. List of Stormwater NPDES Permits by Island

Island	Individual Permits	General Permits	Total Permits
Hawaii	1	17	18
Kauai	5	20	25
Lanai	1	2	3
Maui	2	25	27
Molokai		3	3
Oahu	28	115	143
State of Hawaii[1]	6		6

[1] These permits are for the Hawaii Department of Transportation, Department of Agriculture, Department of Accounting and General Services, and the Department of Education for Oahu schools.

Table 5 – Primary Drinking Water Standards and Monitoring Results – Microorganisms

Contaminant	MCL (mg/L) or TT	MCLG	Reported Range (ug/L)	Total Reports	Total Quantifiable Reports	Total Quantifiable Reports Greater Than Limit
Cryptosporidium	TT[1]	Zero	No Data	--	--	--
Giardia Lamblia	TT[1]	Zero	No Data	--	--	--
Heterotrophic plate count (HPC)	TT[1]	n/a	No Data	--	--	--
Legionella	TT[1]	Zero	No Data	--	--	--
Total Coliforms (including fecal coliform and E. coli)[2]	5.0%[3]	Zero	No Data	--	--	--
Turbidity	TT[1]	n/a	4.3 to 2810	20	20	20
Viruses (enteric)	TT[1]	Zero	No Data	--	--	--

[1] EPA's surface water treatment rules require systems using surface water or GWUDI of surface water to (1) disinfect their water and (2) filter their water or meet criteria for avoiding filtration so that the following contaminants are controlled at the following levels:

- *Cryptosporidium:* (as of 1/1/02 for systems serving >10,000 and 1/14/05 for systems serving <10,000) 99% removal.
- *Giardia lamblia:* 99.9% removal/inactivation.
- Viruses: 99.99% removal/inactivation.
- *Legionella:* No limit, but EPA believes that if *Giardia* and viruses are removed/inactivated, *Legionella* will also be controlled.
- Turbidity: At no time can turbidity (cloudiness of water) go above 5 nephelolometric turbidity units (NTU); systems that filter must ensure that the turbidity go no higher than 1 NTU (0.5 NTU for conventional or direct filtration) in at least 95% of the daily samples in any month. As of January 1, 2002, for systems servicing > 10,000, and January 14, 2005, for systems servicing < 10,000, turbidity may never exceed 1 NTU and must not exceed 0.3 NTU in 95% of daily samples in any month.
- HPC: No more than 500 bacterial colonies per milliliter.
- Long Term 1 Enhanced Surface Water Treatment (Effective Date: January 14, 2005); Surface water systems or GWUDI systems serving fewer than 10,000 people must comply with the applicable LT1ESWTR provisions (e.g. turbidity standards, individual filter monitoring, *Cryptosporidium* removal requirements, updated watershed control requirements for unfiltered systems).
- Filter Backwash Recycling; The FBRR requires systems that recycle to return specific recycle flows through all processes of the system's existing conventional or direct filtration system or at an alternate location approved by the state.

[2] Fecal coliform and *E. coli* are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Disease-causing microbes (pathogens) in these wastes can cause diarrhea, cramps, nausea, headaches or other symptoms. These pathogens may pose a special health risk for infants, young children and people with severely compromised immune systems

[3] No more than 5% samples total coliform-positive in a month. (For water systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive per month.) Every sample that has total coliform must be analyzed for either fecal coliforms or *E. coli* if two consecutive TC-positive samples and one is also positive for *E.coli* fecal coliforms, system has an acute MCL violation.

Table 6 – Primary Drinking Water Standards and Monitoring Results – Disinfection By-Products

Contaminant	MCL (mg/L) or TT	MCLG (mg/L)	Reported Range (ug/L)	Total Reports	Total Quantifiable Reports	Total Quantifiable Reports Greater Than Limit
Bromate	0.010	Zero	No Data	--	--	--
Chlorite	1.0	0.8	No Data	--	--	--
Haloacetic acids (HAA5)	0.060	n/a[1]	No Data	--	--	--
Total Trihalomethanes (TTHMs)	0.10; 0.080 after 12/31/03	n/a[1]	No Data	--	--	--

[1] Although there is no collective MCLG for this contaminant group, there are individual MCLG for some of the individual contaminants:

- Haloacetic acids: dichloroacetic acid (zero); trichloroacetic acid (0.3 mg/L)
- Trihalomethanes: bromodichloromethane (zero); bromoform (zero); dibromochloromethane (0.06 mg/L).

Table 7 – Primary Drinking Water Standards and Monitoring Results – Disinfectants

Contaminant	MRDL (mg/L)	MRDLG (mg/L)	Reported Range (ug/L)	Total Reports	Total Quantifiable Reports	Total Quantifiable Reports Greater Than Limit
Chloramines (as Cl_2)	4.0	4	No Data	**--**	**--**	**--**
Chlorine (as Cl_2)	4.0	4	< 0.2 to 50	3	2	0
Chlorine dioxide (as ClO_2)	0.8	0.8	No Data	**--**	**--**	**--**

Table 8 – Primary Drinking Water Standards and Monitoring Results – Inorganic Chemicals

Contaminant	MCL (mg/L) or TT	MCLG (mg/L)	Reported Range, (ug/L)	Total Reports	Total Quantifiable Reports	Total Quantifiable Values Greater Than Limit
Antimony	0.006	0.006	< 10	1	0	0
Arsenic	0.010 as of 1/23/06	0	ND to 21.3	18	4	3
Asbestos (fiber>10 µm)	7 million fibers per Liter (MFL)	7 MFL	No Data	--	--	--
Barium	2	2	No Data	--	--	--
Beryllium	0.004	0.004	ND to < 4	2	0	0
Cadmium	0.005	0.005	ND to < 5	16	0	0
Chromium (total)	0.1	0.1	ND to 110	7	3	1
Copper	TT[1]; Action Level=1.3	1.3	ND to 146	30	25	0
Cyanide (as free cyanide)	0.2	0.2	N/A	0	0	0
Fluoride	4.0	4.0	No Data	--	--	--
Lead	TT[1]; Action Level=0.015	Zero	ND to 331	41	22	13
Mercury (inorganic)	0.002	0.002	< 1	1	0	0
Nitrate (measured as Nitrogen)	10	10	ND	4	0	0
Nitrite (measured as Nitrogen)	1	1	ND	4	0	0
Total Nitrate + Nitrite (as N)	10	10	ND to 71,000	128	106	2
Selenium	0.05	0.05	< 10	1	0	0
Thallium	0.002	0.0005	< 1	1	0	0

1. Lead and copper are only listed in EPA's Federal Standards

2. Lead and copper are regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10% of tap water samples exceed the action level, water systems must take additional steps. For copper, the action level is 1.3 mg/L and for lead is 0.015 mg/L.

Table 9 – Primary Drinking Water Standards and Monitoring Results – Organic Chemicals

Contaminant	MCL (mg/L) or TT	MCLG (mg/L)	Reported Range, (ug/L)	Total Reports	Total Quantifiable Reports	Total Quantifiable Values Greater Than Limit
Acrylamide	TT[1]	Zero	No Data	--	--	--
Alachlor	0.002	Zero	No Data	--	--	--
Atrazine	0.003	0.003	No Data	--	--	--
Benzene	0.005	Zero	ND to 1000	33	1	1
Benzo(a)pyrene (PAHs)	0.0002	Zero	ND to < 12.5	16	0	0
Carbofuran	0.04	0.04	No Data	--	--	--
Carbon tetrachloride	0.005	Zero	< 5	11	0	0
Chlordane	0.002	Zero	No Data	--	--	--
Chlorobenzene	0.1	0.1	No Data	--	--	--
2,4-D	0.07	0.07	No Data	--	--	--
Dalapon	0.2	0.2	No Data	--	--	--
Dibromochloropropane[2]	0.00004		No Data	--	--	--
1,2-Dibromo-3-chloropropane (DBCP)	0.0002	Zero	No Data	--	--	--
o-Dichlorobenzene	0.6	0.6	No Data	--	--	--
p-Dichlorobenzene	0.075	0.075	No Data	--	--	--
1,2-Dichloroethane	0.005	Zero	< 5	10	0	0
1,1-Dichloroethylene	0.007	0.007	No Data	--	--	--
cis-1,2-Dichloroethylene	0.07	0.07	No Data	--	--	--
Trans-1,2-Dichloroethylene	0.1	0.1	No Data	--	--	--
Dichloromethane	0.005	Zero	No Data	--	--	--
1,2-Dichloropropane	0.005	Zero	No Data	--	--	--
Di(2-ethylhexyl)adipate	0.4	0.4	No Data	--	--	--
Di(2-ethylhexyl)phthalate	0.006	Zero	No Data	--	--	--
Dinoseb	0.007	0.007	No Data	--	--	--
Dioxin (2,3,7,8-TCDD)	0.00000003	Zero	No Data	--	--	--
Diquat	0.02	0.02	No Data	--	--	--
Endothall	0.1	0.1	No Data	--	--	--
Endrin	0.002	0.002	No Data	--	--	--
Epichlorohydrin	TT[1]	Zero	No Data	--	--	--
Ethylbenzene	0.7	0.7	ND to < 5	29	0	0
Ethylene dibromide	0.00004	Zero	No Data	--	--	--
Glyphosate	0.7	0.7	No Data	--	--	--

Table 9 – Primary Drinking Water Standards and Monitoring Results – Organic Chemicals (continued)

Contaminant	MCL (mg/L) or TT	MCLG (mg/L)	Reported Range, (ug/L)	Total Reports	Total Quantifiable Reports	Total Quantifiable Values Greater Than Limit
Heptachlor	0.0004	Zero	No Data	--	--	--
Heptachlor epoxide	0.0002	Zero	No Data	--	--	--
Hexachlorobenzene	0.001	Zero	No Data	--	--	--
Hexachlorocyclopentadiene	0.05	0.05	No Data	--	--	--
Lindane	0.0002	0.0002	No Data	--	--	--
Methoxychlor	0.04	0.04	No Data	--	--	--
Monochlorobenzene[3]	0.1		No Data	--	--	--
Oxamyl (Vydate)	0.2	0.2	No Data	--	--	--
Pentachlorophenol	0.001	Zero	No Data	--	--	--
Picloram	0.5	0.5	No Data	--	--	--
Polychlorinated biphenyls (PCBs)	0.0005	Zero	< 0.505 to < 0.541	4	0	0
Simazine	0.004	0.004	No Data	--	--	--
Styrene	0.1	0.1	No Data	--	--	--
Tetrachloroethylene	0.005	Zero	< 5	3	0	0
Toluene	1	1	ND to 2600	33	2	1
Toxaphene	0.003	Zero	No Data	--	--	--
2,4,5-TP (Silvex)	0.05	0.05	No Data	--	--	--
1,2,4-Trichlorobenzene	0.07	0.07	No Data	--	--	--
1,1,1-Trichloroethane	0.2	0.2	No Data	--	--	--
1,1,2-Trichloroethane	0.005	0.003	No Data	--	--	--
Trichloroethylene	0.005	Zero	ND to < 5	4	0	0
1,2,3-Trichloropropane [3]	0.0006		No Data	--	--	--
Vinyl Chloride	0.002	Zero	ND to < 2	12	0	0
Xylenes (total)	10	10	ND to < 5	16	0	0

[1] Acrylamide, Chlorobenzene, 1,2-Dibromo-3-chloropropane and Epichlorohydrin are only listed in EPA's Federal Standards. Each water system must certify, in writing, to the state (using third-party or manufacturer's certification) that when it uses acrylamide and/or epichlorohydrin to treat water, the combination (or product) of dose and monomer level does not exceed the levels specified, as follows:

- Acrylamide = 0.05% dosed at 1 mg/L (or equivalent)
- Epichlorohydrin = 0.01% dosed at 20 mg/L (or equivalent)

[2] Dibromochloropropane is only listed in DOH's HAR 11-20. Does not list a MCLG.

[3] Monochlorobenzene and 1,2,3-Trichloropropane are only listed in DOH's HAR 11-20. Does not list a MCLG.

Table 10 – Primary Drinking Water Standards and Monitoring Results – Radionuclides

Contaminant	MCL (mg/L) or TT	MCLG (mg/L)	Reported Range, (ug/L)	Total Reports	Total Quantifiable Reports	Total Quantifiable Values Greater Than Limit
Alpha particles	15 picocuries per Liter (pCi/L)	Zero	No Data	--	--	--
Beta particles and photon emitters	4 millirems per year	Zero	No Data	--	--	--
Radium 226 and Radium 228 (combined)	5 pCi/L	Zero	No Data	--	--	--
Uranium	30 µg/L as of 12/08/03	Zero	No Data	--	--	--

Table 11 – Secondary Drinking Water Standards and Monitoring Results

Contaminant	Secondary Standard	Reported Range, (ug/L)	Total Reports	Total Quantifiable Reports	Total Quantifiable Values Greater Than Limit
Aluminum	0.05 to 0.2 mg/L	ND to 23,400	21	17	17
Chloride	250 mg/L	63,700	1	1	0
Color	15 (color units)	No Data	--	--	--
Copper	1.0 mg/L	No Data	--	--	--
Corrosivity	Noncorrosive	No Data	--	--	--
Fluoride	2.0 mg/L	No Data	--	--	--
Foaming Agents	0.5 mg/L	No Data	--	--	--
Iron	0.3 mg/L	ND to 23,000	25	21	18
Manganese	0.05 mg/L	47	1	1	0
Odor	3 threshold odor number	No Data	**--**	**--**	**--**
pH	6.5-8.5	3.34 to 10.07	139	139	20
Silver	0.10 mg/L	ND, < 10	2	0	0
Sulfate	250 mg/L	No Data	--	--	--
Total Dissolved Solids	500 mg/L	17,000 to 24,100,000	13	13	5
Zinc	5 mg/L	ND to 1,310	30	24	0

Table 12. Hawaii Water Quality Standards for Surface Water

Constituent	Surface Water Quality Standards[1]				Reported Range, (ug/L)	Total Reports	Total Quantifiable Reports	Total Quantifiable Values Greater than Limit
	Freshwater		Saltwater					
	Acute	Chronic	Acute	Chronic				
Acenapthene	570	ns	320	ns	ND to <12.5	21	0	0
Acrolein	23	ns	18	ns	Not monitored			
Acrylonitrile	2500	ns	ns	ns	Not monitored			
Aldrin	3	ns	1.3	ns	Not monitored			
Aluminum	750	260	ns	ns	ND to 23,400	21	17	13
Antimony	3000	ns	ns	ns	<10	1	0	0
Arsenic	360	190	69	36	ND to 21.3	18	4	0
Benzene	1800	ns	1700	ns	ND to 1,000	33	1	0
Benzidine	800	ns	ns	ns	Not monitored			
Beryllium	43	ns	ns	ns	ND to <4	2	0	0
Cadmium	3+	3+	43	9.3	ND to <5	16	0	0
Carbon tetrachloride	12,000	ns	16000	ns	ND to <5	11	0	0
Chlordane	2.4	0.0043	0.09	0.004	Not monitored			
Chlorine	19	11	13	7.5	<0.2 to 50	3	2	2
Chloroesters-ethyl (bis-2)	ns	ns	ns	ns	Not monitored			
Chloroesters-isoprophyl	ns	ns	ns	ns	Not monitored			
Chloroesters-methyl (bis)	ns	ns	ns	ns	Not monitored			
Chloroform	9600	ns	ns	ns	<5	11	0	0
Chlorophenol	1400	ns	ns	ns	Not monitored			
Chlorpyrifos	0.083	0.041	0.011	0.0056	v			
Chromium (VI)	16	11	1100	50	ND to 110	7	3	2
Copper	6+	6+	2.9	2.9	ND to 146	31	25	25
Cyanide	22	5.2	1	1	Not monitored			
DDT	1.1	0.001	0.013	0.001	Not monitored			
DDT – metabolite TDE	0.03	ns	1.2	ns	Not monitored			
Demeton		0.1	ns	0.1	Not monitored			
Dichloro-benzene	370	ns	660	ns	ND to <10.1	11	0	0
Dichloro-benzidine	ns	ns	ns	ns	Not monitored			
Dichloro-ethane (1,2)	39000	ns	38000	ns	<5	10	0	0
Dichloro-ethylene (1,1)	3900	ns	75000	ns	Not monitored			
Dichloro-phenol (2,4)	670	ns	ns	ns	Not monitored			
Dichloro-propanes	7700	ns	3400	ns	Not monitored			

Table 12. Hawaii Water Quality Standards for Surface Water (continued)

Constituent	Surface Water Quality Standards[1]				Reported Range, (ug/L)	Total Reports	Total Quantifiable Reports	Total Quantifiable Values Greater than Limit
	Freshwater		Saltwater					
	Acute	Chronic	Acute	Chronic				
Dichloro-propene	2000	ns	260	ns	Not monitored			
Dieldrin	2.5	0.0019	0.71	0.0019	Not monitored			
Dinitro o-cresol (2,4)	ns	ns	ns	ns	Not monitored			
Dinitro toluenes	110	ns	200	ns	Not monitored			
Dioxine	0.003	ns	ns	ns	Not monitored			
Diophenyl-hydrazine (1,2)	ns	ns	ns	ns	Not monitored			
Endosulfan	0.22	0.056	0.034	0.0087	Not monitored			
Endrin	0.18	0.0023	0.037	0.0023	Not monitored			
Ethylbenzene	11000	ns	140	ns	ND to <5	29	0	0
Fluoroethene	1300	ns	13	ns	Not monitored			
Guthion	ns	0.01	ns	0.01	Not monitored			
Heptachlor	0.52	0.0038	0.053	0.0036	Not monitored			
Hexachloro-benzene	ns	ns	ns	ns	Not monitored			
Hexachloro-butadiene	30	ns	11	ns	Not monitored			
Hexachloro-cyclohexane-alpha	ns	ns	ns	ns	Not monitored			
Hexachloro-cyclohexane-beta	ns	ns	ns	ns	Not monitored			
Hexachloro-cyclohexane-technical	ns	ns	ns	ns	Not monitored			
Hexachloro-cyclopentadiene	2	ns	2	ns	Not monitored			
Hexachloro-ethane	330	ns	310	ns	Not monitored			
Isophorone	39000	ns	4300	ns	Not monitored			
Lead	29+	29+	140	5.6	ND to 331	41	22	19
Lindane	2	0.08	0.16	ns	Not monitored			
Malathione	ns	0.1	ns	0.1	Not monitored			
Mercury	2.4	0.55	2.1	0.025	<1	1	0	0
Methoxychlor	ns	0.03	ns	0.03	Not monitored			
Mirex	ns	0.001	ns	0.001	Not monitored			
Naphthalene	770	ns	780	ns	ND to <10.3	26	2	0
Nickel	5+	5+	75	8.3	ND to 6,200	6	4	4
Nitrobenzene	9000	ns	2200	ns	Not monitored			
Nitrophenols	77	ns	1600	ns	Not monitored			
Nitrosamines	1950	ns	ns	ns	Not monitored			

Table 12. Hawaii Water Quality Standards for Surface Water (continued)

Constituent	Surface Water Quality Standards[1]				Reported Range, (ug/L)	Total Reports	Total Quantifiable Reports	Total Quantifiable Values Greater than Limit
	Freshwater		Saltwater					
	Acute	Chronic	Acute	Chronic				
Nitroso dibutylamine-N	ns	ns	ns	ns	Not monitored			
Nitroso diethylamine-N	ns	ns	ns	ns	Not monitored			
Nitroso dimethylamine-N	ns	ns	ns	ns	Not monitored			
Nitroso diphenylamine-N	ns	ns	ns	ns	Not monitored			
Nitroso pyrrolidine-N	ns	ns	ns	ns	Not monitored			
Parathione	0.065	0.013	ns	ns	Not monitored			
Pentachloroethanes	2400	ns	130	ns	Not monitored			
Pentachlorobenzene	ns	ns	ns	ns	Not monitored			
Pentachlorophenol	20	13	13	ns	Not monitored			
Phenol	3400	ns	170	ns	ND	1	0	0
Phenol, 2,4-dimethyl	700	ns	ns	ns	Not monitored			
Phthalate esters – dibutyl	ns	ns	ns	ns	Not monitored			
Phthalate esters – diethyl	ns	ns	ns	ns	Not monitored			
Phthalate esters – di-2-ethylhexyl	ns	ns	ns	ns	Not monitored			
Phthalate esters – dimethyl	ns	ns	ns	ns	Not monitored			
Polychlorinated biphenyls	2	0.014	10	0.03	<0.505 to <0.541	4	0	0
Polynuclear aromatic hydrocarbons	ns	ns	ns	ns	Not monitored			
Selenium	20	5	300	71	<10	1	0	0
Silver	1+	1+	2.3	ns	ND to <10	2	0	0
Tetrachloro-ethanes	3100	ns	ns	ns	Not monitored			
Tetrachloro-benzene (1,2,4,5)	ns	ns	ns	ns	Not monitored			
Tetra-chloro-ethane (1,1,2,2)	ns	ns	3000	ns	<5	11	0	0
Tetrachloro-ethylene	1800	ns	3400	145	<5	3	0	0
Tetrachloro-phenol (2,3,5,6)	ns	ns	ns	440	Not monitored			
Thallium	470	ns	710	ns	<1	1	0	0
Toluene	5800	ns	2100	ns	ND to 2,600	33	2	1
Toxaphene	0.73	0.0002	0.21	0.0002	Not monitored			
Tributyltin	ns	0.026	ns	0.1	Not monitored			

Table 12. Hawaii Water Quality Standards for Surface Water (continued)

Constituent	Surface Water Quality Standards[1]				Reported Range, (ug/L)	Total Reports	Total Quantifiable Reports	Total Quantifiable Values Greater than Limit
	Freshwater		Saltwater					
	Acute	Chronic	Acute	Chronic				
Trichloro-ethane (1,1,1)	6000	ns	10400	ns	<5	11	0	0
Trichloro-ethane (1,1,2)	6000	ns	ns	ns	<5	11	0	0
Trichloro-ethylene	15000	ns	700	ns	ND to <5	4	0	0
Trichloro-phenol (2,4,6)	ns	ns	ns	ns	Not monitored			
Vinyl chloride	ns	ns	ns	ns	ND to <2	12	0	0
Zinc	22+	22+	95	86	ND to 1,310	31	24	24

Table 13. Microbiological Parameters by Regulation

DOH Branch	Reference	Regulation	Microbiological Parameter
Safe Drinking Water Branch	HAR 11-20	Rules Relating to Potable Water Systems	▪ Total and fecal coliform ▪ *Cryptosporidium* ▪ *Giardia* ▪ *Viruses*
Clean Water Branch	HAR 11-54	Water Quality Standards (surface)	▪ *Enterococcus*
	HAR 11-55	NPDES Permits	▪ *Enterococcus*
Wastewater Branch	HAR 11-62	Wastewater Systems and Guidelines for the Treatment and Use of Recycled Water	▪ Fecal coliform

Table 14. Comparison of Microbiological Quality from Various Oahu Water Sources

Bacteriological Indicator	Honouliuli WWRF	Impacted Well	Pristine Well	Waiahole Ditch
Cryptosporidium Oocysts	<0.1 to 0.2	<0.1	<0.1	<0.1 to <0.8
Cryptosporidium Oocysts	<0.1 to 0.8	<0.1	<0.1	<0.1 to <0.8
Clostridium perfingens	<0.1 to 47	<1	<1	12 to 82
Fecal Coliform	<1 to 24	<1 to < 2	<1 to 1	80 to 3,000
Fecal Streptococcus	<1 to 2	<1 to <2	<1 to <2	300 to 1,600
Giardia species cysts, DAPi & DIC Positive	<0.1 to 2	<0.1	<0.1	<0.1 to <0.8
Giardia species cysts, Florescence antibody	<0.1 to 0.5	<0.1	<0.1	<0.1 to <0.8
Total coliform	<1 to 1,000	<1 to < 2	< 1 to 1	300 to 9,000
Total Suspended Solids	**<0.5 to 6.5**	**<0.5 to 3.5**	**<0.5 to 1.2**	**<0.5 to 7.5**

Table 15. Summary of the Constituents which Exceeded Applicable Standards

Constituent	Applicable Standard	Island	No. of Exceedances
Aluminum	Drinking Water (Secondary Standards)	Oahu	9
		Kauai	2
		Maui	3
		Hawaii	1
		Molokai	1
		Lanai	1
	Surface Water	Oahu	6
		Kauai	2
		Maui	3
		Hawaii	1
		Lanai	1
Arsenic	Drinking Water (Primary Standards)	Oahu	1
		Kauai	2
Benzene	Drinking Water (Primary Standards)	Kauai	1
Chlorine	Surface Water	Maui	2
Chromium	Drinking Water (Primary Standards)	Oahu	1
	Surface Water	Oahu	1
		Kauai	1
Copper	Surface Water	Oahu	14
		Kauai	3
		Maui	6
		Hawaii	2
Iron	Drinking Water (Secondary Standards)	Oahu	13
		Kauai	1
		Maui	1
		Hawaii	1
		Molokai	1
		Lanai	1
Lead	Drinking Water (Primary Standards)	Oahu	13
	Surface Water	Oahu	18
		Kauai	1
Nickel	Surface Water	Oahu	1
		Kauai	2
		Maui	1
pH	Drinking Water (Secondary Standards)	Oahu	11
		Kauai	1
		Maui	6
		Hawaii	2
Toluene	Drinking Water (Primary Standards)	Kauai	1
	Surface Water	Kauai	1
Total Dissolved Solids	Drinking Water (Secondary Standards)	Oahu	5
Total Nitrate + Nitrite (as N)	Drinking Water (Primary Standards)	Kauai	1
		Hawaii	1
Turbidity	Drinking Water (Primary Standards)	Oahu	17
		Kauai	1
		Maui	1
		Hawaii	1
	Recycled Water	Oahu	17
		Maui	1
		Hawaii	1
Zinc	Surface Water	Oahu	18
		Kauai	2
		Maui	1
		Hawaii	1
		Molokai	1
		Lanai	1

Table 16. Residential Rates

Usage	Dollars per 1,000 gallons			
	HBWS [1]	HDWS [2]	KDOW	MDWS
Block 1 [A]	2.46	2.45	2.65	1.60
Block 2 [B]	2.96	3.25	3.40	2.80
Block 3 [C]	4.42	4.45	4.90	3.90
Block 4 [D]	N/A	5.35	N/A	N/A

[1] The three rates for HBWS apply to a different block structure for multi-family residences: Block 1 is 0 – 9,000 gallons; Block 2 is 9,001 - 22,000 gallons; Block 3 is 22,000 + gallons.

[2] Each rate includes a $1.70 per 1,000 gallons power charge.

[A] HBWS (0 – 13,000 gallons); HDWS (0 – 5,000 gallons); KDWS (0-20,000 gallons); MDWS (0 – 10,000 gallons)

[B] HBWS (13,001 – 30,000 gallons); HDWS (5,001 – 15,000 gallons); KDWS (20,001 - 40,000 gallons); MDWS (10,001 – 25,000 gallons)

[C] HBWS (30,001+ gallons); HDWS (15,001- 40,000 gallons); KDWS (40,001+ gallons); MDWS (25,001+ gallons)

[D] HDWS (40,001+ gallons)

Table 17. Agricultural Rates

Usage	Dollars per 1,000 gallons				
	HDOA	HBWS	HDWS [1]	KDOW	MDWS
Block 1 [A]	0.42	2.46	2.55	1.30	1.55
Block 2 [B]	N/A	1.05	N/A	N/A	2.40
Block 3 [C]	N/A	N/A	N/A	N/A	1.00

[1] The rate includes a $1.70/1,000 gallon power cost charge.

[A] HBWS (0 – 13,000 gallons); HDWS (0 – 5,000 gallons); KDWS (0-20,000 gallons); MDWS (0 – 10,000 gallons)

[B] HBWS (13,001 – 30,000 gallons); MDWS (10,001 – 25,000 gallons)

[C] HBWS (30,001+ gallons); MDWS (25,001+ gallons)

Table 18. Non-Potable Rates

Usage	Dollars per 1,000 gallons			
	HBWS	HDWS	KDOW	MDWS
All	1.38	N/A	N/A	1.00

Table 19. Recycled Water Rates

Source	Type	Use	Volume, MGD	Rate, Dollars per 1,000 gallons
Hawaii				
Waikaloa Beach Resort WRF	R-2	Golf Course	0.5	0.30
Mauna Lani WWRF	R-2	Nursery/Sod Farming/Composting	0.25	Free
Heeia WWRF	R-2	Golf Course	0.5	Pumping Costs
Punalu'u Water and Sewer	R-2	Golf Course	0.012	Free
South Kohala WW Corporation	R-2	Golf Course	0.27	0.35
Kealakehe WWRF	R-2	Driving Range	0.06	Free
Waimea Wastewater Company WRF	R-3	Pasture	0.045	Free
Keahole International Airport WWRF	R-1	Landscape	0.03	Free
Oahu				
Marine Corps Base Hawaii WWRF	R-2	Golf Course	0.5	Free
Laie WWRF	R-1	Agriculture/Landscape	0.3	Free[1]
Kulima WWRF	R-2	Golf Course	0.16	Free
Wahiawa WWRF	R-2	Agriculture	3.6	Free[2]
Wahiawa WWRF	R-2	Agriculture	0.58	0.30
Kunia WRF	R-1	Agriculture	0.05	Free
Waiawa Correctional Facility WWRF	R-2	Agriculture/Landscape	0.035	Free
Honouliuli WWRF	R-1	Golf Course/Landscape	6.1+	1.20
Honouliuli WWRF	R-O	Industrial	1.58	4.00 – 5.00
Kauai				
Lihue WWRF	R-2	Golf Course	1.2	Free
Wailua WWRF	R-2	Golf Course	0.65	Free
Waimea WWRF	R-2	Agriculture	0.3	Free
Princeville Utilities Company	R-2	Golf Course	0.65	0.16
Grove Farm Development – Puhi WWRF	R-1	Golf Course	0.2	Free
Poipu WWRF	R-2	Golf Course	0.25	Free
Hyatt WWTP	R-2	Golf Course	0.2	Free

Table 19. Recycled Water Rates (continued)

Source	Type	Use	Volume, MGD	Rate, Dollars per 1,000 gallons
Maui				
Lanai Water Company	R-1	Golf Course	0.25	Free
Manele Bay Resort WWRF	R-1	Golf Course	0.16	Free
Kihei WWRF	R-1	Golf Course	0.9	0.20
Kihei WWRF	R-1	Agriculture, Landscape, Toilet Flushing	0.25	0.20 - 0.97
Kihei WWRF	R-1	Landscape	1.03	0.97
Kihei WWRF	R-1	Sediment Control/Pasture Irrigation	0.01	0.10
Kihei WWRF	R-1	Landscape/Fish Pond	0.02	0.45
Kihei WWRF	R-1	Cooling Algae Domes	0.02	0.97
Kihei WWRF	R-1	Dust Control	0.020	0.97
Kihei WWRF	R-1	Dust Control/Landscape	0.001	0.97
Kihei WWRF	R-1	Green Waste Composting/Vermiculture	0.007	0.2
Kaunakakai WWRF	R-2	Landscape	0.005	0.97
Lahaina WWRF	R-1	Golf Course/Landscape	1.0	0.16
Lahaina WWRF	R-1	Agriculture	0.01	0.02
Kahului WWRF	R-1	Landscape	0.02	0.97
Pukalani WWRF	R-2	Golf Course	0.23	0.55
Kaluakoi WWRF	R-2	Golf Course	0.04	Free
Makena WWRF	R-1	Golf Course	0.07	Free
Haleakala National Park WWRF	R-1	Toilet/Urinal Flushing	0.0001	Free
Puu O Hoku Ranch Constructed Wetland	R-3	Landscape	0.0037	Free

[1] Plans to charge $1.00 per 1,000 gallons

[2] Army pays $9 million for seven years

Table 20. Public Water Supply Facility Charges

Meter Size, inch	Facilities Charge, dollars			
	HDWS	HBWS[1]	KDOW	MDWS
5/8	1,190	4,820	4,600	6,030
¾	--	6,670	14,300	8,442
1	13,750	10,930	26,400	15,678
1-1/2	27,500	29,650	53,200	34,974
2	44,000	64,865	90,700	61,506
3	82,500	--	170,000	138,690
4	137,500	--	283,400	247,230
6	275,000	--	566,800	555,966
8	495,000	--	907,000	987,714
10	797,500	--	--	1,543,680
12	1,182,500	--	--	2,222,658

[1] These charges are for agriculture only. Facilities Charges for residential and non-residential users are based on fixture units (e.g., sink, toilet, etc.). The charge per fixture unit is $185 for a single family residence; $271 per multifamily low-rise (three stories or less); $204 per multifamily high rise; $621 for non-residential with 50 fixture units or less; and $220 for non-residential units with more than 50 fixture units.

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Appendix A

Table 2F-2

Conventional and Nonconventional Pollutants

Bromide
Chlorine, Total Residual
Color
Fecal Coliform
Fluoride
Nitrate-Nitrite
Nitrogen, Total Organic
Oil and Grease
Phosphorus, Total
Radioactivity
Sulfate
Sulfite
Surfactants
Aluminum, Total
Barium, Total
Boron, Total
Cobalt Total
Iron, Total
Magnesium, Total
Molybdenum, Total
Manganese, Total
Tin, Total
Titanium, Total

Table 2F-3

Toxic Pollutants

Toxic Pollutants and Total Phenol

Antimony, Total
Arsenic, Total
Beryllium, Total
Cadmium, Total
Chromium, Total
Copper, Total
Lead, Total
Mercury, Total
Nickel, Total
Selenium, Total
Silver, Total
Thallium, Total
Zinc, Total
Cyanide, Total
Phenols, Total

GC/MS Fraction Volatiles Compounds

Acrolein
Acrylonitrile
Benzene
Bromoform
Carbon Tetrachloride
Chlorobenzene
Chlorodibromomethane
Chloroethane
2-Chloroethylvinyl Ether
Chloroform
Dichlorobromomethane
1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethylene
1,2-Dichloropropane
1.3-Dichloropropylene
Ethylbenzene
Methyl Bromide
Methyl Chloride
Methylene Chloride
1,1,2,2,-Tetrachloroethane
Tetrachloroethylene
Toluene
1,2-Trans-Dichloroethylene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethylene
Vinyl Chloride

Acid Compounds

2-Chlorophenol
2,4-Dichlorophenol
2,4-Dimethylphenol
4,6-Dinitro-O-Cresol
2,4-Dinitrophenol
2-Nitrophenol
4-Nitrophenol
p-Chloro-M-Cresol
Pentachlorophenol
Phenol
2,4,6-Trichlorophenol
2-methyl-4,6 dinitrophenol

Base/Neutral

Acenaphthene
Acenaphthylene
Anthracene
Benzidine
Benzo(a)anthracene
Benzo(a)pyrene
3,4-Benzofluoranthene
Benzo(ghi)perylene
Benzo(k)fluoranthene
Bis(2-chloroethoxy)methane
Bis(2-chloroethyl)ether
Bis(2-chloroisopropyl)ether
Bis(2-ethylyhexyl)phthalate
4-Bromophenyl Phenyl Ether
Butylbenzyl Phthalate
2-Chloronaphthalene
4-Chlorophenyl Phenyl Ether
Chrysene
Dibenzo(a,h)anthracene
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
3,3'-Dichlorobenzidine
Diethyl Phthalate
Dimethyl Phthalate
Di-N-Butyl Phthalate
2,4-Dinitrotoluene
2,6-Dinitrotoluene
Di-N-Octyphthalate
1,2-Diphenylhydrazine (as Azobenzene)
Fluroranthene
Fluorene
Hexachlorobenzene
Hexachlorobutadiene
Hexachloroethane
Indeno(1,2,3-cd)pyrene
Isophorone
Napthalene
Nitrobenzene
N-Nitrosodimethylamine
N-Nitrosodi-N-Propylamine
N-Nitrosodiphenylamine
Phenanthrene
Pyrene
1,2,4-Trichlorobenzene

Pesticides

Aldrin
Alpha-BHC
Beta-BHC
Gamma-BHC
Delta-BHC
Chlordane
4,4'-DDT
4,4'-DDE
4,4'-DDD
Dieldrin
Alpha-Endosulfan
Beta-Endosulfan
Endosulfan Sulfate
Endrin
Endrin Aldehyde
Heptachlor
Heptachlor Epoxide
PCB-1242
PCB-1254
PCB-1221
PCB-1232
PCB-1248
PGB-1260
PCB-1016
Toxaphene

Table 2F-4

Hazardous Substances

Toxic Pollutant

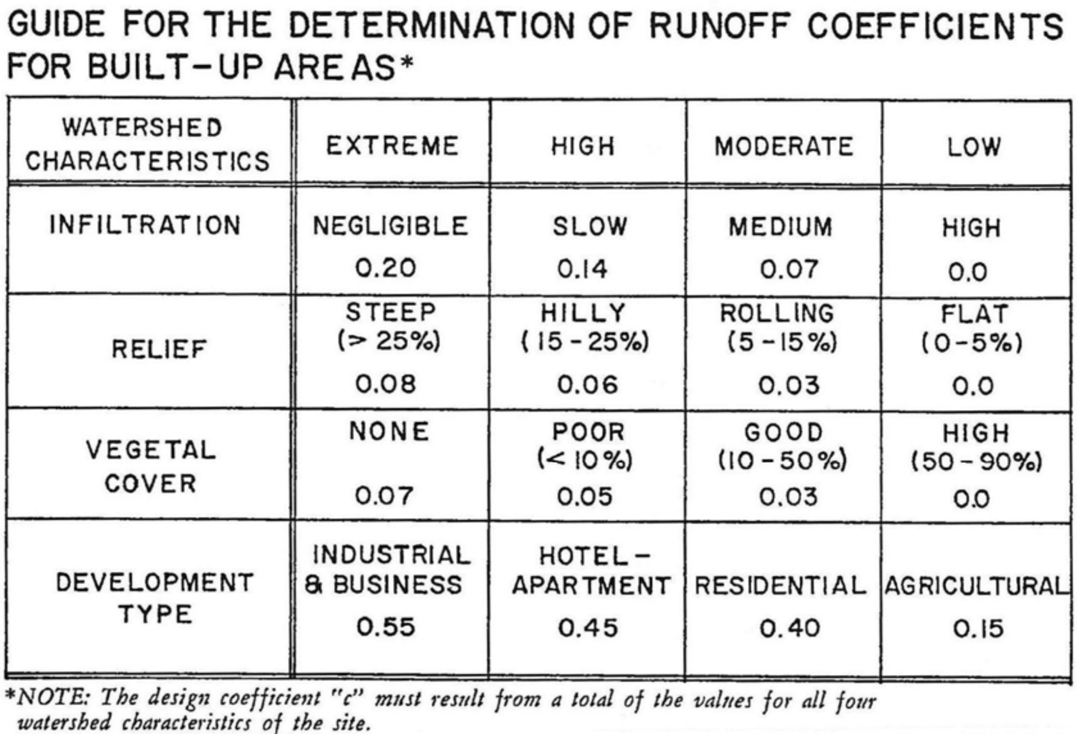
Asbestos

Hazardous Substances

Acetaldehyde
Allyl alcohol
Allyl chloride
Amyl acetate
Aniline .
Benzonitrile
Benzyl chloride
Butyl acetate
Butylamine
Carbaryl
Carbofuran
Carbon disulfide
Chlorpyrifos
Coumaphos
Cresol
Crotonaldehyde
Cyclohexane
2,4-D (2,4-Dichlorophenoxyacetic acid)
Diazinon
Dicamba
Dichlobenil
Dichlone
2,2-Dichloropropionic acid
Dichlorvos
Diethyl amine
Dimethyl amine
Dinitrobenzene
Diquat
Disulfoton
Diuron
Epichlorohydrin
Ethion
Ethylene diamine
Ethylene dibromide
Formaldehyde
Furfural
Guthion
Isoprene
Isopropanolamine
Kelthane
Kepone
Malathion
Mercaptodimethur
Methoxychlor
Methyl mercaptan
Methyl methacrylate
Methyl parathion
Mevinphos
Mexacarbate
Monoethyl amine
Monomethyl amine
Naled
Napthenic acid
Nitrotoluene
Parathion
Phenolsulfonate
Phosgene
Propargite
Propylene oxide
Pyrethrins
Quinoline
Resorcinol
Stronthium
Strychnine
Styrene
2,4,5-T (2,4,5-Trichlorophenoxyacetic acid)
TDE (Tetrachlorodiphenyl ethane)
2,4,5-TP [2-(2,4,5-Trichlorophenoxy) propanoic acid]
Trichlorofan
Triethylamine
Trimethylamine
Uranium
Vanadium
Vinyl acetate
Xylene
Xylenol
Zirconium

APPENDIX B
DESIGN STANDARD TABLES

Table 1

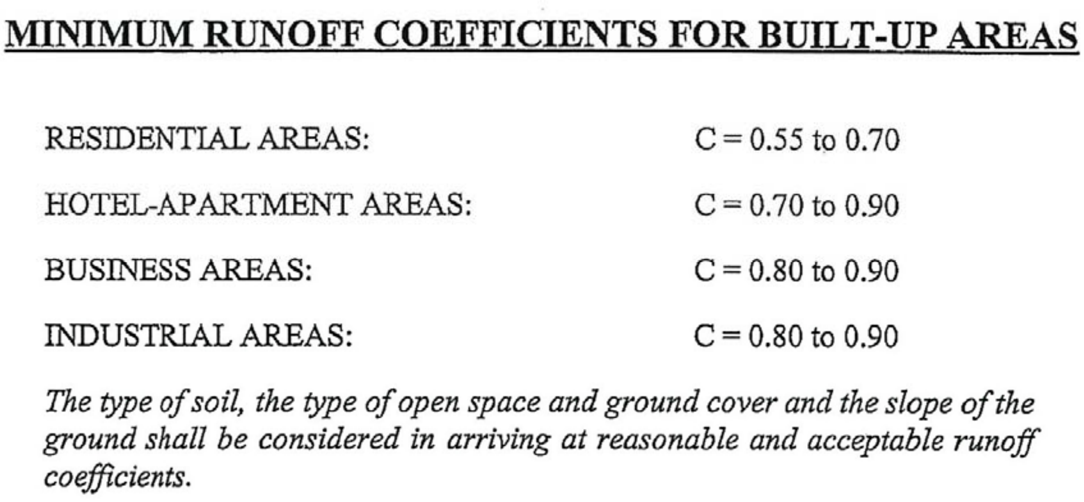


GUIDE FOR THE DETERMINATION OF RUNOFF COEFFICIENTS FOR BUILT-UP AREAS*

WATERSHED CHARACTERISTICS	EXTREME	HIGH	MODERATE	LOW
INFILTRATION	NEGLIGIBLE 0.20	SLOW 0.14	MEDIUM 0.07	HIGH 0.0
RELIEF	STEEP (> 25%) 0.08	HILLY (15 - 25%) 0.06	ROLLING (5 - 15%) 0.03	FLAT (0-5%) 0.0
VEGETAL COVER	NONE 0.07	POOR (< 10%) 0.05	GOOD (10 - 50%) 0.03	HIGH (50 - 90%) 0.0
DEVELOPMENT TYPE	INDUSTRIAL & BUSINESS 0.55	HOTEL-APARTMENT 0.45	RESIDENTIAL 0.40	AGRICULTURAL 0.15

*NOTE: *The design coefficient "c" must result from a total of the values for all four watershed characteristics of the site.*

Table 2



MINIMUM RUNOFF COEFFICIENTS FOR BUILT-UP AREAS

RESIDENTIAL AREAS:	C = 0.55 to 0.70
HOTEL-APARTMENT AREAS:	C = 0.70 to 0.90
BUSINESS AREAS:	C = 0.80 to 0.90
INDUSTRIAL AREAS:	C = 0.80 to 0.90

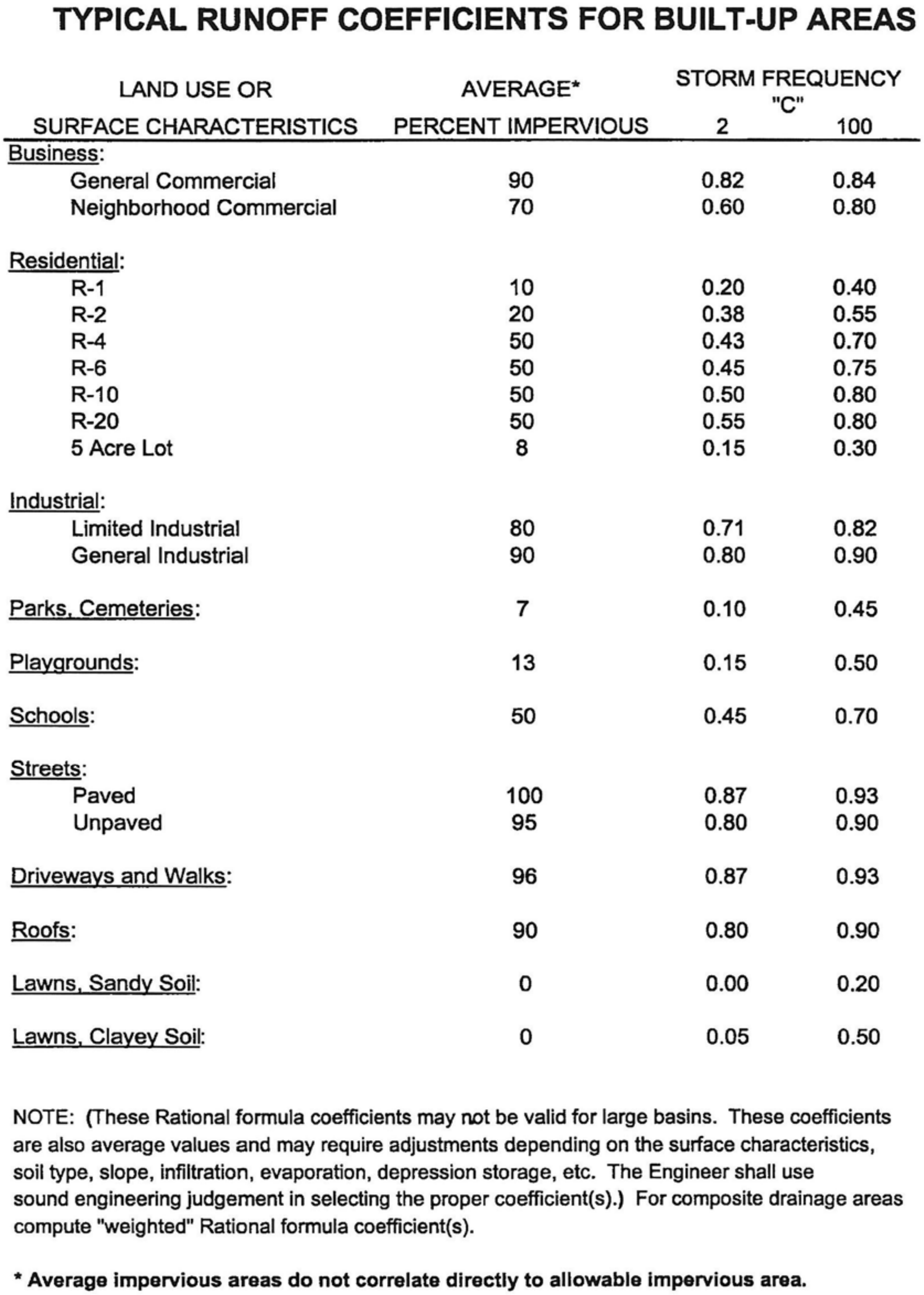
The type of soil, the type of open space and ground cover and the slope of the ground shall be considered in arriving at reasonable and acceptable runoff coefficients.

Table 3

RUNOFF COEFFICIENTS

Type of Drainage Area	Runoff Coefficient C
Business:	
Downtown areas	0.95
Neighborhood areas	0.70
Residential:	
Single-family areas	0.50
Multi-units, detached	0.60
Multi-units, attached	0.75
Suburban	0.40
Apartment dwelling areas	0.70
Industrial:	
Light areas	0.80
Heavy areas	0.90
Parks, cemeteries	0.25
Playgrounds	0.35
Railroad-yard areas	0.40
Unimproved areas	0.30
Streets:	
Asphaltic	0.95
Concrete	0.95
Brick	0.85
Drive and walks	0.85
Roofs	0.95
Lawns:	
Sandy, soil, flat, 2%	0.10
Sandy, soil, avg., 2-7%	0.15
Sandy, soil, steep, 7%	0.20
Heavy soil, flat, 2%	0.17
Heavy soil, avg., 2-7%	0.22
Heavy soil, steep, 7%	0.35

Table 4



TYPICAL RUNOFF COEFFICIENTS FOR BUILT-UP AREAS

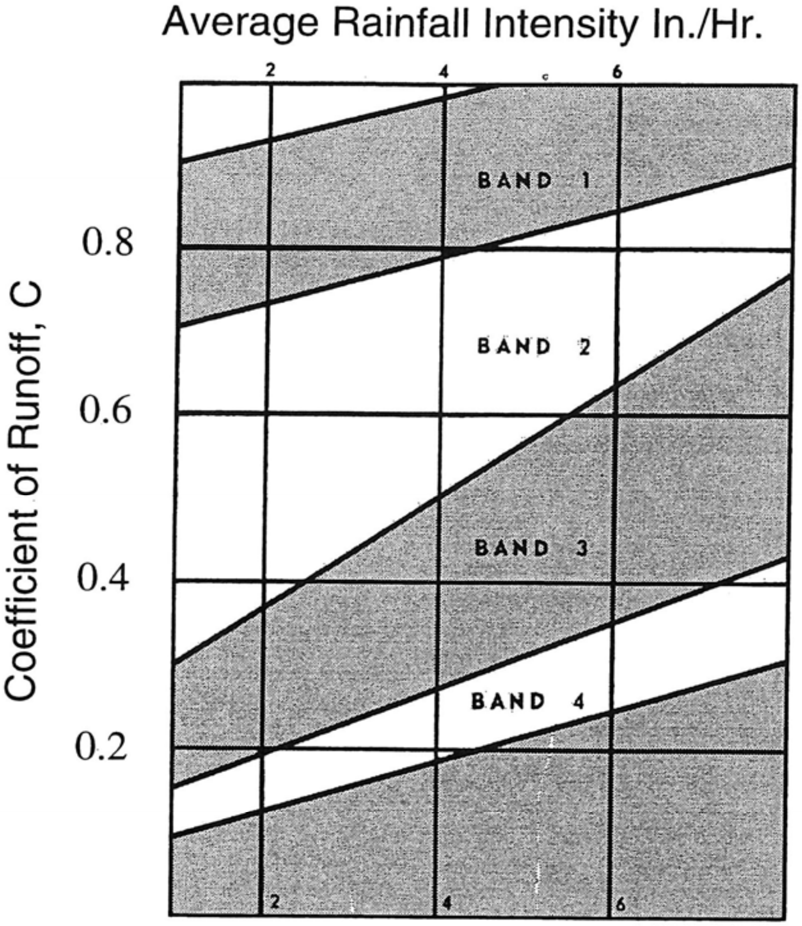
LAND USE OR SURFACE CHARACTERISTICS	AVERAGE* PERCENT IMPERVIOUS	STORM FREQUENCY "C" 2	100
Business:			
General Commercial	90	0.82	0.84
Neighborhood Commercial	70	0.60	0.80
Residential:			
R-1	10	0.20	0.40
R-2	20	0.38	0.55
R-4	50	0.43	0.70
R-6	50	0.45	0.75
R-10	50	0.50	0.80
R-20	50	0.55	0.80
5 Acre Lot	8	0.15	0.30
Industrial:			
Limited Industrial	80	0.71	0.82
General Industrial	90	0.80	0.90
Parks, Cemeteries:	7	0.10	0.45
Playgrounds:	13	0.15	0.50
Schools:	50	0.45	0.70
Streets:			
Paved	100	0.87	0.93
Unpaved	95	0.80	0.90
Driveways and Walks:	96	0.87	0.93
Roofs:	90	0.80	0.90
Lawns, Sandy Soil:	0	0.00	0.20
Lawns, Clayey Soil:	0	0.05	0.50

NOTE: (These Rational formula coefficients may not be valid for large basins. These coefficients are also average values and may require adjustments depending on the surface characteristics, soil type, slope, infiltration, evaporation, depression storage, etc. The Engineer shall use sound engineering judgement in selecting the proper coefficient(s).) For composite drainage areas compute "weighted" Rational formula coefficient(s).

*** Average impervious areas do not correlate directly to allowable impervious area.**

Table 5

RUNOFF COEFFICIENT FOR AGRICULTRUAL AND OPEN AREAS



Band 1	Steep, barren, impervious surfaces
Band 2	Rolling barren in upper band values, flat barren in lower part of band, steep forested and steep grass meadows
Band 3	Timber lands of moderate to steep slopes, mountainous, farming
Band 4	Flat pervious surface, flat farmlands, wooded areas and meadows

Table 6

APPROXIMATE AVERAGE VELOCITIES OF RUNOFF FOR CALCULATING TIME OF CONCENTRATION

TYPE OF FLOW	**VELOCITY IN FPS FOR SLOPES (in percent) INDICATED**			
OVERLAND FLOW:	0-3%	4-7%	8-11%	12-15%
Woodlands	1.0	2.0	3.0	3.5
Pastures	1.5	3.0	4.0	4.5
Cultivated	2.0	4.0	5.0	6.0
Pavements	5.0	12.0	15.0	18.0
OPEN CHANNEL FLOW:				
Improved Channels	Determine Velocity by Manning's Formula			
Natural Channel* (not well defined)	1.0	3.0	5.0	8.0

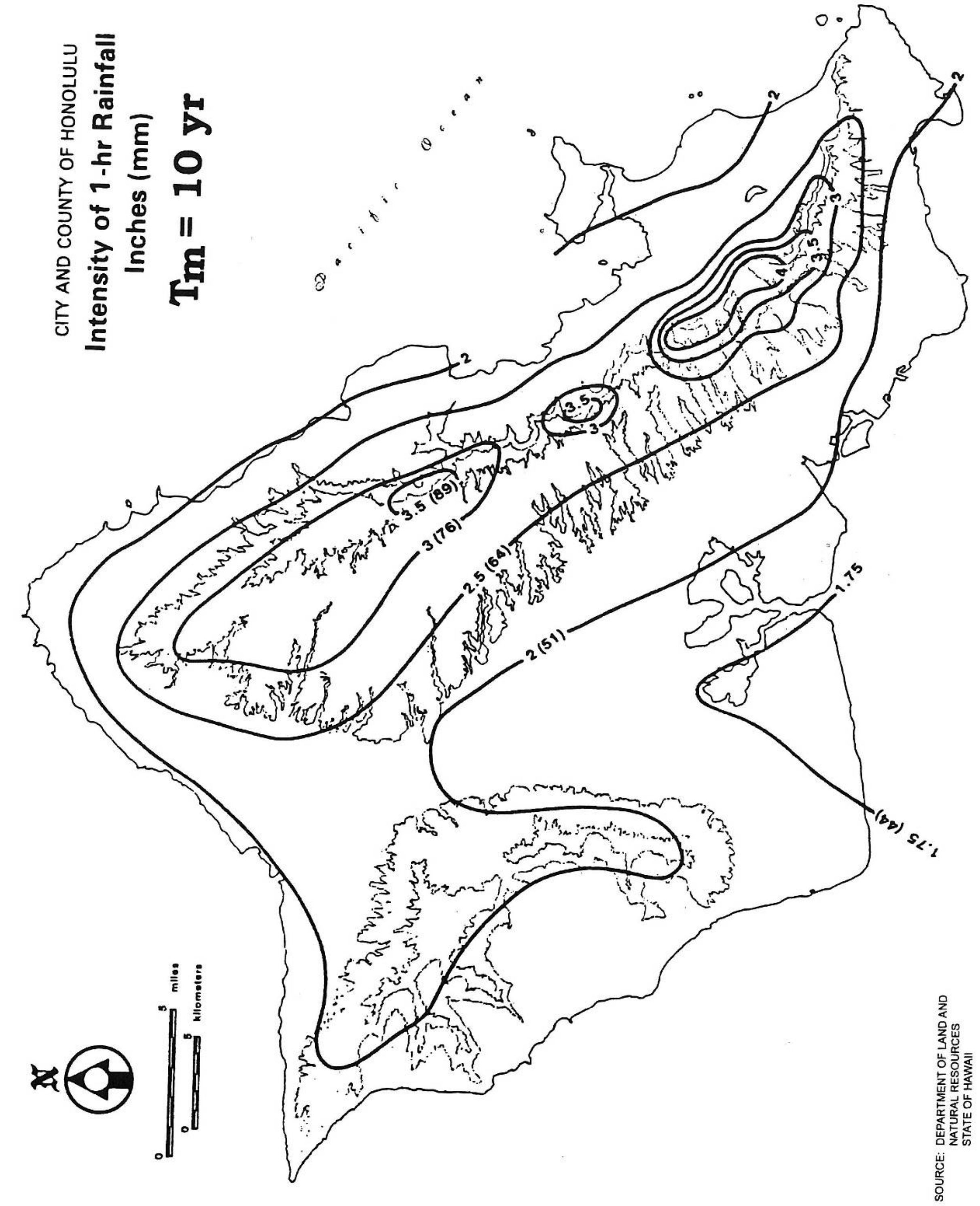
Italic note:

**These values vary with the channel size and other conditions so that the ones given are the averages of a wide range. Wherever possible, more accurate determinations should be made for particular conditions by Manning's formula.*

APPENDIX C
TIME OF CONCENTRATIONPLATES

PLATE 1

Intensity of 1-hr Rainfall Inches (mm): Tm = 10 yr



SOURCE: DEPARTMENT OF LAND AND NATURAL RESOURCES STATE OF HAWAII

PLATE 2

Intensity of 1-hr Rainfall Inches (mm): Tm = 10 yr

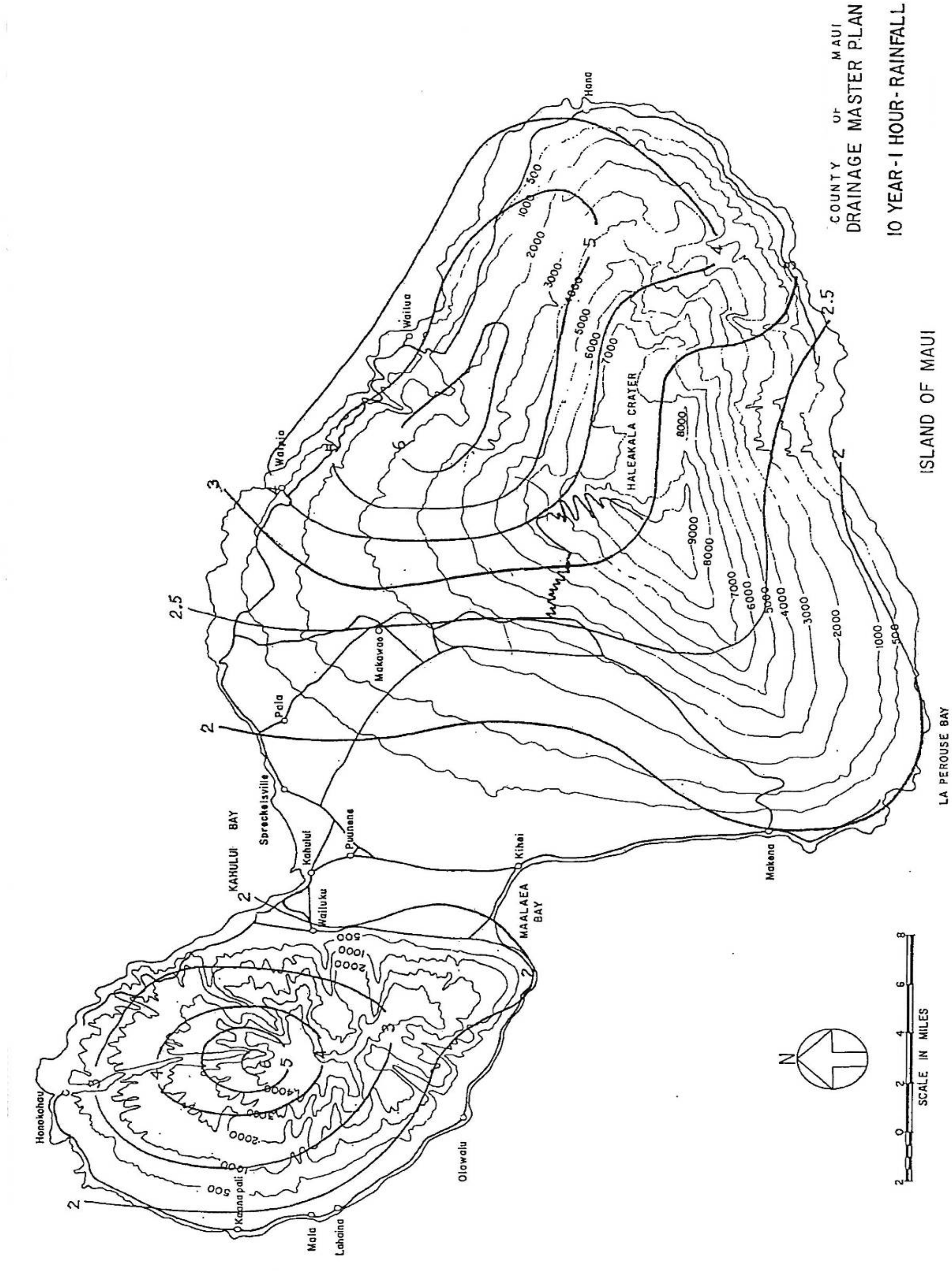


PLATE 3

Intensity of 1-hr Rainfall Inches (mm): Tm = 10 yr

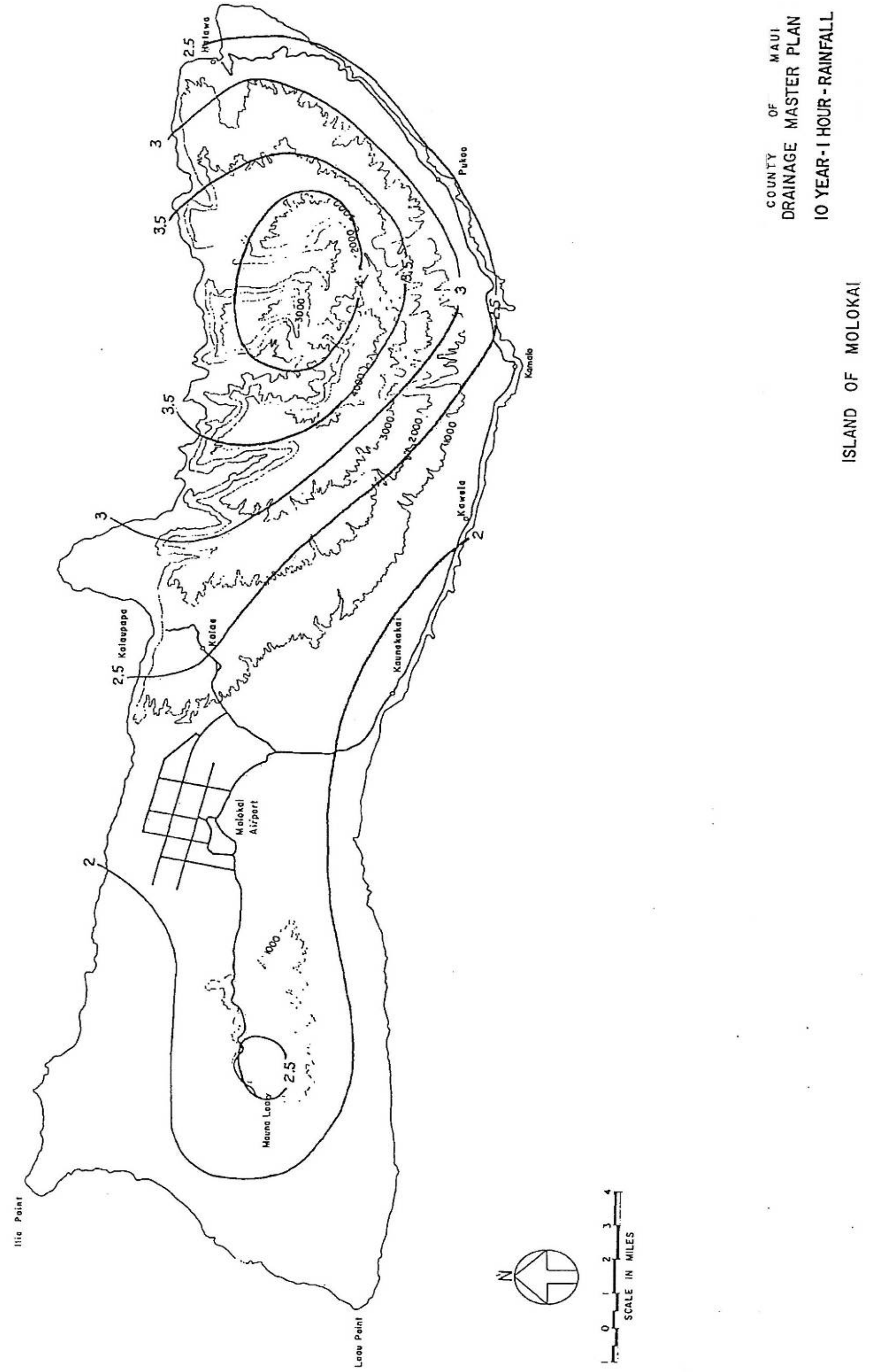


PLATE 4

Intensity of 1-hr Rainfall Inches (mm): Tm = 10 yr

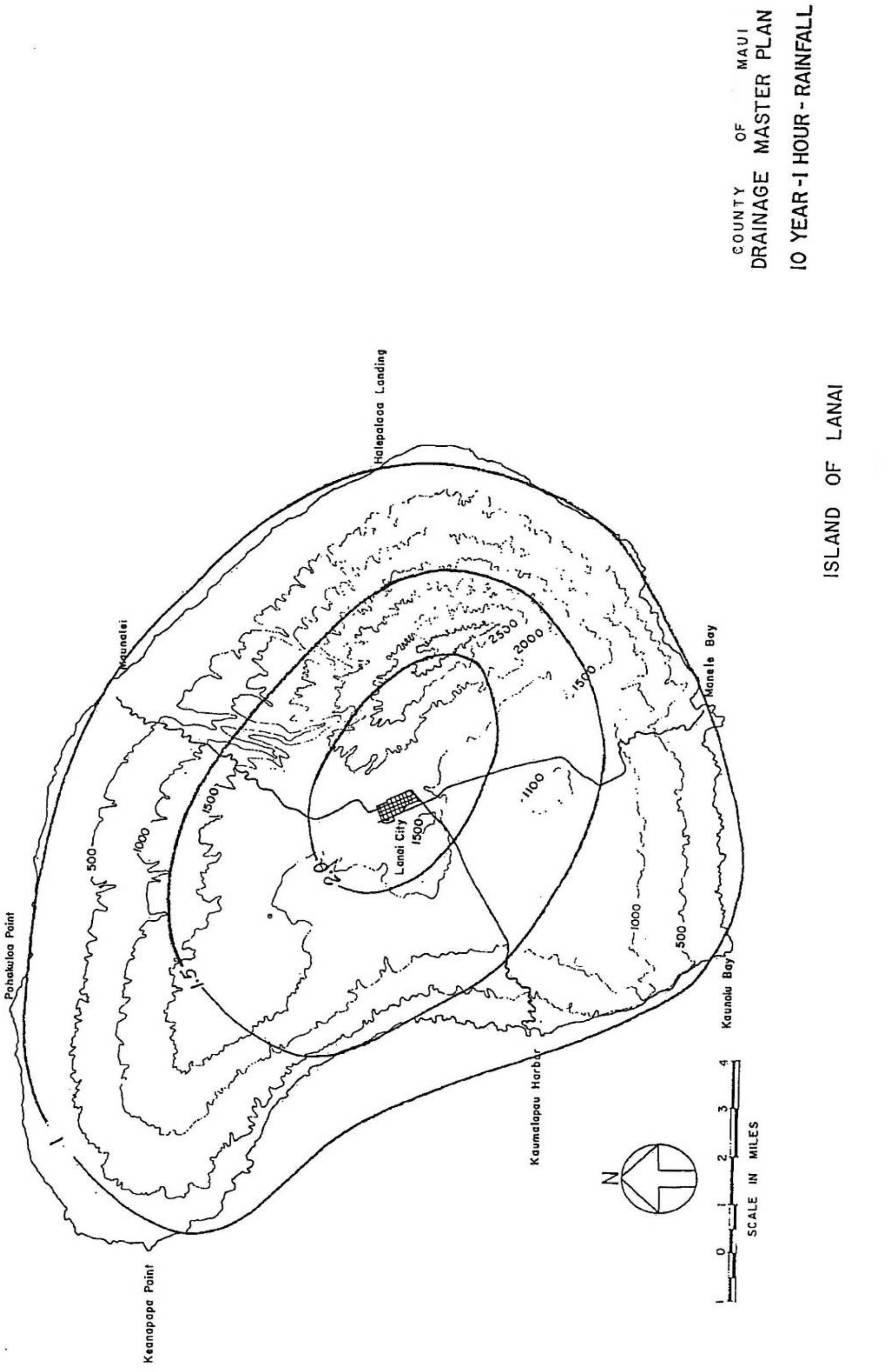


PLATE 5

Intensity of 1-hr Rainfall Inches (mm): Tm = 10 yr

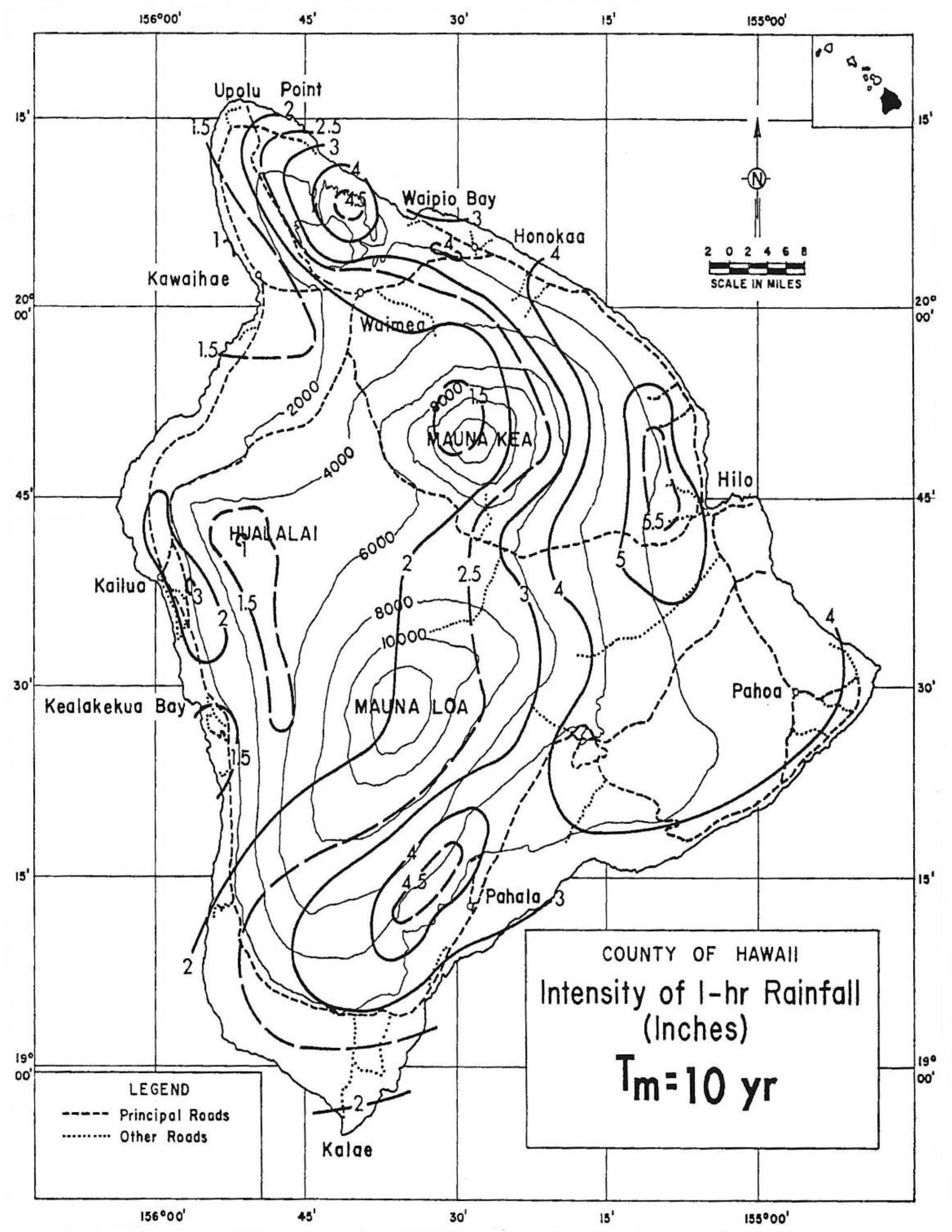


PLATE 6
Intensity of 1-hr Rainfall Inches (mm): Tm = 2 yr

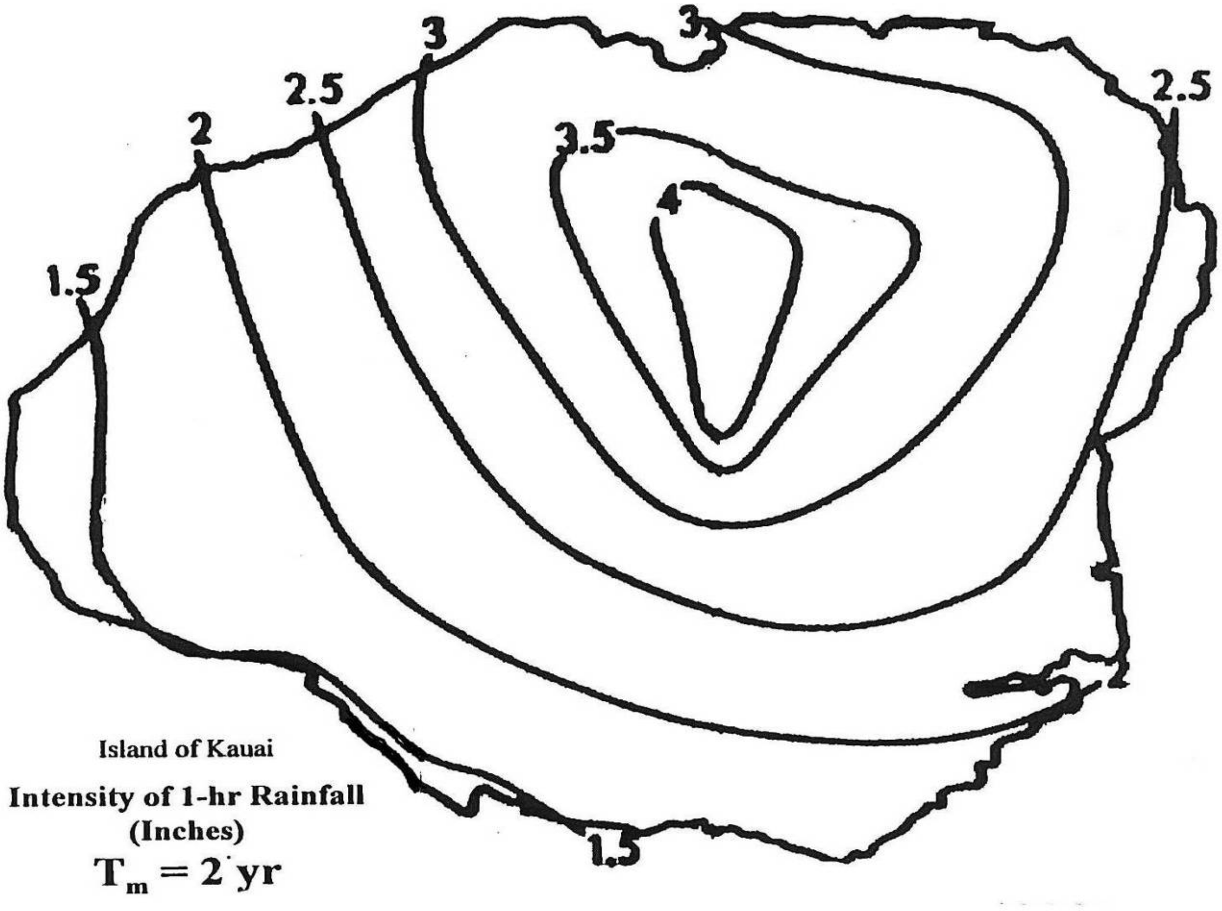


PLATE 7
2-year 24-hr Rainfall Inches (in)

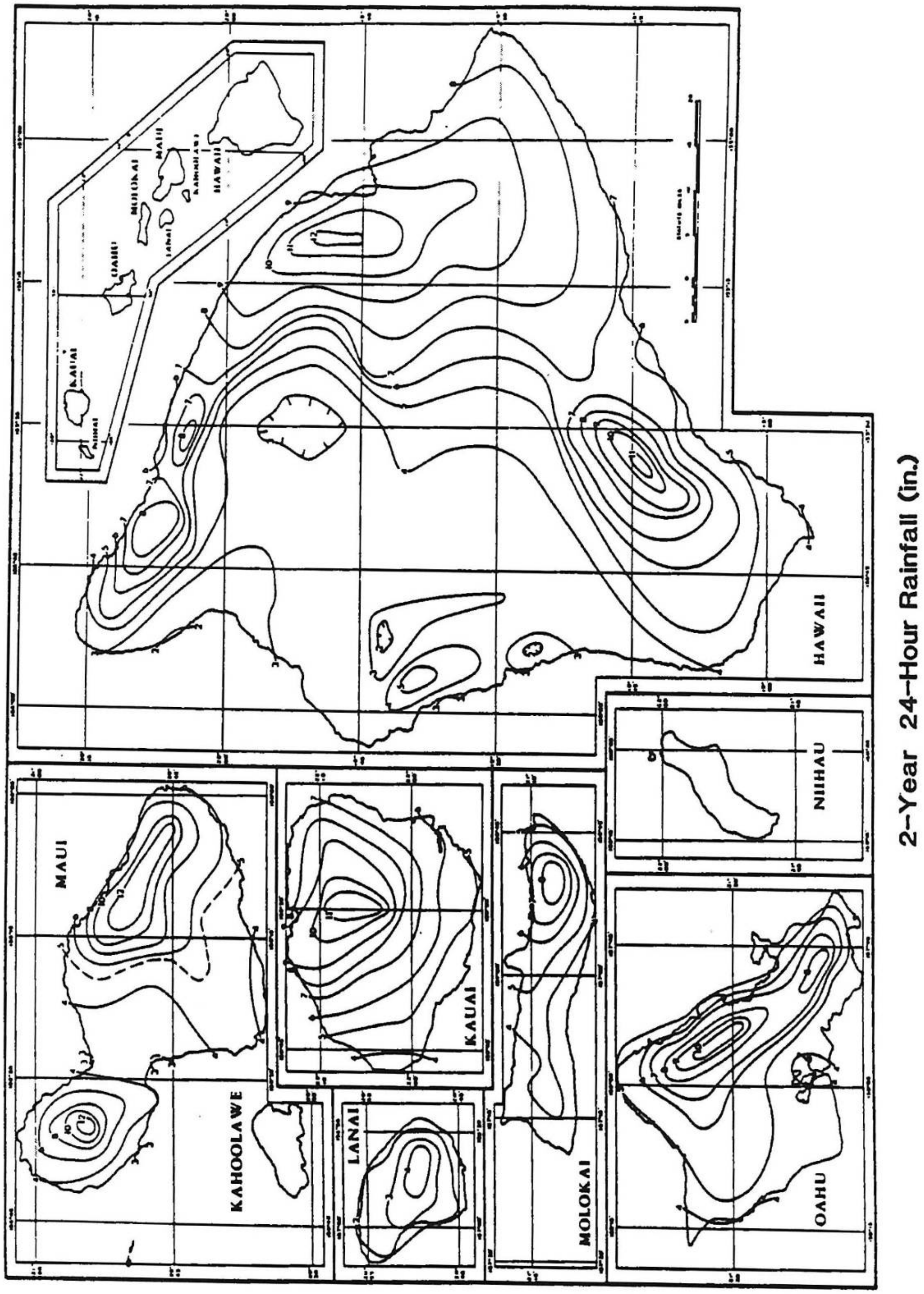
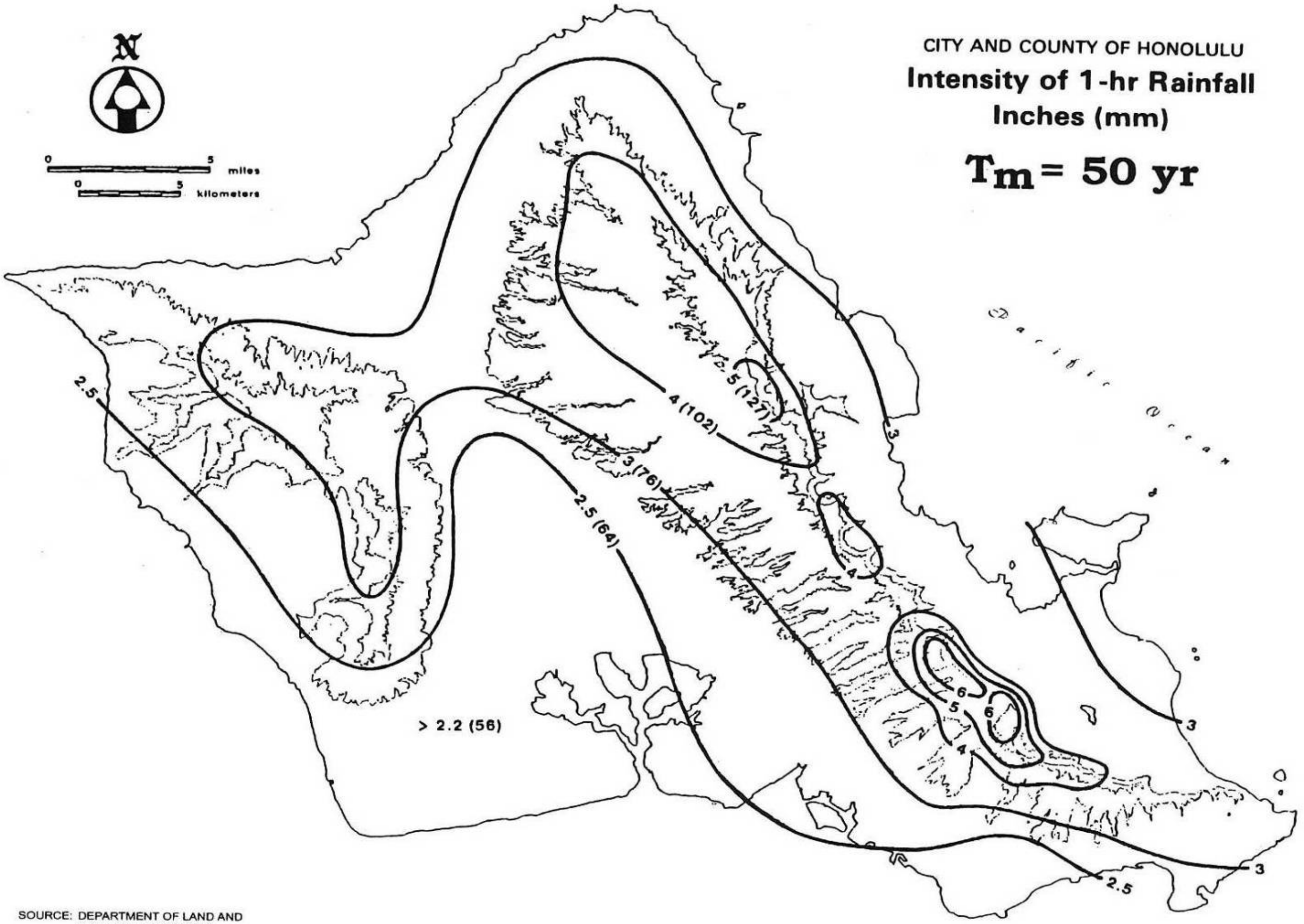


PLATE 8

Intensity of 1-hr Rainfall Inches (mm): Tm = 50 yr



SOURCE: DEPARTMENT OF LAND AND
NATURAL RESOURCES
STATE OF HAWAII

PLATE 9
Intensity of 1-hr Rainfall Inches (mm): Tm = 50 yr

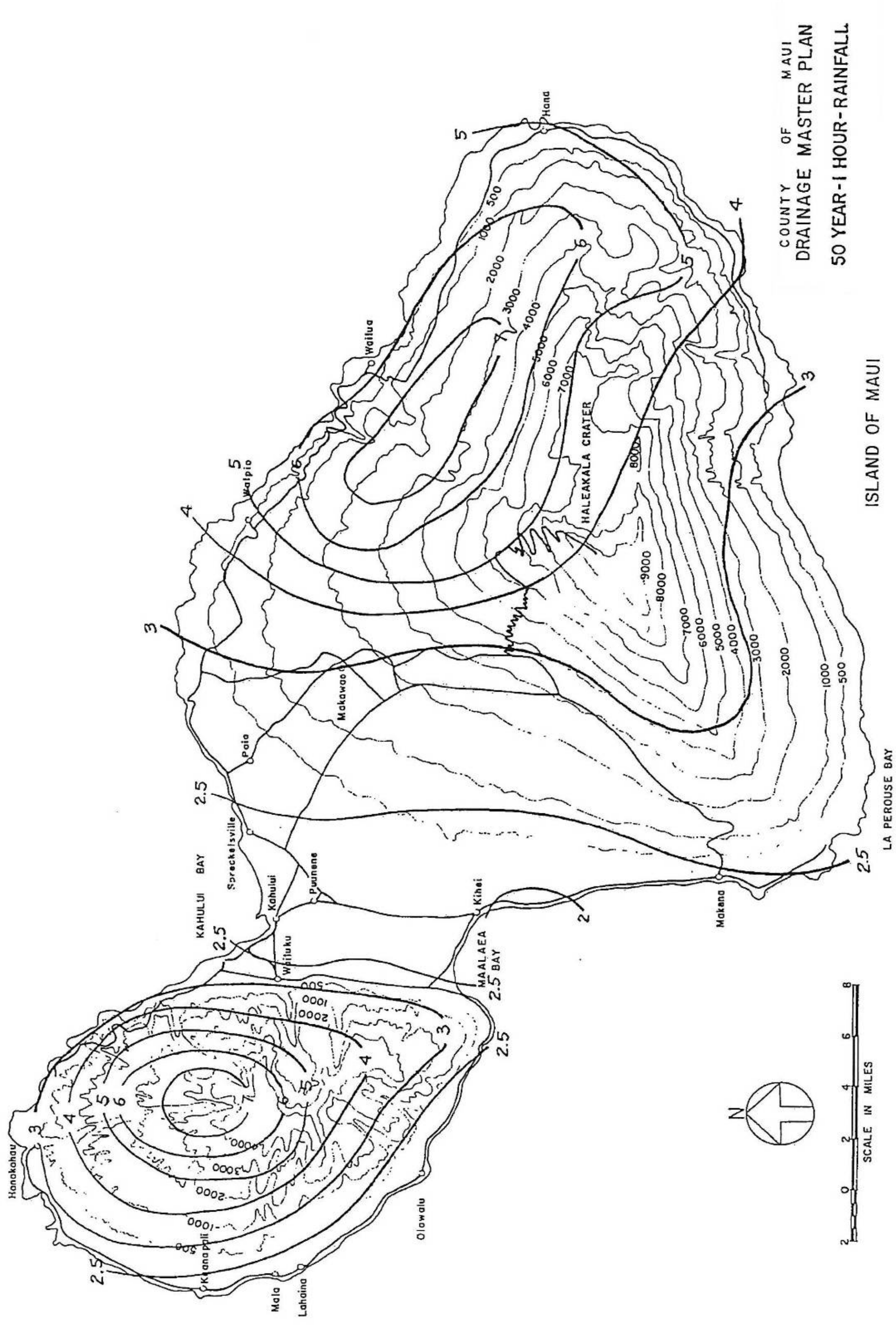


PLATE 10

Intensity of 1-hr Rainfall Inches (mm): Tm = 50 yr

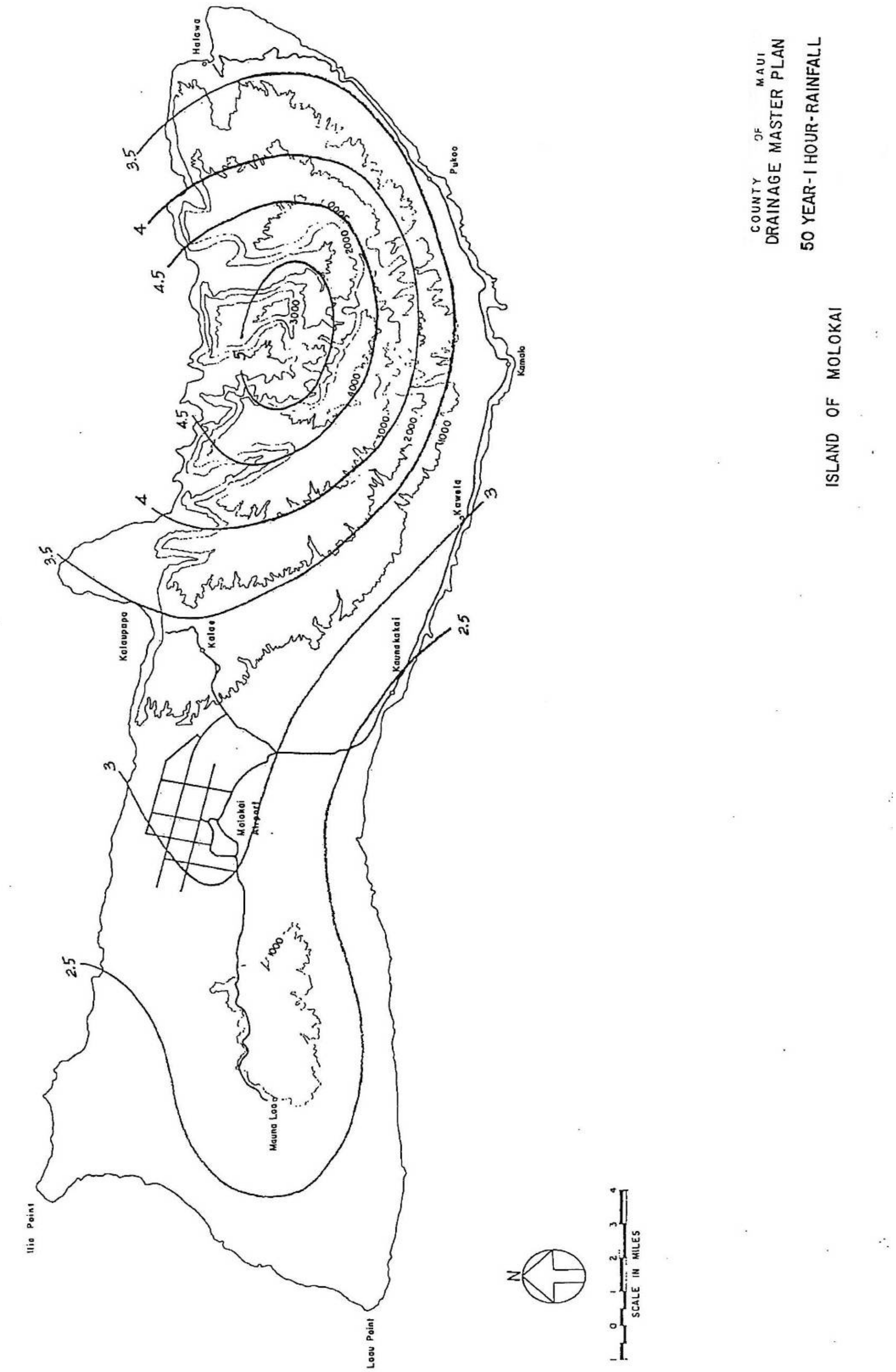


PLATE 11

Intensity of 1-hr Rainfall Inches (mm): Tm = 50 yr

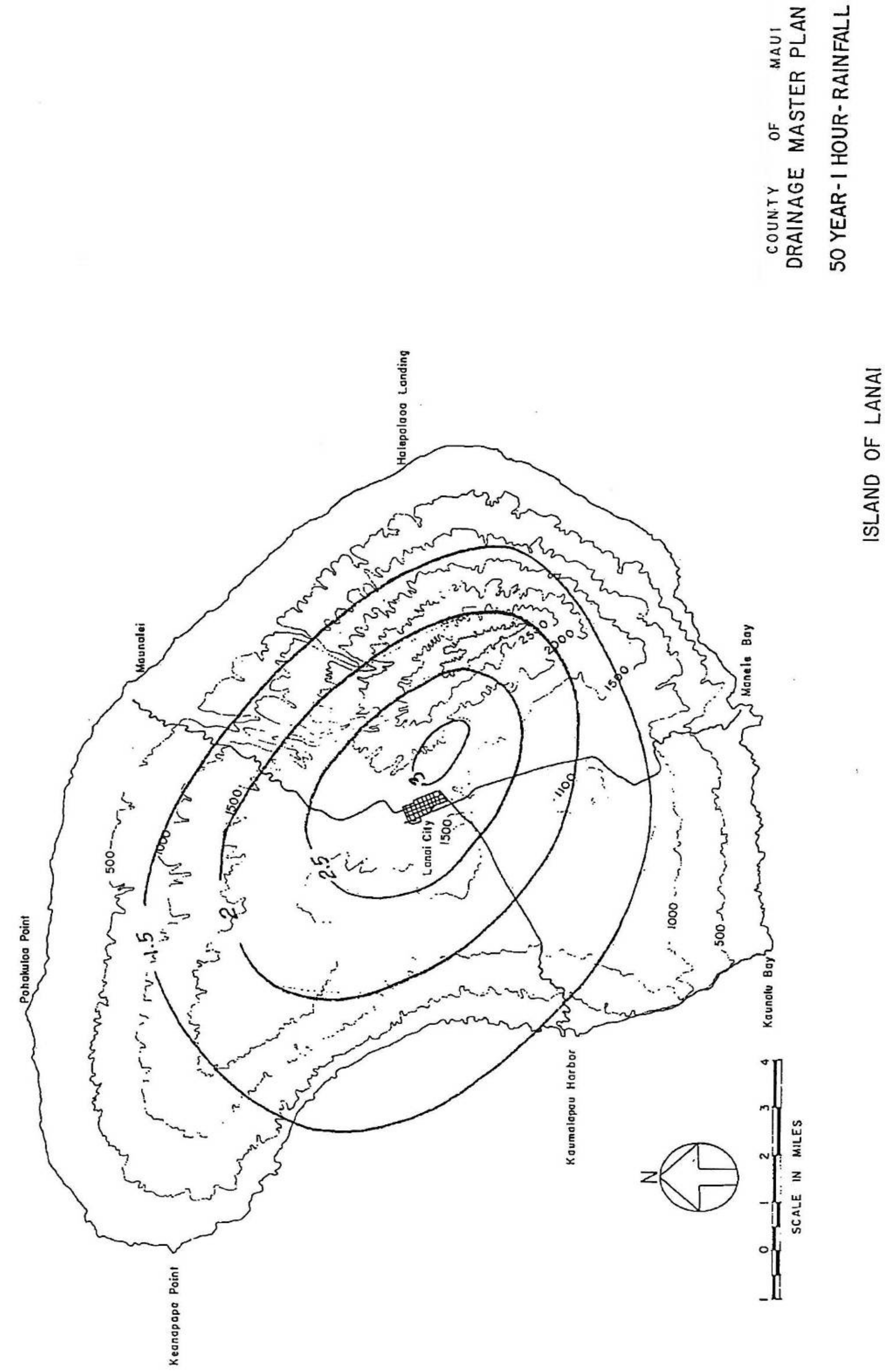


PLATE 12

Intensity of 1-hr Rainfall Inches (mm): Tm = 50 yr

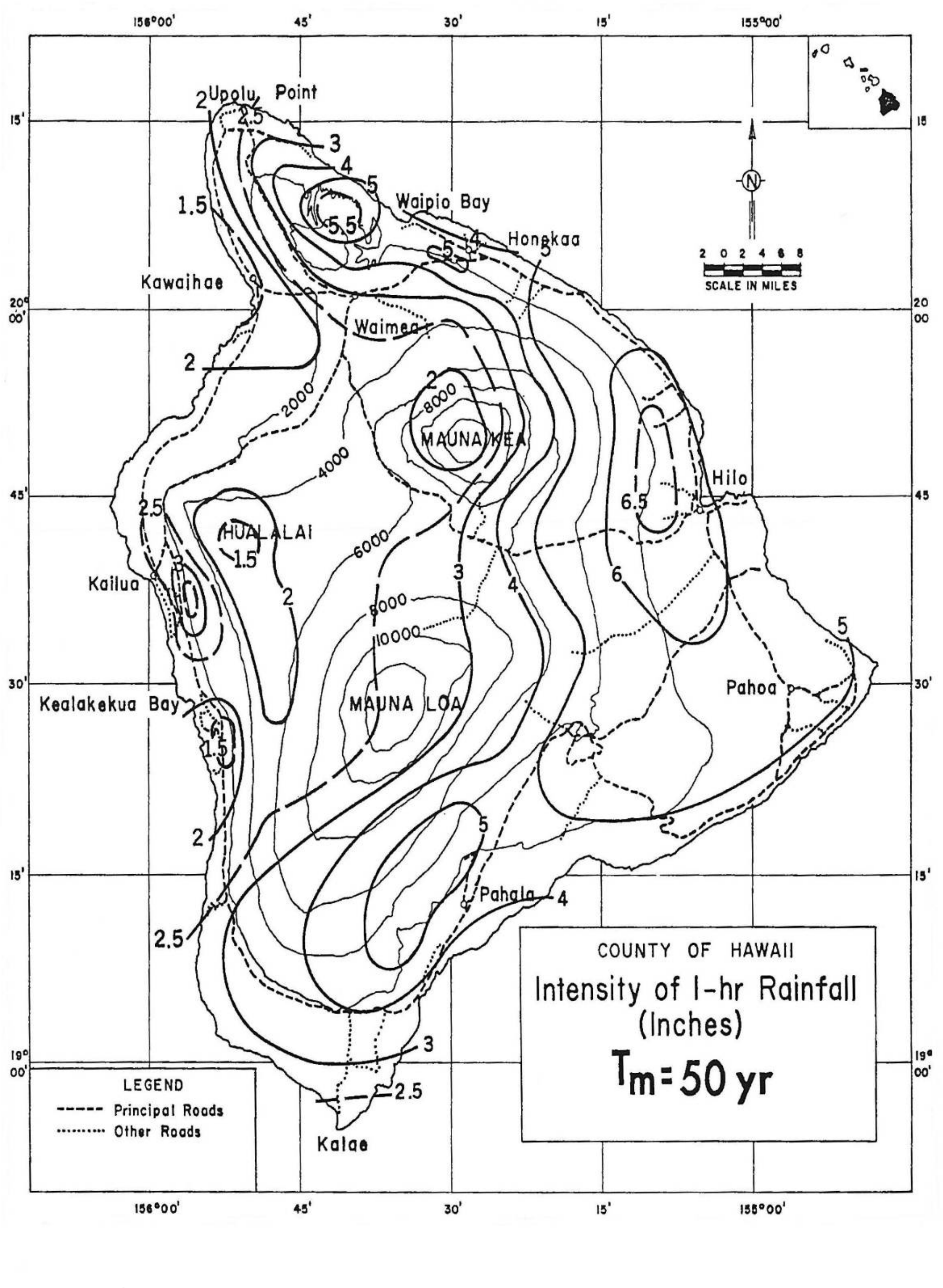


PLATE 13

100-year 1-hr Rainfall Inches (in)

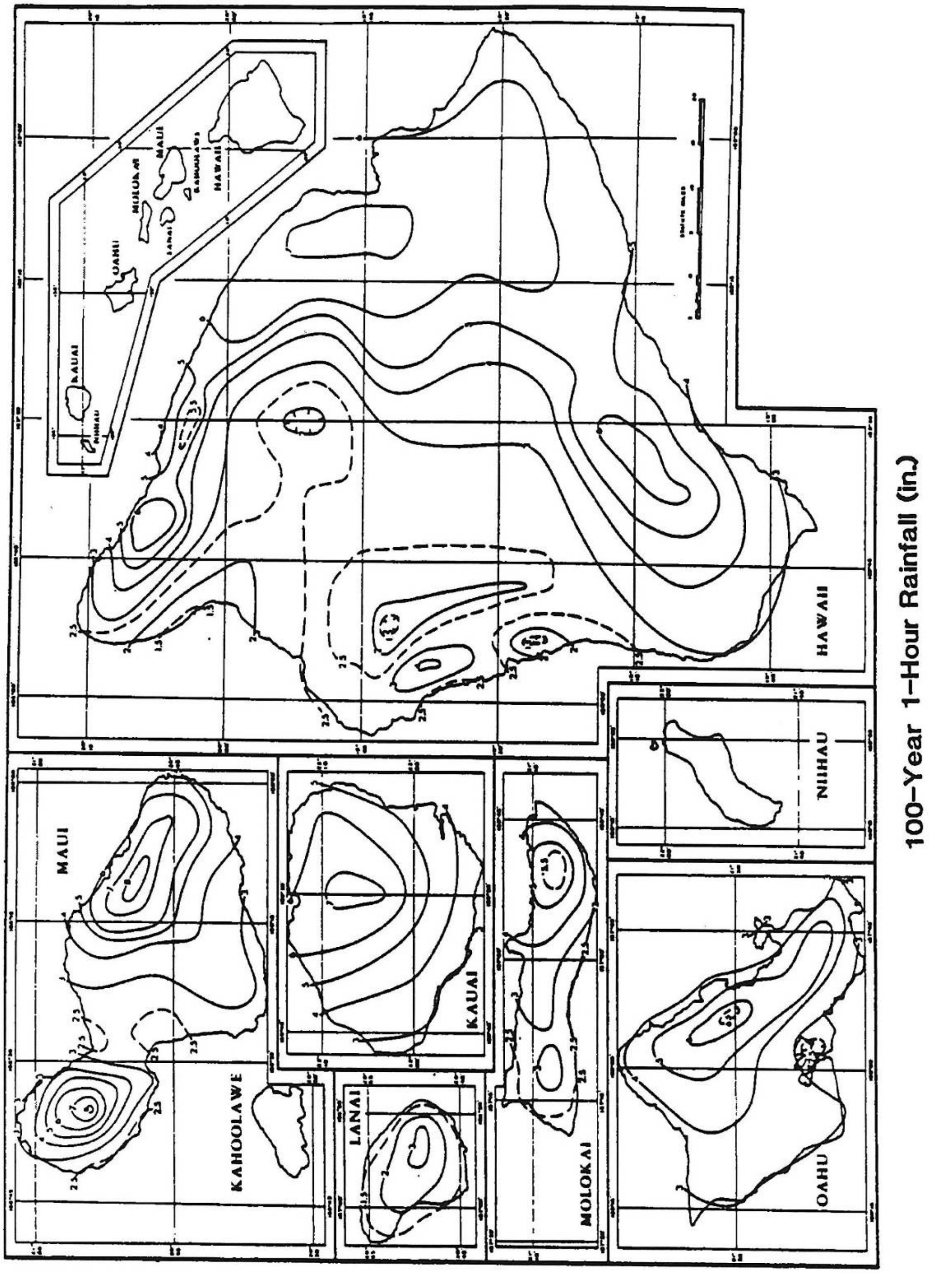
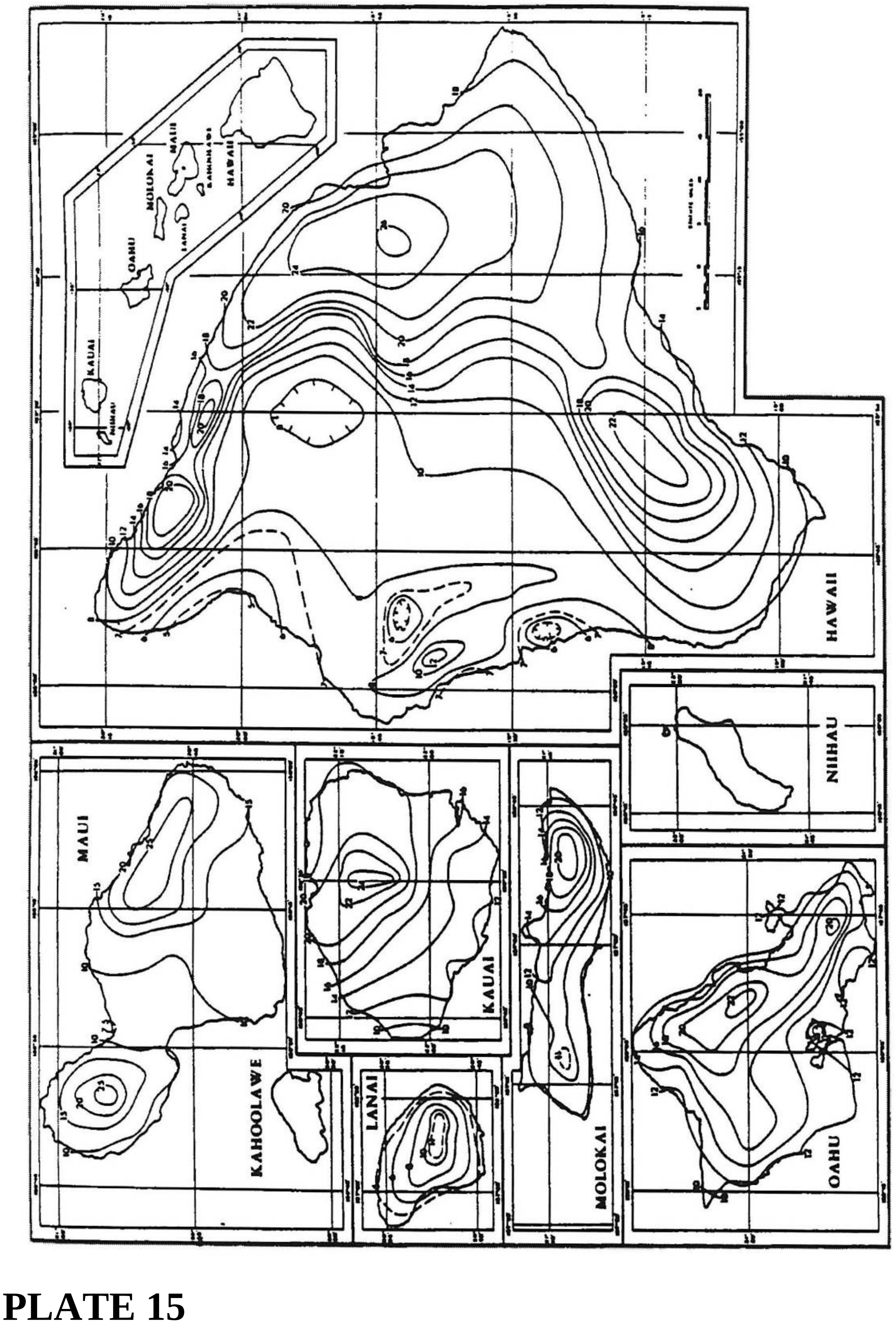


PLATE 14

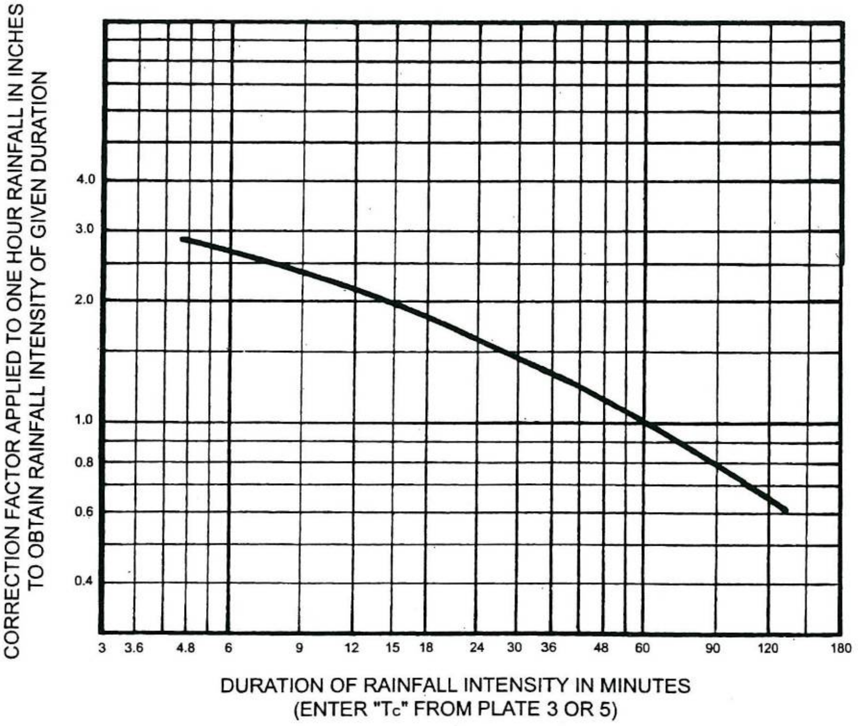
100-year 24-hr Rainfall Inches (in)



100–Year 24–Hour Rainfall (in.)

PLATE 15

Correction Factor for Converting 1-hr rainfall to Rainfall Intensity (I) of various durations



CORRECTION FACTOR

FOR CONVERTING 1 HR. RAINFALL
TO RAINFALL INTENSITY
OF VARIOUS DURATIONS

TO BE USED FOR AREA
LESS THAN 100 ACRES

(See Plate 6 for area
more than 100 acres)

PLATE 16

Intensity Duration 1hr Rainfall Curves

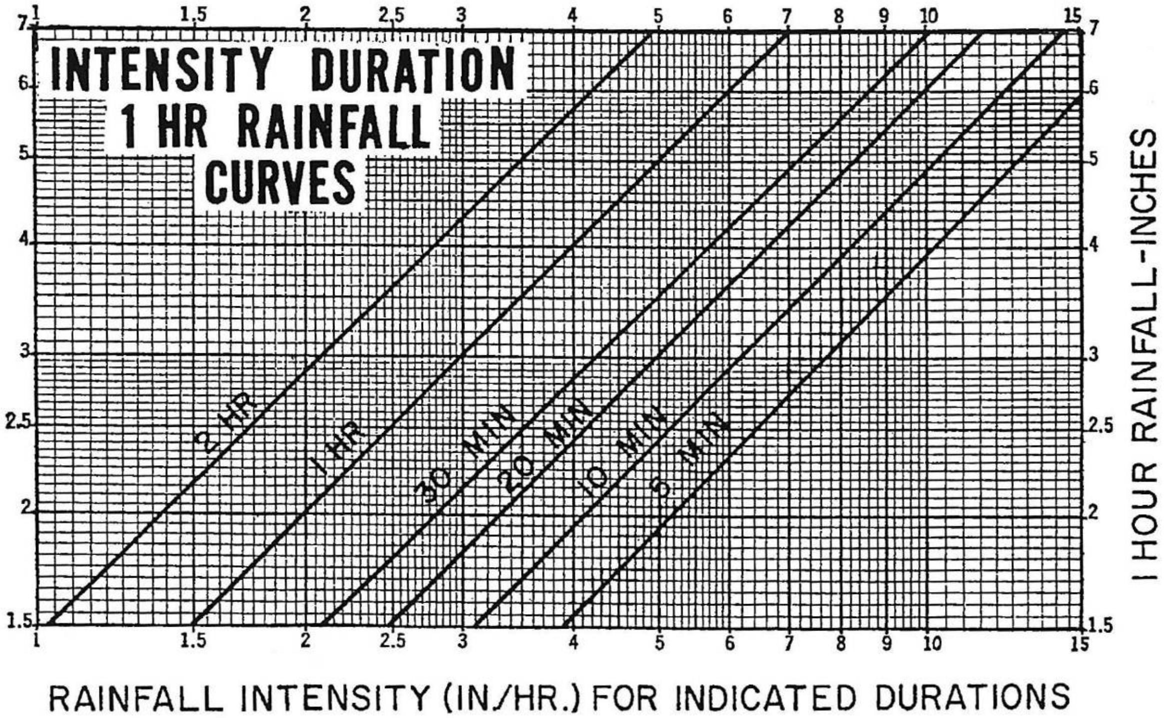


PLATE 17

Overland Flow Chart

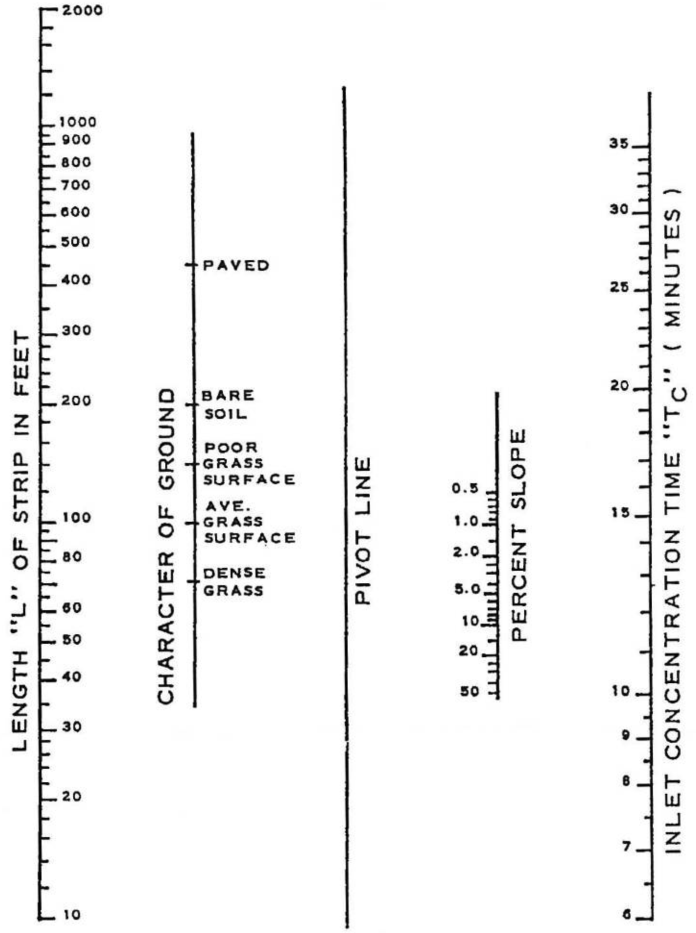
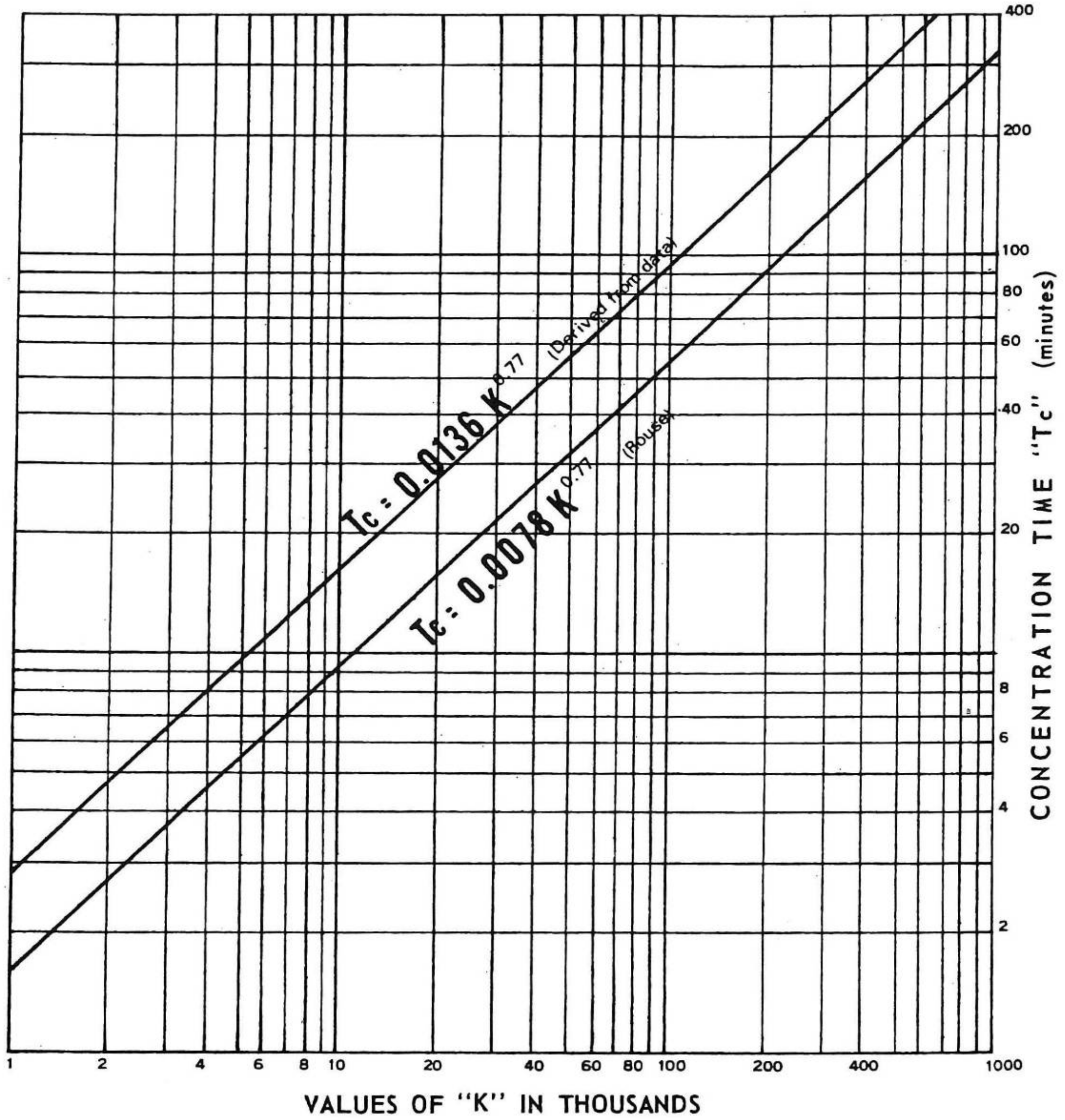


Plate 3

Overland Flow Chart

PLATE 19

Time of Concentration (of small Agricultural Drainage Basins)



L = Maximum length of travel in feet

H = Difference in elevation between most remote point and outlet in feet.

S = Slope H/L

$K = \frac{L}{\sqrt{S}} = \sqrt{\frac{L^3}{H}}$

Use upper curve for well forested areas

Use lower curve for areas with little or no cover.

NOTE: Use 5 minutes if Tc is 5 minutes or less.

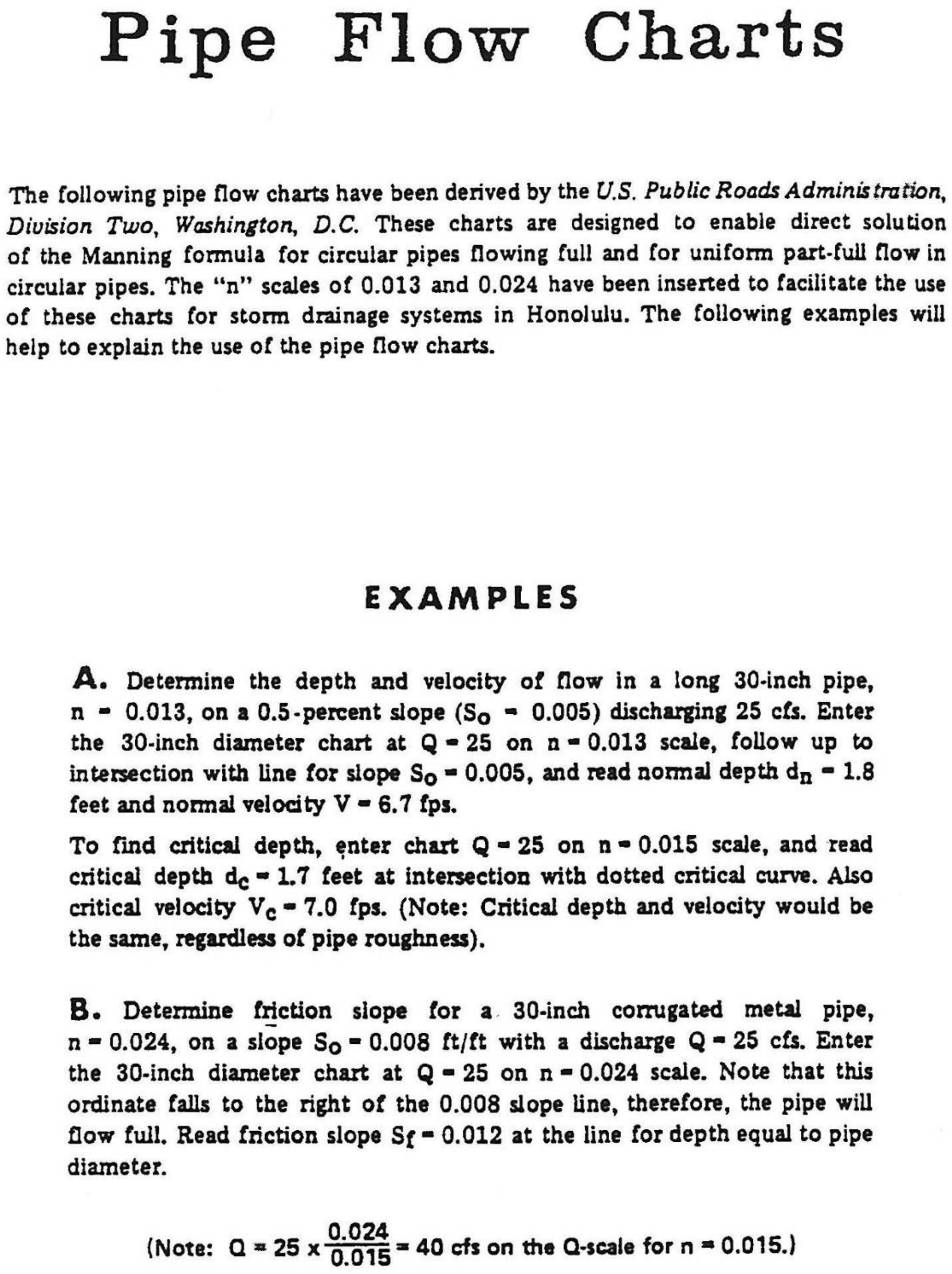
SOURCE: CITY PLANNING COMMISSION
graph from Hunter Rouse "Engineering Hydraulics."

Time of Concentration

(OF SMALL AGRICULTURAL DRAINAGE BASIN)

PLATE 20

Pipe Flow Charts



Pipe Flow Charts

The following pipe flow charts have been derived by the *U.S. Public Roads Administration, Division Two, Washington, D.C.* These charts are designed to enable direct solution of the Manning formula for circular pipes flowing full and for uniform part-full flow in circular pipes. The "n" scales of 0.013 and 0.024 have been inserted to facilitate the use of these charts for storm drainage systems in Honolulu. The following examples will help to explain the use of the pipe flow charts.

EXAMPLES

A. Determine the depth and velocity of flow in a long 30-inch pipe, $n = 0.013$, on a 0.5-percent slope ($S_o = 0.005$) discharging 25 cfs. Enter the 30-inch diameter chart at $Q = 25$ on $n = 0.013$ scale, follow up to intersection with line for slope $S_o = 0.005$, and read normal depth $d_n = 1.8$ feet and normal velocity $V = 6.7$ fps.

To find critical depth, enter chart $Q = 25$ on $n = 0.015$ scale, and read critical depth $d_c = 1.7$ feet at intersection with dotted critical curve. Also critical velocity $V_c = 7.0$ fps. (Note: Critical depth and velocity would be the same, regardless of pipe roughness).

B. Determine friction slope for a 30-inch corrugated metal pipe, $n = 0.024$, on a slope $S_o = 0.008$ ft/ft with a discharge $Q = 25$ cfs. Enter the 30-inch diameter chart at $Q = 25$ on $n = 0.024$ scale. Note that this ordinate falls to the right of the 0.008 slope line, therefore, the pipe will flow full. Read friction slope $S_f = 0.012$ at the line for depth equal to pipe diameter.

(Note: $Q = 25 \times \frac{0.024}{0.015} = 40$ cfs on the Q-scale for $n = 0.015$.)

PLATE 21

Pipe Flow Chart 18” Diameter

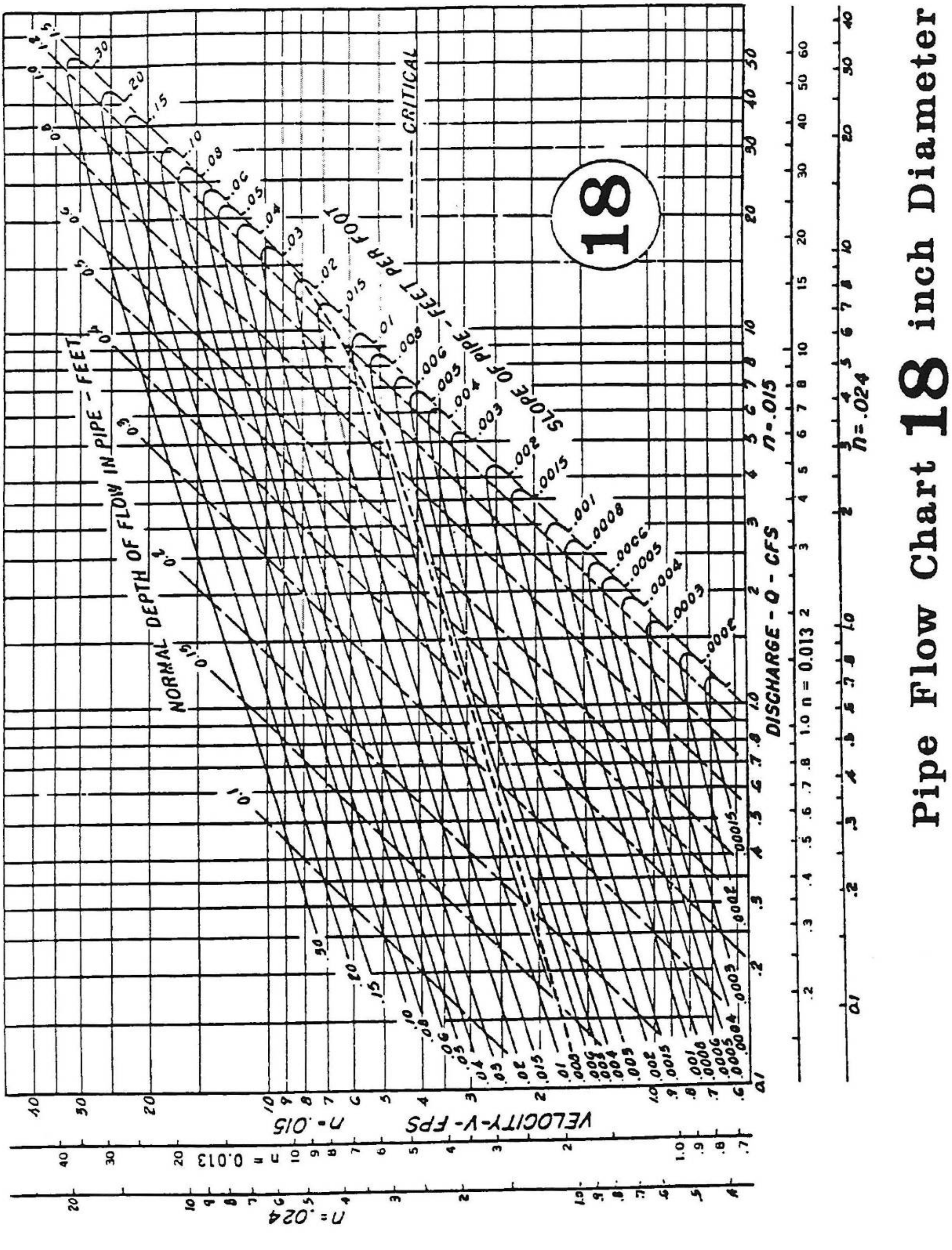


PLATE 22

Pipe Flow Chart 24” Diameter

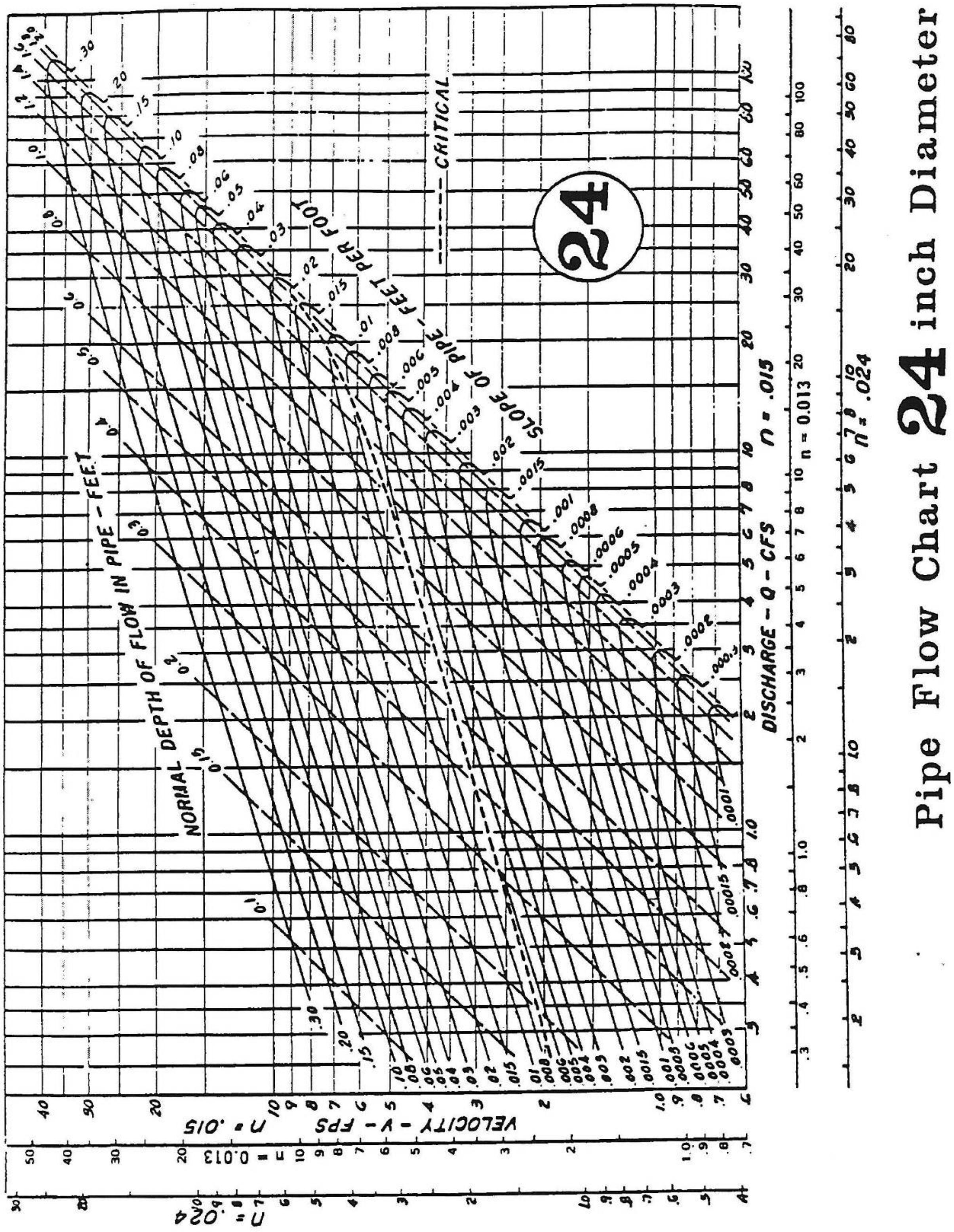


PLATE 23

Pipe Flow Chart 30” Diameter

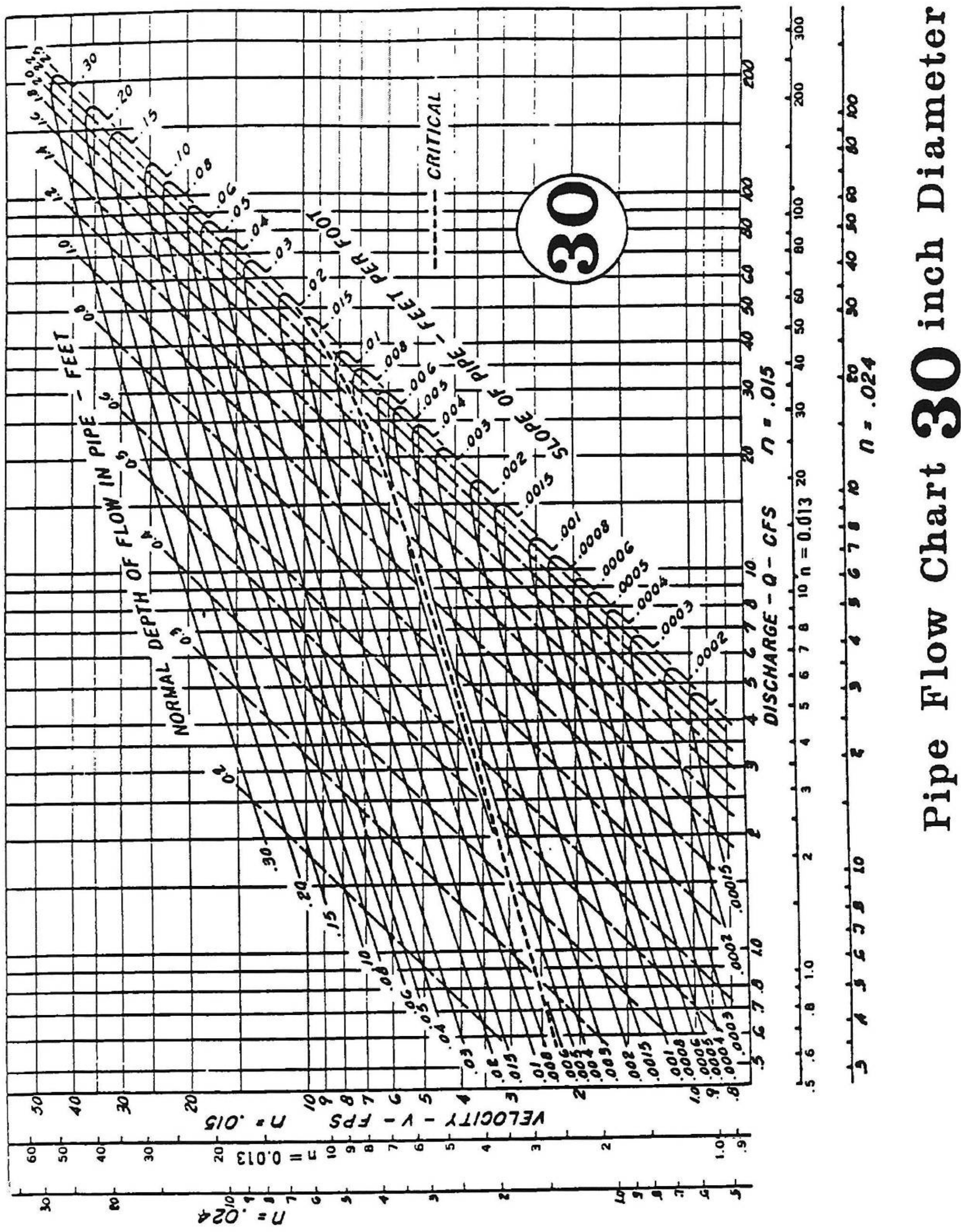


PLATE 24

Pipe Flow Chart 36” Diameter

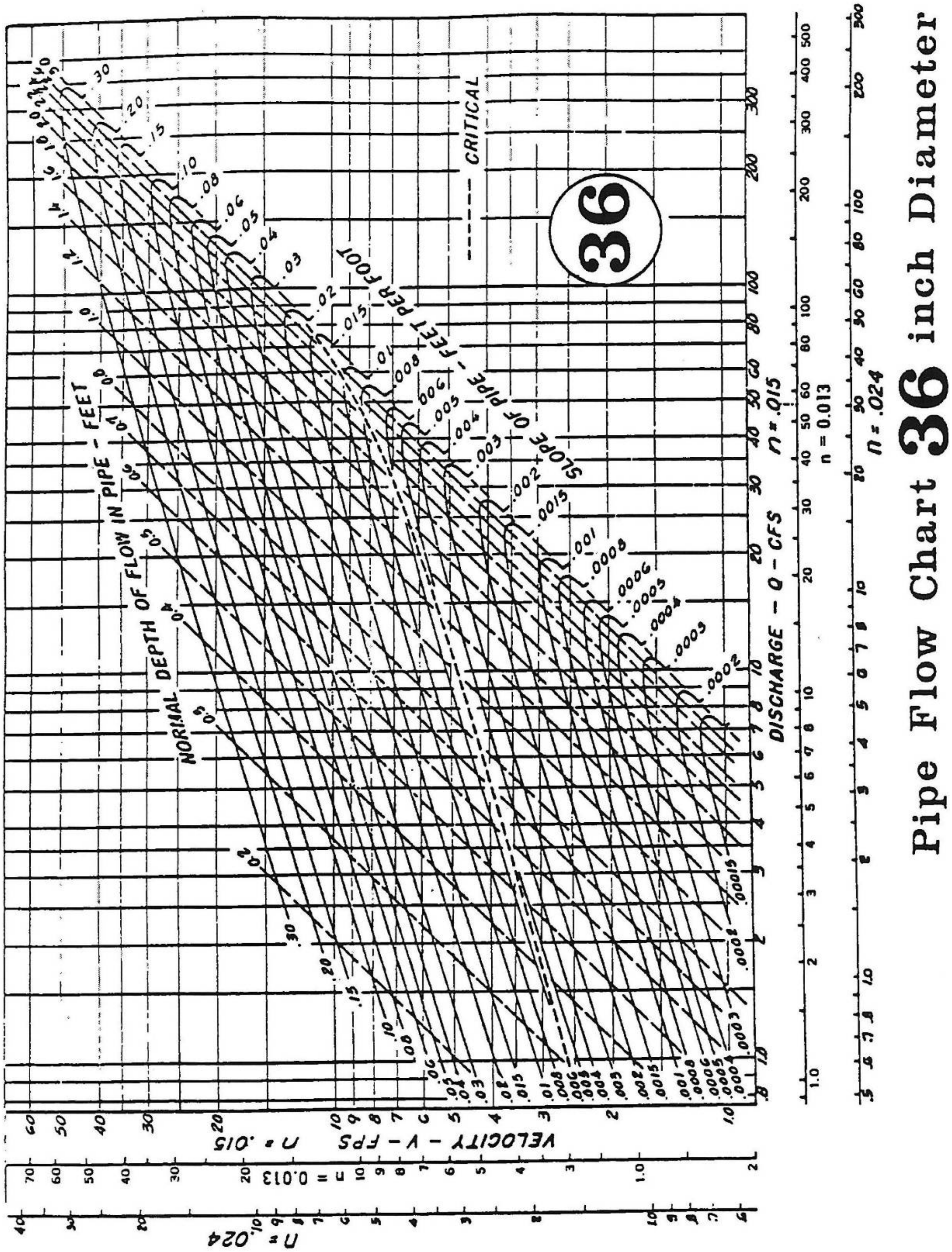


PLATE 25

Pipe Flow Chart 42" Diameter

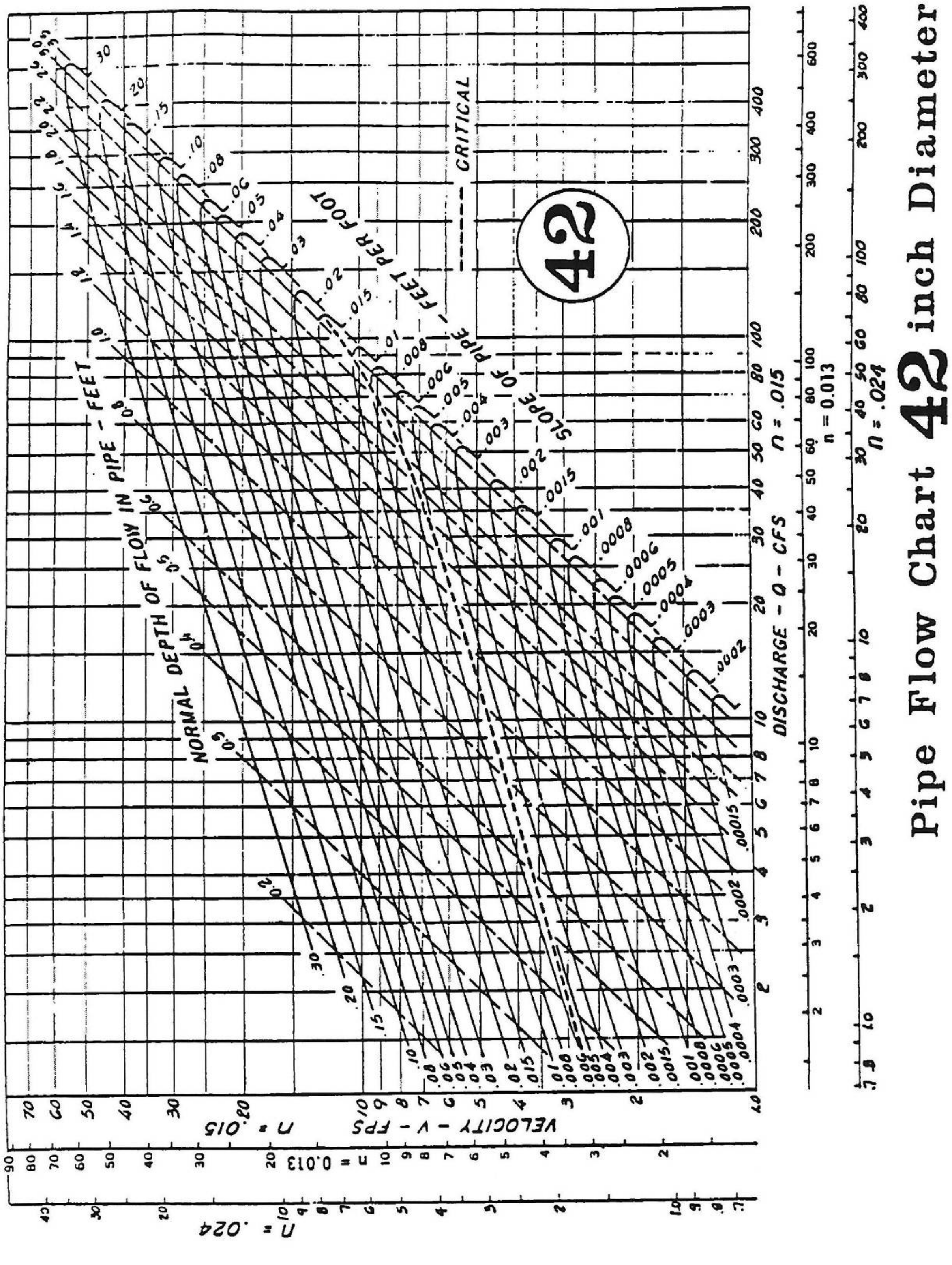


PLATE 26

Pipe Flow Chart 48” Diameter

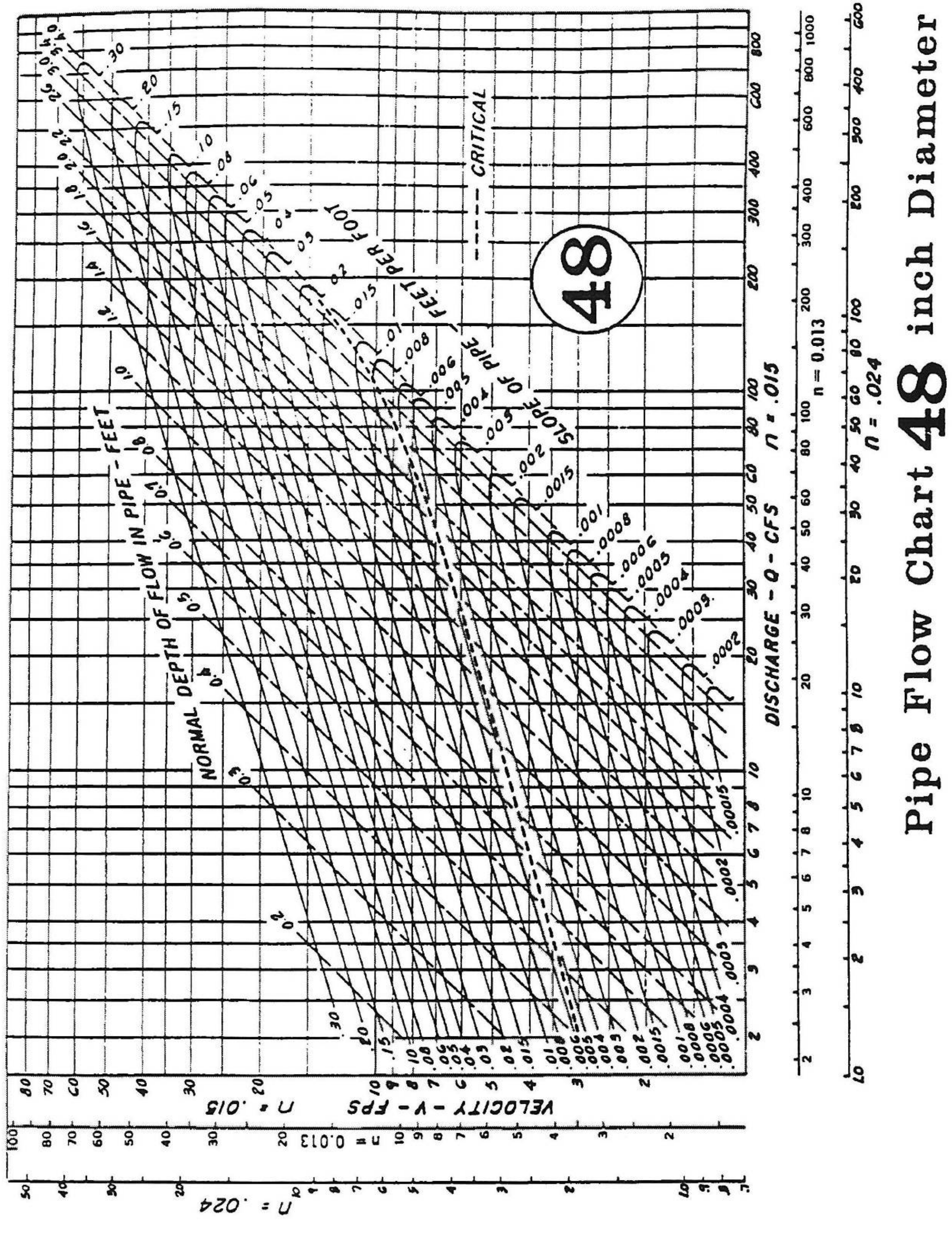


PLATE 27

Pipe Flow Chart 54” Diameter

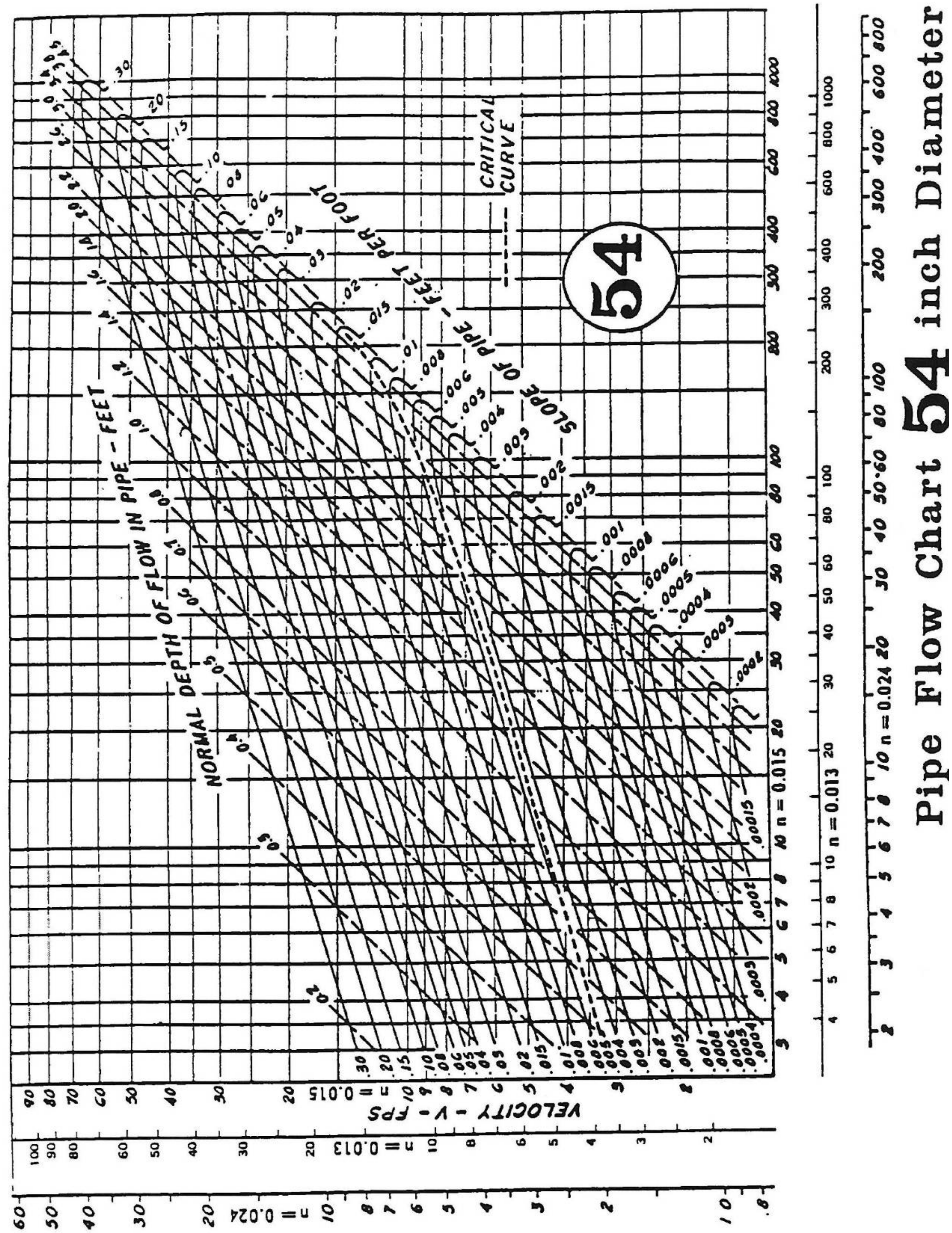


PLATE 28

Pipe Flow Chart 60” Diameter

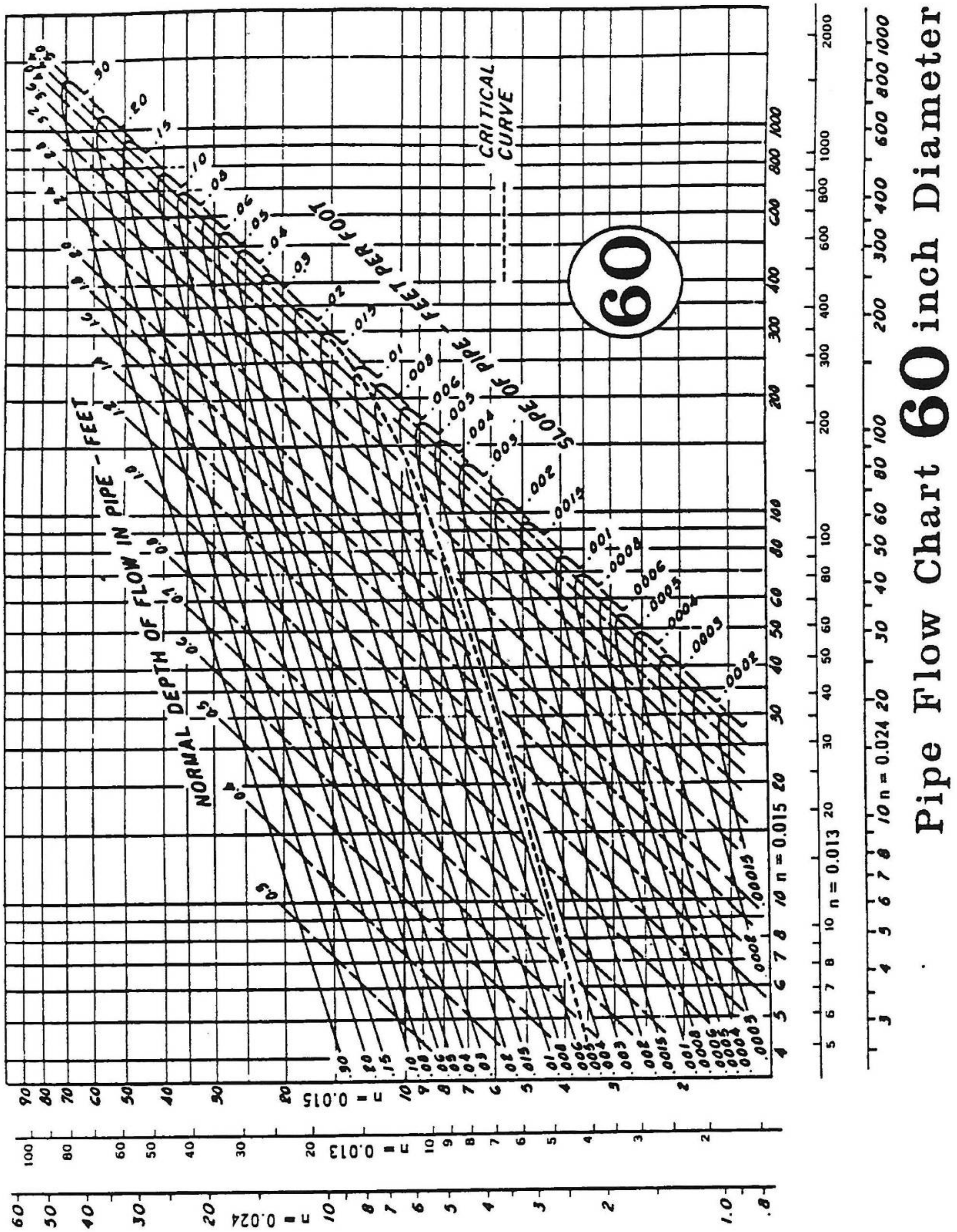


PLATE 29

Pipe Flow Chart 66” Diameter