IRRIGATION MANAGEMENT GUIDELINES FOR THE WEST COUNTY AND SOUTH COUNTY ALTERNATIVES

SANTA ROSA SUBREGIONAL LONG-TERM WASTEWTER PROJECT

Prepared for

City of Santa Rosa
and
U.S. Army Corps of Engineers

July 1996

Prepared by

QUESTA ENGINEERING CORP.
JEFFREY H. PETERS, C.P.S.S., C.P.E.S.C.
LYNN BRITTAN, C.P.E.S.C.
VERN MARBLE, Ph.D., AGRONOMIST

for

HARLAND BARTHOLOMEW & ASSOCIATES, INC.

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1 INTRODUCTION

1.1 PURPOSE AND OBJECTIVE

The purpose of these Irrigation Management Guidelines (IMG) is to identify the recommended procedures and practices that may be utilized by the City of Santa Rosa in overall irrigation system planning, as well as the design principles and guidelines for incorporating individual farms and ranches into any future reclaimed water irrigation system expansion. The IMG identifies the framework and performance criteria that the City may utilize for proper management of agricultural lands for which it is furnishing reclaimed water.

The objective of the IMG is two-fold: first, to insure that the system as a whole, and each irrigation system, is designed and managed to control environmental impacts to the maximum extent that current technology allows; and second, where monitoring indicates trends toward adverse impacts are occurring, to take steps to remedy the situation.

The IMG is not intended to be an irrigation design manual or agricultural management handbook. Where specific design procedures or management practices are preferred or are recommended to be used, then the appropriate book or manual is referenced. However, the IMG may be used as a management tool for system designers and planners, as well as individual irrigators.

This IMG has been used to assist in the development of the project description for both the West County and South County Irrigation Project Components. The Sebastapol area is included in both the West and South County alternatives. The IMG has identified some of the project impacts that may result from reclaimed water irrigation application without proper planning and management, and includes recommended provisions to minimize and greatly reduce the possibility of such impacts occurring at levels that would be considered more than insignificant. Measures to avoid potential irrigation impacts that the City has adopted as part of the project description are listed in Section 2.2 of the EIR/EIS. The provisions of this IMG may apply to all agricultural areas that will receive reclaimed water for irrigation (urban irrigation is not intended to be covered by the IMG).

1.2 BACKGROUND

Application of reclaimed irrigation water to previously non-irrigated lands in Sonoma County has the potential to expand the diversity and choice of crops which may be grown by individual farms and ranches. Applying reclaimed water also has the potential to greatly increase the yield and productivity of haylands and pasture lands. Crops may be grown and sold as a source of cash income in some situations; alternatively, hay and fodder crop yields may be increased through irrigation, thus reducing the purchases of supplemental feeds for dairy and animal production operations. Developing irrigated pasture may also reduce the need for purchase of outside hay. Such purchases are currently a major cost to dairies, significantly affecting their profitability.

Despite the economic advantages, unless properly planned and managed, application of reclaimed water to previously non-irrigated lands has the potential to increase non-point source water pollution of a watershed area, including groundwater degradation and impacts to surface water quality in streams and rivers. Unmanaged irrigation of prior dry-farmed areas or range lands also has the potential to negatively impact seasonal wetlands and adjacent riparian areas, as well as downstream receiving waters, wetlands and estuaries. Such impacts are typically associated with poorly controlled irrigation or over-irrigation, in which water is applied at rates that exceed soil infiltration capacity or the water needs of the crop. The result is surface runoff (runoff) of excess water or subsurface flow (subflow) of water to local drainage ways and stream courses. The runoff or subflow water may contain sediment, attached pesticides, nutrients and metals which may be native to the soil, occur in small quantities in the reclaimed water, or come from applied agrochemicals or animal waste.

By implementing proper irrigation and drainage planning and management, existing technologies may be used to control and reduce the significance of non-point source water quality impacts on watersheds and wetland systems. In fact, there is an excellent opportunity to enhance, restore and improve the quality and character of existing surface water, and seasonal and riparian wetlands that are being impacted from prior and ongoing dry land farming, dairy and grazing activities in West and South Sonoma Counties. Through integrated on-farm Irrigation Conservation and Management Planning along with good management of operations that will receive reclaimed project water for irrigation, eroding and gullied lands may be stabilized and healed, high value seasonal wetlands and oak woodlands enhanced and protected, and riparian corridors restored. Animal wastes may also be managed effectively when integrated with irrigation and cultivation practices, by incorporating the wastes directly into the soil and then seeding the areas with improved pasture grasses, hay or silage crops prior to irrigation. The practice of applying animal wastes directly onto the land surface, without cultivation and seeding may, under certain circumstances, result in winter runoff containing high levels of organic nitrogen and other pollutants.

Good use and management of the soil and water resources will result in improved watershed conditions, while increasing the viability of agricultural operations and improving the climate for long-term project success. Many of the identified management programs and practices contained in this IMG have been developed by the U.S. Department of Agriculture and the University of California Cooperative Extension Service, and are known and accepted to be reliable methods for control of wetlands and water quality impacts from farming, dairy, and ranching operations.

The net effect of implementing a planning and management program that both anticipates and mitigates potential non-point source impacts, and recognizes and corrects historic and ongoing problems, is an improvement in water quality and wetlands conditions within a watershed. Enhancement of watersheds and wetlands requires knowledge, commitment, capital, water, and follow-up management. Having water available for irrigation, the Santa Rosa Long-Term Wastewater Management Program may help provide the impetus to achieve these results by providing an organized and coordinated planning and management process.

In nearly all cases for the proposed West or South County projects, the City will not be responsible for directly applying the reclaimed water, or managing the farming, dairy or ranching operations. However, the City may indirectly control management practices that are being utilized on lands which receive reclaimed water by participating in the planning process and by providing incentives (and penalties, where needed) that encourage application of identified Best Management Practices (BMPs). This will require educating the irrigation water users, as well as irrigation management oversight and monitoring by the City.

1.3 ORGANIZATION AND CONTENTS OF THE IRRIGATION MANAGEMENT PLAN

Beyond this introductory section (Section 1.0), the IMG is organized into six sections. The contents of each section are summarized below.

Section 2.0 - System Wide Planning and Management

This section provides an overall description of broader system-wide planning and management issues. It includes a discussion of the procedures that may be used to insure that only suitable lands are brought into the irrigation project and that erosive and environmentally sensitive lands are avoided and protected. It also outlines a system of prioritizing water availability, pricing structure, incentives for good management, cost sharing and financial, educational, and technical assistance that the City may provide to implement the project. In addition, this section presents how the City may work with state and federal resource agencies toward a goal of overall improved watershed management and enhancement. Irrigation Conservation and Management Planning may be conducted cooperatively with the Resource Conservation District (RCD) technical staff, with required Irrigation Conservation and Management Plans (ICMPs) covering an entire property, not just immediate irrigation areas. In addition, state and federal agencies would be asked to participate in coordinated resource planning for the watersheds which would receive reclaimed water for irrigation.

Section 3.0 - Irrigation Water Management Policy

The proper use and management of applied irrigation water to avoid runoff and subsurface flows is deemed so critical to the success of either of the irrigation project alternatives and to the avoidance of adverse wetland and water quality impacts, that a separate section of the IMG is devoted to this topic. A high level of control may be provided in irrigation scheduling by direct participation in the irrigation programming by City reclamation staff and through the use of state-of-the art irrigation scheduling technology, including automated real-time irrigation weather forecasting systems (CIMIS), the use of electronic soil moisture probes, and irrigation scheduling software. Irrigation scheduling may be overseen by the City's reclamation staff or by an independent irrigation professional. High efficiency irrigation management techniques may be employed in the South County. Deficit irrigation management methods may be utilized in most of the West County.

Section 4.0 - Planning and Design Guidelines

This section of the IMG outlines the recommended elements of individual or site specific Irrigation Conservation and Management Plans (ICMPs). It includes specific avoidance and setback criteria from sensitive environmental features as well as restoration of gullies and riparian areas. Vegetative filter strips may be used to filter runoff. Riparian plantings may be used to increase evapotranspiration rates along water courses to remove nutrients and counter-balance any additional irrigation subflow inputs to the stream corridors. Irrigation may be closely managed to avoid drainage problems necessitating construction of large-scale drainage systems. Such ICMPs may be required for all agricultural property owners who wish to receive reclaimed water for irrigation and enter the City's irrigation system. These ICMPs may be prepared by City reclamation staff, working cooperatively with RCD technical staff. In addition to technical requirements, this section also contains design guidelines and recommended BMPs.

Section 5.0 - On-going Management

Guidelines and procedures for on-going management are addressed in this section. This includes management of irrigation water application, crop management, use and control of agrochemicals (fertilizers, herbicides and pesticides), and soil erosion control. The City may provide on-going management consultation to irrigation participants on such issues as irrigation scheduling, fertilizers and herbicide/pesticide recommendations, as well as crop and pasture management and problem solving.

Section 6.0 - Monitoring and Reporting

The final section of the IMG outlines criteria for developing the monitoring network for soils, surface water and groundwater. An actual monitoring network cannot be designed at this time since the specific parcels that will be irrigated and the order in which they would enter the irrigation program are not known. The general density and distribution of observations, and the suggested sampling, analytical and interpretive program are addressed. The monitoring network and any sampling and analysis plan would be coordinated with the Regional Water Quality Control Boards. Procedures for reporting the results and updating the IMG based on the monitoring results and new technology are also included in this section.

1.4 SUMMARY OF SPECIFIC PROJECT ELEMENTS AND RECOMMENDATIONS

In addition to specific design guidelines, operations and management practices, and monitoring procedures and recommendations, the IMG also contains a number of recommendations that would require governmental agency cooperation and participation. Many of the recommendations involve coordinating agency efforts to enhance natural resources and watersheds, and to improve water quality extending beyond the immediate boundaries of the irrigation lands; in a sense, beyond the more narrowly defined mitigation obligations of the project. Since the City cannot require the other entities to cooperate, these recommendations cannot be formally a part of the Mitigation Monitoring Plan. Nonetheless, they are included herein as a recommendation to the City to cooperate with other agencies and to utilize the project as a vehicle to assist in achieving overall watershed management goals, as outlined in the Stemple Creek-Estero de Americano Enhancement Plan.

A summary of specific elements (design guidelines, operations and management practices) that may be considered for use in development of the project description for CEQA/NEPA purposes as well as the recommendations which depend upon cooperation from others (and therefore not part of the project description) is presented in **Table 1**. Where applicable, agencies from which the City may also consider requesting assistance and support to implement the project are included in the summary, along with a brief description of the purpose or objective, as well as comments on methods and procedures.

In several instances in **Table 1**, both the “In-Project” and “Recommendations” boxes are checked. This was done to denote management and enhancement practices that would be required for irrigated lands and immediately adjacent areas (i.e., gully stabilization and stream bank fencing and restoration). Furthermore, these may also be extended to more distant areas of farms, ranches and nearby lands not directly associated with an irrigation area. Coordination with other agencies for technical support as well as contributions in funding watershed enhancement and conservation measures may be sought.

TABLE 1
SUMMARY OF IRRIGATION MANAGEMENT PLAN ELEMENTS

Section #	Project Component	In Project Description			Recommend-ation	Purpose/Comment	Agencies That Could Support City in Implementation
		System Planning and Design	Operations and Management	Monitoring and Reporting			
2.1	Formation of CRMP				✓	Cooperate in overall watershed management	M/S MAD, RCD, Reg Bd., CDFG, NMFS, NRCS, USFWS, Corps, NMS, CC
2.1	Coordination with NRCS/RCD				✓	Technical input in project design	NRCS, RCD
2.1	Feasibility Evaluation of Irrigation Advisory Committee				✓	Involve local participation in management	NRCS, RCD
2.2	Acreage Limitations on Lands That Can Be Irrigated	✓				Cost efficiency	
2.2	Soil and Slope Limitations on Lands That Can Be Irrigated	✓				Reduce erosion/hydrology impacts	NRCS, RCD
2.3	Irrigation System Restrictions	✓				Reduce hydrology impacts	UCCE
2.4	Crop Restrictions	✓				Reduce erosion impacts	NRCS, UCCE
2.5	Land Prioritization and Reclaimed Water Pricing Structures	✓				Provide incentive for good water management	RCD, UCCE
2.6	Cool Summer Contingency	✓	✓			Preclude over irrigation	
2.7	Dry Winter Contingency	✓	✓			Preclude over irrigation	
2.8	Incentive Program for Proper Farm Management	✓	✓	✓		Incentive for good land management	RCD

TABLE 1 (Con't)

Section #	Project Component	In Project Description			Recommend-ation	Purpose/Comment	Agencies That Could Support City in Implementation
		System Planning and Design	Operations and Management	Monitoring and Reporting			
2.9	Education and Training of Irrigators		✓			Education in good land management	RCD, UCCE, M/S MAD
2.10	Assistance in Cropping		✓			Assist farmers/ranchers	UCCE
2.11	Implementation and Cost Sharing		✓			Assist farmers/ranchers	BCD, CDFG, Rg Bd, USFWS, EPA, USDA
3.1-3.3	High Efficiency and Deficit Irrigation Management	✓	✓			Reduce hydrology, water quality impacts	
3.4	Programmed Over-irrigation of Reyes Soil		✓	✓		Reduce hydrology, water quality impacts	NRCS, UCCE
3.5-3.9	Proper Irrigation Scheduling		✓			Reduce hydrology, water quality impacts	UCCE
4.1	Irrigation System Design Review and Approval	✓				Provide high level of design QC to reduce impacts	RCD, UCCE
4.2	System Layout Considerations	✓				Reduce soils and biology impacts	NRCS, RCD, UCCE
4.3-4.5	Design Criteria	✓				Reduce hydrology impacts	RCD
4.6	Crop Establishment and Management Practices		✓			Provide assistance to farmers/ ranchers	RCD, UCCE
4.7	Irrigated Pasture Management		✓	✓		Reduce soil erosion impacts	RCD, UCCE

TABLE 1 (Con't)

Section #	Project Component	In Project Description			Recommend-ation	Purpose/Comment	Agencies That Could Support City in Implementation
		System Planning and Design	Operations and Management	Monitoring and Reporting			
4.8	Soil Erosion Control		✓		✓	Reduce soil erosion impacts	NRCS, RCD
4.9	Management of Agrochemicals		✓			Reduce water quality impacts	CDFA, CoAgComm
4.10	Mosquito Control	✓			✓	Mosquito Control	M/S MAD
4.11	Sensitive Area Setbacks and Buffers	✓		✓		Protect biological resources	RCD, USFWS, CDFA, NMFS
4.12	Use of Vegetated Filter Strips	✓	✓			Runoff, water quality management	RCD
4.13	Protection and Restoration of Gullied Lands	✓			✓	Mitigate soil erosion impacts	RCD
4.14	Protection and Enhancement of Stream Corridors	✓	✓		✓	Mitigate biological impacts, enhance watershed	RCD, CDFA, USFWS
4.15	Management of Animal/Dairy Wastes	✓	✓	✓	✓	Reduce water quality impacts	RCD, Rg Bd, UCCE
4.16	Integration with Bio-Solids Beneficial Use Program	✓				Avoid conflicts with biosolids program	UCCE
4.17	Tail Water Return System		✓			Reduce hydrology water quality impacts	
4.18	Drainage Management		✓			Reduce hydrology water quality impacts	RCD, UCCE

TABLE 1 (Con't)

Section #	Project Component	In Project Description			Recommend-ation	Purpose/Comment	Agencies That Could Support City in Implementation
		System Planning and Design	Operations and Management	Monitoring and Reporting			
4.19	Operations and Maintenance Manual			✓		Reduce hydrology water quality impacts	NRCS, RCD
5.1	Soil Moisture Monitoring			✓		Reduce hydrology water quality impacts	RCD, UCCE
5.2	Use of Flow Meters			✓		Monitor water application	UCCE
5.3	Agronomic Consultation		✓			Assist farmers/ranchers	UCCE, RCD
5.4	Vector Control		✓	✓	✓	Mosquito Control	UCCE, M/S MAD
5.4	Agrochemical Recommendations		✓			Reduce water impacts	CDFA, CoAgComm
5.5	Irrigation System Checks			✓		Maintain irrigation efficiency	UCCE
5.6	Maintenance		✓			Preclude system failures	
6.1	Monitoring			✓		Monitor potential impacts for remediation	Rg Bd, Corps, CDFG
6.2-6.3	Plan Update		✓	✓	✓	Periodic plan update	RCD

TABLE 1 (Con't)

TABLE NOTES:

Abbreviations

City: City of Santa Rosa
RCD: Resource Conservation Districts
CDFG: California Department of Fish and Game
NRCS: Natural Resources Conservation Service
USDA: Various conservation/commodity support programs run by USDA (Farm Service Agency)
CDFA: California Department of Food and Agriculture
NMS: National Marine Sanctuary
NMFS: National Marine Fisheries Service
USFWS: U.S. Fish and Wildlife Service
Rg Bd: Regional Water Quality Control Board
UCCE: University of California Cooperative Extension
EPA: Varoius state and federal programs for watershed and water quality enhancement; i.e., 319H
Corps: U.S. Army Corps of Engineers
M/S MAD: Sonoma-Marin Mosquito Abatement District
CoAgComm: County Agricultural Commissioner
CC: State Coastal Conservancy

Ref.: 93012IMP.T1A

2 SYSTEM-WIDE PLANNING AND MANAGEMENT

2.1 INTER-AGENCY PROGRAM COORDINATION

To be successful and useful in meeting the needs of the farmer and rancher as well as achieving environmental objectives, planning cannot narrowly focus solely on a proposed irrigation field. Overall farm and ranch planning must consider how irrigated forage crops, irrigated pasture and dryland range will be utilized together. Systems for animal waste management and use may be revised and applied to irrigation lands to meet the higher nitrogen demands of irrigated hay and silage crops. Gullies may be stabilized to compensate for any envisioned increases in erosion from cultivated fields. Vegetated filter strips and field check berms may be added to control and treat runoff, and riparian areas enhanced to intercept any increased subflow. Clearly, multiple resources planning on at least a sub-watershed basis is needed for the proposed project. Many of the planning and enhancement needs extend beyond the responsibilities and obligations of the Long-Term Wastewater Project, yet it would be short-sighted not to take advantage of the opportunities offered by the project.

Historically, the Natural Resources Conservation Service (NRCS, formerly SCS) and the Resource Conservation Districts (RCDs) have been the principal entities for on-farm resources planning and implementation. Their plans are called “conservation plans” and preparation and implementation may be a requirement to participate in certain USDA-supported programs. Because of the needs of the project to closely design and carefully control application of irrigation water and to integrate irrigation with other resource management needs, the combined plan (when applied to an individual parcel of farm property) will be termed an Irrigation Conservation and Management Plan (ICMP). The preparation and implementation of farm-specific ICMPs will be required for all new irrigation lands. Where ICMP’s cover an entire form and all its resource management needs, encompassing several USDA programs, the term “Whole Farm Plan” is used. ICMP’s may encompass the concepts and procedures used by the USDA in whole farm planning.

A number of state and federal resource agencies have ongoing programs for planning or funding the implementation of wetlands, wildlife habitat and water quality improvement initiatives. Several programs deal specifically with irrigated agriculture, dairy and livestock feeding operations and rangeland uses. Over the last several years the impetus has been for the agencies to work together in solving problems on a watershed-wide basis. A formal cooperative agreement may be reached among several interested agencies and landowners to conduct environmental planning for a specific geographic area. One such program is called a Coordinated Resources Management Program (CRMP).

Although interested agencies and landowners may work together informally by forming advisory groups, CRMPs are often advantageous as a means to secure support for implementation. The following agencies (in addition to the landowners) may have an interest in a CRMP for the West and South County irrigation components:

- Natural Resources Conservation Service
- Marin, Southern Sonoma, Santa Rosa, Sotoyome, Gold Ridge RCDs
- California Department of Fish and Game
- California Department of Forestry
- Farm Bureau
- U.C. Cooperative Extension Service
- North Coast and San Francisco Bay Regional Water Quality Control Boards
- U.S. Fish and Wildlife Service
- National Marine Fisheries Service
- National Oceanic and Atmospheric Administration (Gulf of the Farallones Marine Sanctuary)
- State Coastal Conservancy
- Sonoma-Marin Mosquito Abatement District

Following selection of the preferred alternative (West County, South County, Geysers, etc.), the City may discuss with the above agencies the possible preparation of a joint Memorandum of Understanding (MOU) for coordinated resource planning and implementation for land areas (sub-watersheds) that will be irrigated with project reclaimed water. Of particular importance will be coordinating with the Natural Resources Conservation Service (NRCS), and the Resource Conservation District (RCD) in preparing site specific ICMPs (see next section). These two agencies will also be involved in further planning and implementing elements of the Stemple Creek-Estero de Americano Enhancement Plan, and in similar planning efforts for the Petaluma River watershed. The City may also seek to work with the U.C. Cooperative Extension Service (the Marin and Sonoma County Farm Advisors) to coordinate education and technology transfer regarding irrigation practices and management of crops not previously grown in the County.

Coordination with the California Department of Fish and Game, California Department of Forestry, U.S. Fish and Wildlife Service and the Regional Water Quality Control Boards will be beneficial in protecting and enhancing stream corridors and wetlands, and rehabilitating eroded and gullied lands.

In many cases, grants and cost-sharing funding are available through these agencies to complete certain portions of a Conservation Program, such as fencing, gullied land restoration, wetlands and conservation reserve programs for erodible lands, and tree planting in wetland areas. These programs may also be coordinated through the creation of an inter-agency CRMP or Technical Advisory Group.

2.1.1 Coordination with NRCS and RCD

The NRCS may be asked to assist the City in verifying compliance with the Food Securities Act (see Section 2.2), and together with the RCDs, in preparing Irrigation Conservation and Management Plans, providing ongoing management consultation, and coordinating watershed restoration and enhancement activities with other state and federal agencies. Staffing requirements and personnel needs for providing this assistance will be reviewed with the NRCS. If substantial RCD staff time is required, the City would need to negotiate an equitable funding mechanism for providing technical assistance.

2.1.2 Formation of an Irrigation Advisory Committee

As a means of providing objectivity and increasing local participation in management of the irrigation lands, the City may cooperate with the RCDs and/or the Sonoma County Water Agency (SCWA) in investigating the feasibility of the formation of an Irrigation Advisory Committee. The make-up, role and responsibility of the committee would need to be determined.

2.2 DETERMINATION OF LANDS SUITABLE AND ELIGIBLE FOR PARTICIPATION IN THE IRRIGATION PROJECT

2.2.1 Acreage Limitations

Because of the high costs of providing infrastructure, negotiating leases and system maintenance and monitoring, normally only parcels over 20 acres, or multiple parcels under the same ownership and/or management totaling over 20 acres will be included in the agricultural irrigation system. The City may consider smaller parcels on a case-by-case basis.

2.2.2 Resource Limitations

One method to control and reduce adverse impacts from irrigation application is to restrict water availability so that large areas of marginal or problem soils are not included in the project. Problem soils may include steep erosive soils, gullied lands, shallow soils, soils with subsurface barriers to water movement, or poorly drained or wet soils. In addition, problem soils may readily develop perched water tables, and require new drainage ditches or tile drain installation. These soils are often difficult to irrigate without causing runoff, erosion and subsurface drainage flow problems.

Project soils have been evaluated as to their suitability for irrigation utilizing U.S. Bureau of Reclamation Irrigation Land Classification Standards (see Irrigation Suitability Technical Reports). This classification system recognizes deficiencies in soils. Where such deficiencies are significant, the soils are considered marginally irrigable or non-irrigable. However, because of access problems not all parcels were evaluated with on-site field inspections. Some were evaluated by off-site methods through examination of aerial photography, roadside observations, and data extrapolation between observation points. The large project area also precluded a detailed field examination of each parcel.

Prior to incorporating a parcel into the reclaimed water irrigation project, additional field examination of soils, drainage and other natural resource conditions (biology, wetlands) may be required for certain parcels in association with preparing site specific irrigation designs.

A resource map may be compiled and prepared for each parcel. The map may identify soils suitable for irrigation and the sensitive areas that are not suitable for irrigation (wet areas, stream corridors, erosive soils, gullied lands, etc.) Standard methods utilized by the U.S. Department of Agriculture may be used to identify soils and wetland areas. Additional infiltration tests and drainage evaluations may also be conducted to optimize irrigation designs. Soil constraints and soil management needs, such as high clay content soils or soils with perching layers and barriers to water movement, may be identified on the map. This resource map (to be signed by a CPSS)[1] may form the basis for final determination whether to include lands into the irrigation project. The map may also be used in the subsequent preparation of the Irrigation Conservation and Management Plan.

In addition to meeting the Bureau of Reclamation Irrigation Suitability criteria, the City's policy may normally require that prospective irrigation parcels conform with USDA Food Security Act (of 1990 and 1995) Swampbuster and Sodbuster provisions. These programs are designed to protect erosive soil areas and wetlands from being inappropriately brought into cultivation. Although not required, the project will irrigate only those lands identified as eligible (i.e., non-wetlands and not highly erodible lands) under the FSA. This will also ensure that farmers and ranchers remain eligible for participation in federally funded conservation and commodity support programs.

2.3 IRRIGATION SYSTEM RESTRICTIONS

A number of types of water application systems have been used in other areas for irrigating level agricultural fields with reclaimed water, including flood irrigation, border check, furrow, sprinkler and drip. Although much of the West County and South County areas consists of sloping lands suitable only to sprinkler or drip irrigation, flood and furrow irrigation may be utilized in some portions of both areas, after leveling. Since sprinkler and trickle or drip irrigation provide irrigation systems that allow for a higher degree of irrigation application efficiency, only these two methods are recommended for lands irrigated utilizing project reclaimed water.

2.4 CROP RESTRICTIONS

Some crops may be unsuited to certain soils because of inherent incompatibilities between plant growth needs and soil conditions. For example, alfalfa typically does not grow well in poorly drained, clayey, or acidic soils because of poor root environment conditions. Other crops may not be well suited because the type and intensity of

1 CPSS, Certified Professional Soil Scientist
CPESC, Certified Professional Erosion and Sediment Control Specialist

management practices results in unacceptable adverse impacts to water quality or watershed conditions. Cool season vegetable crops (such as broccoli) or perennial crops such as artichokes typically are managed with clean cultivation between rows. In addition, these crops may require applications of fertilizers and herbicides/ pesticides to achieve the grower's desired yield and quality, or to manage weed and pest infestations. Where these crops are grown on sloping lands adjacent to stream courses and where cultivation practices expose bare soils to rainfall or high rate sprinkler irrigation applications, unacceptable levels of soil erosion and runoff may occur. The eroded soil particles may contain attached agrochemicals and nutrients which may enter surface water bodies.

Because of these and other environmental concerns, the project may place certain restrictions on the types of crops which may be grown by sprinkler irrigation with project reclaimed water under certain soil and slope conditions. Possible crop restrictions may be reviewed on a case-by-case basis with individual farmers and ranchers, in consultation with the RCD and U.C. Extension specialists. In some instances, special management practices may be specified in the ICMP. Measures such as contour forming, inter-row cover crops, seeded and water-barred roadways, filter strips and sediment detention structures may allow otherwise unsuited crops to be grown on sloping lands.

The following guidelines have been prepared to plan when restrictions may be imposed on lands which receive project irrigation water. For simplicity, the restrictions are largely based on slope classes of soil map units using Soil Survey procedures identified in the NRCS National Soils Handbook. In general, the USDA Land Capability Classification System may be utilized to identify management needs and concerns of soils. Other limitations and restrictions may be imposed for highly erosive soils on flatter slopes, shallow soils, or soils with barriers to water movement. These additional restrictions may be outlined by the City or RCD in the Irrigation Conservation and Management Plan.

Where restrictions are identified, they may be contained in the agreement between the City and the individual farmer/rancher. A variance may be required from the City along with the preparation of specific management practices that must be put into effect and monitored before the City would deliver project water to restricted lands. Failure to adhere to the restrictions and conform with the identified management practices may result in the curtailment of water delivery.

Slopes 0-5%, No Crop Choice Restrictions.

1. Typical crops may include:

   - Cool season vegetables, field and truck crops
   - Specialty crops
   - Orchards and vineyards
   - Hay, forage and silage crops
   - Permanent irrigated pasture

2. An ICMP plan possible developed with the RCD will be required.

Slopes 6-9%, Cultivated truck, row and field crops generally restricted.

1. Planting of cultivated crops (including drip irrigated specialty crops) will require a variance from the City along with a conservation plan developed with RCD.

2. Typical crops grown without restrictions may include:

   - Irrigated hay, forage and silage crops (sudan, corn, alfalfa, oat ryegrass, vetch, and clover mixes)
   - Orchards and vineyards (with cover crops)
   - Permanent irrigated pasture

3. An ICMP plan possible developed with the RCD will be required.

Slopes 10-15%, Intensively cultivated crops regulated.

1. Generally, only improved, irrigated pasture will be allowed. Other crops will require a variance from the City.

2. An ICMP plan possible developed with the RCD will be required. Elements of the plan will include:

   - Improved plant establishment through use of non-till drill, fencing and gullied/eroded land restoration.
   - Seed and establish protective cover prior to October 15. Use sprinklers to germinate and establish cover.
   - Fence and restore eroded and gullied lands.
   - Water development for livestock.

3. Development of a pasture management plan including cross-fencing, proper stocking rates and grazing periods, maintenance of correct amount of plant residue, and rest-rotation management.

4. Existing orchards and vineyards may be sprinkler irrigated but will require establishment and maintenance of a permanent cover crop. Lands in this slope class may also be considered for new orchards and vineyards by sprinkler irrigation with a cover crop.

Slopes 16-20%, Incidental and Included Acreage.

1. Land areas with this slope may be included in the irrigation program, provided they are small inclusions within an existing field or pasture area of flatter slopes.

2. The policies and requirements for the 10-15% slope class also apply to these areas. Existing vineyards and orchards may be drip-irrigated with project water. A special variance,

including preparation of an erosion control plan will be required for new drip-irrigated vineyards and orchards on this slope class.

Slopes 20%+, Ineligible Lands

1. Lands with average slopes greater than 20% will normally not be eligible for participation in the City's reclaimed water program. Exceptions may be made for existing vineyards and orchards, provided erosion control plans are prepared and implemented.

Drip Irrigation Systems.

Drip or trickle irrigation of existing and new plantings of orchard crops, vineyards and other specialty crops (artichokes, strawberries, roses, berries, etc.) might be permitted by variance on slopes up to 20 percent. Detailed erosion control plans, including such elements as on-field sediment detention structures, grassed and water-barred roadways with tail water and rainfall or trickle pick-up structures, may be required for all lands with slopes over five percent. In general, drip irrigation utilizing project reclaimed water may only be permitted in the late spring, summer and early fall months. A winter cover crop seeded and established utilizing a temporary sprinkler irrigation system may be in place by October 15 for crops including orchards and vineyards, grown on slopes percent or steeper.

2.5 PRIORITIZATION OF LANDS FOR WATER APPLICATION AND PRICING STRUCTURE

A water delivery prioritization system with an associated pricing structure may be developed and implemented. This would provide assurance of water availability to growers with water deficit sensitive (non-drought tolerant) crops. A pricing structure or fee for use may also provide a small incentive for good irrigation management. Under a guaranteed delivery system a water volume need would be identified and a reserve held in storage (contracted), with a firm commitment that the water would be made available when needed. For instance, a grower raising lettuce would need a firm commitment that he has water available to irrigate during a hot day in August. The City would contract to provide a commitment for a quantity of water (in acre-feet) based on the acreage and water demand of the crop to these High Priority water users.

Other growers (e.g., cropping irrigated pasture) need much less water available on demand assurance since their crops are not as sensitive to moisture stress. Although in most instances, irrigation water will be available to these growers, a firm commitment cannot be made to all users for water on demand, particularly during periods of much warmer than normal weather when consumptive water use may be very high. Typically, water may be provided within a three-day window. However, during periods of water scarcity the high priority water users would have their needs met first. Growers in this priority category may be able to rely on water availability to the extent that their crops will not fail or that yields will not be significantly affected. These are medium priority water users.

The low priority category consists of farmers or ranchers who would have an uncertain or undependable water supply. These growers would typically raise improved irrigated pasture. Such lands would benefit from irrigation, but it is not essential for their lands to be irrigated to achieve an acceptable result. Irrigation water may be available, somewhat unpredictably, several times a year for these lands. The irrigated water would be used essentially for load balancing and peaking purposes. During drier than normal periods these lands may not have irrigation water available; but, in cool, moist summers, when all other irrigation lands are utilizing water according to their maximum crop demand, excess water may be stored or used to irrigate low priority lands.

This system provides flexibility in matching supply and demand so that water is available when necessary to certain crops, but provides assurance that excess water will not be used to over-irrigate.

The prioritization and pricing structure recommended is summarized as follows:

1. **High Priority Lands**. Lands guaranteed water for irrigation of water deficit sensitive crops. Farmers pay a fee for guaranteed water supply for sprinkler irrigation. Drip irrigation users will pay a higher fee because of their generally low use rate relative to the cost of the pipeline and water distribution system infrastructure.

2. **Medium Priority Lands.** Lands not guaranteed water for irrigation. Typically, non-sensitive water demand crops such as irrigated pasture or hay are grown. Water would be delivered only after high priority crop needs are met. Farmers pay a smaller fee than high priority lands or no fee at all.

3. **Low Priority Lands**. Lands are seldom irrigated. They may be irrigated once a year or only in years of surplus water, such as cool moist summers with lower than average evapotranspiration or dry winters. Farmers are paid a small annual per acre sum fee for uncertainty, plus a payment per acre foot for water when applied (see next section on contingencies).

   [Note: The outlined water pricing structure is provided as a beginning point for discussion purposes. Final pricing may be based on a cost-benefit economic analysis, and discussions with interested landowners, U.C. Cooperative Extension and the RCD. The prioritization and pricing structure will likely need to be reviewed by the City on a biannual basis. One important issue for discussion is the pricing of water and providing infrastructure and improvements (pipes, tubing, pressure regulators and valves) to drip and trickle irrigators. On one hand, they use only half the water of sprinkler irrigation; yet, drip irrigation represents the best management control of runoff and subflow and associated nutrient and agrochemical discharges.]

2.6 COOL SUMMER CONTINGENCY

The amount of land required for irrigation in an Irrigation Management System which closely controls application rates to minimize runoff and subflow problem, is directly related to the consumptive water use demands of the planted crops. These are referred to as “Type 1 Systems” in *Irrigation With Reclaimed Municipal Wastewater* (Pettygrove and Asano, July 1984).

For planning purposes, the irrigation land requirements of the West and South County alternatives are based on average crop water use (crop coefficients in normal years, as referenced to the standard coefficient of 1.0 for irrigated pasture) for crops expected to be grown within the irrigation area. The annual water demand of the irrigation area may change slightly if lower (or higher) water demand crops are grown (crops with a lower or higher crop coefficient). More significantly, in cooler than normal summers with lower evapotranspiration rates, demands for irrigation water to meet crop needs may be much lower than average. Late spring rains may also significantly effect the normal irrigation schedule. Extensive use of highly efficient drip irrigation may also significantly effect (reduce) the overall demand on the system for reclaimed water.

A cool summer contingency recommendation thus is included in the IMG to insure that reclaimed water is not merely applied to existing lands in excess of crop needs. Some of the excess water may also be applied to existing City-owned irrigation lands near the Laguna Treatment Plant. Additional lands (i.e., low priority lands) may be identified as needed in either the South or West County which will be available to receive the “excess water” during cooler than normal summers.

These lands may consist of soils on relatively flat slopes (less than ten percent) that do not pond water in the winter months. Usually, improved pasture or hay crops would be grown. The landowners may be paid a small contingency for the uncertainty. Long term contracts and agreements with these landowners may be initiated so that when the need for summer contingency irrigation is identified, these lands may be brought quickly on-line (i.e., using rented sprinkler equipment).

2.7 DRY WINTER CONTINGENCY

The amount of treated effluent that may be discharged to the Russian River and/or applied to agricultural lands is weather dependent. Effluent may be discharged to the river up to a certain percentage of the total river flow (i.e., one percent or more), depending on the alternative. In some years (one out of 20 statistically by design), more reclaimed water is produced than may be discharged to the river. During these low flow periods, reclaimed water accumulates in storage faster than the normal operational plan would allow.

Operationally, at some point in time during dry winter years, reservoir storage will be nearly full and stored water and/or treatment plant effluent will need to be otherwise managed. One strategy is to apply reclaimed water to agricultural lands during dry winters. Normally, irrigation water is not applied to lands during winter months because of higher risks of runoff on wet soils and any coincidental rainfall. Furthermore, many plants are not actively growing during the coldest times of the year and so their water needs are low. However, during dry winters, soils are not saturated and reclaimed water may be carefully and safely applied so that irrigation runoff or increased runoff and flooding does not occur.

The reclaimed water may be applied at rates that exceed the crop or vegetation water demand during this period, but one within the infiltration capacities of the soil. The reclaimed water will mingle with natural rainfall, and the combined total that exceeds the plants' needs will be available for transportation to the shallow groundwater zone. Depending upon site conditions, the shallow zone water (or a portion thereof) may either move laterally to enter an adjacent stream, or move downward to mix with the deep groundwater zone.

To a large extent, the dry winter applied irrigation water will not result in increased runoff to stream courses or subflow contributions to stream base flow. The irrigation water during these dry periods would only displace the normal rainfall that would have occurred. The small additional load of nutrients and salts would occur at a time when they would be greatly diluted by rainfall runoff and groundwater, and at a time of less biological significance.

Most of the winter contingency irrigation will likely continue to occur on City-owned lands near the Laguna Treatment Plant site. Additional lands may be identified as needed in the South and West County which will be available for contingency winter irrigation. These lands may consist primarily of soils on relatively flat slopes (less than 10 percent) that do not pond water in the winter months. Usually, improved pasture or hay crops would be grown. The landowners may be paid a small contingency for the uncertainty. Normally, the additional cool summer and dry winter contingency lands would be the same and would be low priority lands. To achieve maximum management flexibility while minimizing capital costs, it is likely that some of the contingency lands ~~will~~ would be irrigated using temporary systems (portable pumps and rental irrigation pipes).

2.8 INCENTIVE PROGRAM FOR PROPER MANAGEMENT

Payment to irrigators based solely on their total amount of water usage does not provide an incentive for good management. Although soil and resource conservation may be shown to be beneficial to the operator over the long-term, they may require additional short-term expenditures in labor and materials without corresponding increases in yields or productivity. In addition, not all desired resource conservation and Best Management Practices (BMPs) are directly tied to water use and water use rates.

To foster the continuing implementation of BMPs identified in the ICMP for the irrigation property, the City may develop a Conservation Incentive Program (CIP). The CIP may include an annual evaluation of farm and ranch practices that contribute to resource conservation. This may include such evaluations as history of water use and runoff events, proper grazing management, vector control, and progress in meeting restoration of gullied lands and stream corridors. The CIP may reward farmers and ranchers who comply substantially with their individual Irrigation Conservation and Management Plans. This may include payments or payment credits for water usage, low interest loans, and cost sharing for other planned conservation elements. Recommendations for improvements in practices may be included in an Annual Management Plan update (see Section 6). The City may contract with the RCD to develop and implement such an Incentive Program based on other similar existing programs (i.e., for wildlife and forest conservation).

2.9 EDUCATION AND TRAINING

Many of the farmers and ranchers in the West and South County areas are not experienced in controlled applications of irrigation water by sprinkler irrigation. Since good irrigation scheduling, application and system maintenance are fundamental to source control and minimization of irrigation associated impacts, the project may sponsor a series of training and educational short courses on irrigation practices for participating farmers and ranchers. The short course may focus on irrigation and agricultural practices and vector control for the crops that might be grown, but will include other BMPs for water quality management associated with farming, dairy and ranching. Participation in the short course and receipt of an irrigation applicator's completion certification may be a requirement for inclusion in the project, along with periodic refresher courses.

It is recommended that the City of Santa Rosa coordinate with U.C. Cooperative Extension and the NRCS in developing the curriculum and sponsoring the short courses. The short course may include a *Handbook of Irrigation, Agricultural, Water Quality and Resource Management and Conservation Practices* prepared specifically for either the West County or South County area. The format and content is expected to be similar in many respects to *Vineyard Management Practices*: *An Environmental Approach to Development and Maintenance (Southern Sonoma County Resource Conservation District, June 1993).*

2.10 ASSISTANCE IN INITIAL CROP ESTABLISHMENT- MANAGEMENT AND HARVESTING

Currently, some dairymen and ranchers lack the farm machinery, equipment, and experience of proper cultivating practices (including BMPs) that may be required to convert from dry-land farming and ranching to more intensive irrigated agriculture. The City may assist with the establishment, management, and harvesting of the first year's crop of newly irrigated acreage using reclaimed water.

This may include: contracting with knowledgeable farmers and agriculturists for land preparation and seeding; renting or leasing necessary equipment; working with the irrigation users in tailoring and developing cultural, irrigation, and management practices that best suit their operations; and, assistance harvesting and marketing the crops and agricultural commodities. The income from the first year's crop may then be utilized to finance subsequent operations.

This service and commitment is likely necessary from a practical standpoint to insure willingness and feasibility for interested farmers. Hands-on assistance and training in irrigation and crop management the first year will also insure that the BMPs and other elements identified in the individual ICMPs are modified to suit field situations and are actually followed and implemented.

Determining levels of assistance in financing and management may be addressed on a case-by-case basis with individual irrigation users. All terms and conditions may be specified in each individual agreement between the City and the irrigator for water delivery.

2.11 Implementation And Cost Sharing

The City has traditionally provided the pipe, valves, sprinklers, and any necessary pumps and accessory equipment for irrigation water application on lands near the Laguna Treatment Plant. The irrigation operator has traditionally been responsible for construction and system operation. Application of irrigation water to the West County or South County areas will require construction of improvements and environmental enhancements beyond the infrastructure required for transporting and applying water. Fencing, crossing-fencing and watering structures will be needed for better animal control on improved irrigated pastures. Fencing will also be required to protect gullied lands, wetlands and stream corridors. Materials will be needed for check-dam construction, and native plants required for establishing vegetated filter strips and riparian restoration. Some of these enhancements and improvements will need to be constructed before specific irrigation systems are brought on-line. Other restoration and enhancement activities (i.e., gully stabilization) may be phased in over a period of five to seven years.

The site specific ICMP may identify and itemize those enhancement and irrigation elements which are functionally needed for implementation. The City may continue to provide all materials that are identified as being directly required for irrigation within the immediate irrigation area (pipe, fencing and seeding). The operator may remain responsible for constructing necessary fencing and completing enhancement plantings. This may includes planting and maintenance of vegetated filter strips and runoff detention berms for water quality treatment, and planting riparian trees and shrubs to consume any additional irrigation subflow. Gully stabilization may be designed to offset any irrigation related soil erosion. Where construction of an underground system is necessary, the City may also pay for and inspect the construction.

Funding to implement conservation and enhancement elements within an operator's property that are not directly related to the irrigation project or within the immediate irrigation project area, may be evaluated on a case-by-case basis. These may be phased in over a period of time. Funding of these elements may be coordinated with the RCD and other state and federal agencies (e.g., to secure assistance from USDA Conservation Reserve or Clean Water Act funds). In certain situations, the City may provide the materials and technical support required, with the operator responsible for the actual construction. Long-term low interest loans and grants may be provided through the Conservation Incentive Program (Section 2.9) for successful BMP implementation.

Because of the generally low consumptive water use of drip irrigation systems, the City may generally not pay for materials or installation of these systems. The City may provide a main line stub-out and flow meter to connect the drip irrigation system. The drip-irrigator normally may be responsible for purchasing and installing the drip or trickle irrigation system, as well as for constructing vegetated filter strips, stabilizing gullies, and enhancing stream corridors, where needed (see note in Section 2.5).

3 IRRIGATION WATER MANAGEMENT POLICY

3.1 STANDARD IRRIGATION AND HIGH EFFICIENCY IRRIGATION MANAGEMENT

Irrigation efficiency is defined as the amount of water required by a crop, divided by the amount applied and multiplied by 100. Typical efficiencies for sprinkler irrigation range from 60 to 80 percent, indicating approximately 20 to 40 percent more water is applied to a field beyond crop needs. Irrigation application efficiency is influenced by both system design and system management. In a sense, irrigation efficiency really means "inefficiency".

Irrigation efficiency has two components: (1) water losses; and, (2) uniformity of application. If either water losses are significant or uniformity of application is low, the irrigation efficiency will also be low. Uniformity losses are predominantly affected by poor irrigation system design while large water losses are almost always a result of poor management that results in runoff and excess deep percolation.

Over-irrigation, or applying more water than needed by the plant and in excess of soil intake rates, is the most significant cause of water loss in an irrigation system. Proper irrigation scheduling is essential if high irrigation efficiencies are desired. An ideal, well designed irrigation system would apply water evenly or uniformly over all parts of a field and at a frequency less than the smallest soil infiltration rate. In practice, this is difficult to achieve, particularly in areas of complex and variable soils and topography. A significant part of sprinkler irrigation system design and water application management is associated with problems of poor irrigation uniformity and soil variability.

When irrigation water is applied to a field with poor uniformity, some parts of the field will receive more water than other portions. If the irrigation system is managed so that the part of the field that receives a lesser amount of water has its crop consumptive water needs fully met, then the remainder of the field is over-irrigated. On the other hand, if the system is operated so that the water requirements are met only for the portion that happens to receive the most water, then the remainder of the field is under-irrigated.

Standard sprinkler irrigation management guidelines are designed to fully meet the crop water demand of the typically 20 to 25 percent of the field that receives the least amount of water in an irrigation cycle. This is often due to a poor irrigation design that does not uniformly apply irrigation water over the field, or complex field conditions, such as topographic or soil factors, that make irrigation of that portion of the field more difficult. As a result, by attempting to meet the irrigation requirements of a small portion of a field, the majority of the field is over irrigated. This over-irrigation may result in increased runoff or deep percolation, and consequent baseflow discharge (subflow) to stream courses in areas with shallow barriers or perching layers that are intersected by stream channels.

Most standard sprinkler systems are designed and managed with irrigation efficiencies of 60 to 70 percent. In other words, 30 to 40 percent more water is applied than necessary to meet crop consumptive water use needs. Some of this excess water is directly lost to wind drift and evaporation (three to seven percent); however, a good portion of the water in a standard irrigation system may be lost to deep percolation (five to 20 percent). Typically, a smaller portion is lost to runoff (two to seven percent). Highly efficient sprinkler irrigation systems operate at 80 to 85 percent. Efficiency may be increased to 90 percent under diligent management, as well as by using such techniques as night irrigation when wind and air evaporation losses are minimal. Many drip irrigation systems may operate at efficiencies above 90 percent if well designed and maintained. Efficient systems pay careful attention to plant stress and soil conditions and apply water utilizing an irrigation schedule based on specific operation criteria. Highly efficient irrigation operations are commonly found in water-short areas, areas with high water costs, and, increasingly, in areas with shallow or shallow saline groundwater where good water management and conservation are important to successful agricultural operations. Achieving good irrigation efficiencies is perhaps the single most important management measure for controlling runoff and subflow problems, and reducing non-point sources of pollution from nutrients and pesticides.

3.2 DEFICIT IRRIGATION MANAGEMENT

The amount of excess water from irrigation lost to runoff and subflow may be reduced in two ways: 1) by increasing uniformity through good design; and, 2) by reducing irrigation applications (essentially under- irrigating). Under-irrigation, which creates a small water deficit in many drought tolerant crops in a portion of a field, results in negligible yield losses if managed correctly. Drought tolerant crops include many of the hay, forage and pasture grasses that may be grown in Southern Sonoma and Western Marin County. This type of irrigation management system is termed “deficit irrigation”. Deficit irrigation management may be practiced on all drought tolerant or non-water deficit sensitive crops in the West County. This includes irrigated pasture, hay and silage crops. Procedures for deficit irrigation may be based on Chapter 17 of *ASA Monograph on Irrigation Management* and *FAO Irrigation and Drainage Paper No. 33.*

Techniques for applying water in a deficit irrigation management system involve limiting application depths so that a small portion of the field is under-irrigated, and controlling irrigation timing and frequency to improve water use efficiency. This requires carefully monitoring soil moisture conditions and adjusting to these conditions. Usually, if a field is slightly under-irrigated (i.e., for example by receiving 90 percent of the projected crop consumptive water use requirement) only a portion of the field will actually experience a deficit to the extent that the yield is measurably effected.

In a relative sense, converting a non-irrigated pasture or native rangeland to irrigated pasture will increase forage yields or animal carrying capacity by three to four times. A slight reduction in yield from deficit irrigation will still provide a significant economic return (relative to dry-farmed forage or pasture) through reduced purchases of supplemental feed.

Procedures for deficit irrigation management include:

1. Reducing irrigation application amounts early in the season when there is some stored soil moisture from rainfall and/or shallow groundwater, and late in the season when fall rains occur.

2. Assuming a high irrigation application efficiency (i.e., 85 to 95 percent, rather than the usual 70 to 80 percent) in preparing the water budget for irrigation scheduling.

3. Managing the field to meet the average crop water requirements (rather than the requirements of field portions that receive less water due to application uniformity problems).

4. Slightly alternating the location of hand-move or side-roll sprinkler lines between successive irrigation events to improve season long average application uniformity. (Typically, areas immediately adjacent to lines receive more irrigation precipitation.)

Normally, night time irrigation also improves irrigation efficiencies because of reduced evaporation and wind-drift losses. This is particularly valuable where the objective is water conservation. However, night-time irrigation may be discouraged on project irrigated lands because of the reduced opportunity to inspect system performance, observe possible runoff incidents, and respond to leaks and other system problems.

3.3 HIGH EFFICIENCY IRRIGATION MANAGEMENT OF TRUCK CROPS AND SPECIALTY CROPS

Certain crops, such as lettuce and strawberries, are more sensitive to water deficits, particularly at key points in their growth. These crops do not lend themselves to deficit irrigation management; and, therefore, they may be managed by high efficiency irrigation management methods. A high level of care may be provided in scheduling and operating these applications. Currently, only a small portion of the West County area is expected to be converted from dry-farmed oat hay to sprinkler irrigated crops that are not drought tolerant. Therefore, significant problems from careful irrigation of these areas are not expected.

The South County area does not present the same concern and need for tightly controlling runoff and leaching as does the West County area. Consequently, high efficiency irrigation management methods may be utilized for the majority of South County lands. As with truck crops and specialty crops in the West County, a high level of professionalism and care may be utilized in designing and scheduling irrigation and in operating irrigation systems to minimize runoff and deep percolation losses.

3.4 PROGRAMMED OVER-IRRIGATION OF REYES SOILS

Reyes soils occur on reclaimed former tidal marsh in the South County area, between Lakeville Highway and the Petaluma River. These soils are unique; they are highly acidic, have poor water intake rates, a shallow seasonal water table and poor drainage. They are currently utilized for growing dry-farmed oat hay and for sheep and cattle grazing. Reyes soils are suitable for developing irrigated pasture or irrigated hay crops.

Reyes soils are primarily artificially drained by a series of parallel drainage ditches with the collected ditch water pumped over river-front levees into the Petaluma River. The acidity of the drainage ditch water is typically pH 3.0 to 4.0 during much of the year, and may contain active sulfide and manganese compounds; these are conditions that are toxic to many aquatic organisms.

The acidity in the soil and ditch water arises from oxidation of the sulfide compounds. The sulfide and manganese compounds accumulated historically in the marsh sediments in the anaerobic environment which previously existed. Diking and draining of these areas has caused the formation of acid compounds, which lower the soil pH and leach into the drainage ditches.

Areas of Reyes soils may be managed by periodic applications of lime to increase soil pH in the surface soils. This may be accomplished every year or two for areas of annual cultivated hay crops, and every six or seven years for irrigated pasture. The lime may be added at the time of re-seeding for stand improvement. Lime and fertilizer application amounts will be based on soil testing.

As a recommended management strategy, Reyes soils may be purposely over-irrigated to maintain a high water content in the subsoils (below lime application depths). Surface ponding will need to be avoided for mosquito control purposes. This strategy will reduce oxidation of sulfides and consequent leaching of acidic compounds to drain waters. Subsoils may be managed at field capacity and only allowed to dry out during periods of grazing, harvesting and/or mowing/bailing. This will require carefully selecting plant materials tolerant of moist soil conditions. Management may also require that moisture levels, acidity and the shallow groundwater table be carefully monitored to preclude build-up or raising of the water table to depths that affect agricultural uses. When this begins to occur, the fields may have their irrigation application rates significantly reduced for a season to allow water table stabilization. This may be timed with replanting of improved pasture grasses and legumes, surface soil liming, and periodic application of bio-solids every three to five years or more (see **Section 4.15**).

Drainage ditch water may be managed by more frequent introduction of tidal water through hydraulic structures. Management of water and vegetation in ditches will also be required for mosquito control. The tidal waters have a significant natural buffering capacity which may neutralize the acidic ditch water prior to discharge to the Petaluma River. This will also allow water levels to be maintained higher along the ditches and field areas to reduce oxidation. Some re-working of tidal gates to allow better managed inflow and outflow may be needed. The development of proper irrigation management systems for avoid mosquito and water quality problems will require further consideration. The Sonoma-Marin Mosquito Abatement District, NRCS and U.C. Cooperative Extension may be asked to help devise proper management practices for Reyes soil areas.

3.5 IRRIGATION SCHEDULING SYSTEM

Irrigation scheduling entails deciding when to irrigate and how much water to apply. The goal of a well managed irrigation scheduling program is to supply the crop with just enough water to meet the desired yield, and thereby minimize the loss of applied water to runoff, deep percolation or subflow. There are several ways to schedule irrigation, including:

1. Observing or monitoring soil moisture conditions;

2. Observing or measuring plant stress;

3. Tracking evapotranspiration, water application, and estimated water losses in a water budget; and,

4. Combinations of the above.

The greatest control of irrigation involves using the water budget method by employing local real-time reference evapotranspiration data with soil moisture monitoring to verify irrigation timing.

A California Irrigation Management Information System (CIMIS) automated weather station may be constructed in the West County or South County area, as applicable, to aid in irrigation scheduling. The weather station contains instruments that measure temperature, solar radiation, humidity, wind speed, wind direction, and rainfall. The data are relayed to a central computer which calculates and stores reference crop water use. Current (i.e., "real-time") reference evapotranspiration data are then available to irrigation users through a "dial-up" service operated by the California Department of Water Resources. (Note: There is currently a CIMIS station located at the Kelly Farm near the Laguna Treatment Plant as well as in Petaluma.)

Using water budgeting information and CIMIS, along with soil moisture monitoring data, several types of irrigation application schedules may be developed, including:

1. A standard schedule, in which the crops are irrigated at a specified interval of days, but the amount is changed to reflect the recent climatic history.

2. A fixed schedule in which the same amount is always applied, but the time between applications changes in response to the water budget.

3. A flexible schedule where soil moisture is allowed to be depleted to a predetermined level, at which point the field is irrigated.

The flexible schedule, based on measured allowable soil water depletion, provides the most control to protect against unnecessary irrigation and over-irrigation.

Water balance calculations may be used to determine the maximum time allowable between irrigation if goals for soil water depletion are set and monitored. Where the irrigation management goal is to maximize yield, the Yield Threshold Depletion (YTD) concept is used to schedule irrigation. The YTD is the amount of water that may be depleted from the soil before there is an effect on crop yield or quality. With the water budget method and soil moisture monitoring, it is possible to predict the time when YTD will be reached. For water deficit sensitive crops, or where over-irrigation is of less concern, the field may be irrigated before reaching the YTD. In general, the YTD method may be used to develop individual irrigation schedules for the South County alternative, as well as to develop schedules for water deficit sensitive crops in the West County alternative.

Irrigation scheduling for the South County alternative, and for drought tolerant crops such as hay, forage and irrigated pasture in the West County alternative may utilize the Management Allowable Depletion (MAD) concept. MAD values are defined as the percentage of the total available water which will be allowed to be depleted while still maintaining the target yield (i.e., with only negligible reductions in yield). Because MAD values vary with crop water stress tolerance and may change for a crop at different stages of growth, the values must be determined every year for each field and crop. For example, field corn being grown for silage may have a range of MAD values from 40 to 70 percent under deficit irrigation management. As an example, *d*uring critical growth stages (tasseling, silk and kernel formation), MAD values may be kept at about 40 percent, while later in the season MAD values may be allowed to increase to 70 percent, where yields are just beginning to be negatively affected in drier portions of the field.

3.6 DEVELOPING IRRIGATION SCHEDULES

The City (or professional irrigation specialist) may develop an irrigation schedule (water budget) annually for each field to be irrigated which takes into account soils, topography, crop and water priority. For hay, forage and pasture crops in the West County, the deficit irrigation management system may be used. Standard irrigation management may be used for the West County's water deficit sensitive and drip-irrigated crops. Standard irrigation management may also be employed for all lands in the South County, except those located on Reyes soils. The annual irrigation schedule prepared for each farm or ranch may specify the YTD or MAD values that will be utilized. Programmed over-irrigation may be utilized to manage the Reyes soils.

Deficit irrigation management will require the deployment and use of soil moisture monitoring equipment in order that MAD values may be tracked and determined, and subsequently used with the CIMIS real-time weather information.

3.7 SOIL MOISTURE MONITORING

Regular monitoring and measurement of soil moisture is a critical element of a high efficiency sprinkler irrigation application program. Soil water must be maintained between desirable upper and lower limits available to the crop. This requires careful accounting of surface evaporation, plant water use, irrigation applications, rainfall (particularly in the winter contingency) and any runoff or deep leaching losses. An accurate assessment of soil water intake rates (important with clayey South County soils), soil water holding characteristics and soil water status are required. Soil moisture measurements verify that the proper amount of water is being applied, and provide data that must be integrated into the estimated evapotranspiration losses for refinement of irrigation scheduling.

The ICMP prepared for each irrigation site may include information on soil intake rates, soil water holding capacities, YTD or MAD values for each crop expected to be grown, and a routine soil moisture sampling schedule. These may be integrated into an irrigation schedule that would be developed and updated for each field, annually. YTD and MAD values for various crops may be developed based on recommendations from U.C. Cooperative Extension Service.

Several different techniques are available to effectively monitor and directly measure soil moisture including:

- soil feel and appearance
- gravimetric sampling
- tensiometers
- gypsum blocks
- neutron probes
- electric capacitance probes

Generally, soil moisture status may be monitored by the irrigator using the feel and appearance of the soil combined with the use of an electric capacitance probe, such as the Aquaterr 100 probe[1] . This probe is easy to use and comes with an analog color-coded dial gauge (for three different soil types: sand, loam, and clay). The probe, or similar devices such as tensometers or gypsum blocks, may be supplied to each irrigator, with instructions. The probe is pushed into the soil; high readings reflect higher soil water content and low readings reflect drier soil conditions. Probe readings near 100 percent (blue range on the dial meter) represent saturated conditions. Readings in the 85 to 90 percent (dark green) range are near field capacity. Readings in the 50 to 70 percent (light green) range indicate adequate soil water. Readings in the 30 to 50 percent (orange range) represent on-set of water stress and indicate a need to irrigate. Readings below 30

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1 The Aquaterr 100 probe operates on a replaceable 9-volt battery and requires little maintenance. Before each use, the probe must be calibrated daily in water, and dried and cleaned between each insertion into the soil. Costs of the Aquaterr 100 are about $500 each.

percent (red range) represent conditions approaching the permanent wilting point, with immediate irrigation needed.

A routine sampling and moisture monitoring plan developed for each irrigator may be implemented by them with oversight by the City. Soil water may be monitored at regularly scheduled intervals in at least two depths in the expected crop root zone. Monitoring may be conducted at several locations in each field to obtain a field average. Sub-areas within fields having different soil conditions or known irrigation uniformity problems may also be monitored. This information may then be integrated into the irrigation scheduling computer program (see next section) to determine when and how much irrigation will be needed, depending upon whether the field is being managed as a high irrigation efficiency or deficit irrigation management system.

3.8 COMPUTER ASSISTED IRRIGATION SCHEDULING

In most cases it is recommended that irrigation scheduling be conducted with the assistance of a scheduling software program. The City may work closely with each farm or ranch in preparing the schedule. Computer-assisted irrigation scheduling utilizes and integrates various field measurements to predict crop irrigation needs and to schedule irrigation. This may greatly improve levels of irrigation application efficiency. Soil moisture measuring devices may be used to determine the amount of moisture in the soil and to verify computer predicted soil moisture levels. In addition, daily evapotranspiration data may be obtained via a computer modem and down-loaded into the scheduling software from CIMIS.

The irrigation software program may be selected based on its capability to schedule irrigation events dependent on maintaining target soil moisture levels. The field measurements are correlated to specific field numbers and to integrated variables, including soil types, crops, irrigation methods, designated irrigation efficiency, and historical weather data. Using this information, the computer software program may schedule irrigation frequency and amounts. The typical program produces a print-out report with recommendations on when and how much to irrigate. This may also include such information as the amount of time a valve needs to be turned on for a given pipe size and operating pressure, the amount of water that needs to be applied, and the day and time the irrigation may begin. Project irrigation scheduling may be conducted utilizing a software program (such as Orange Software, Roy Level 1) to assist in tracking the ET and soil moisture data and in irrigation application decision making.

3.9 IMPLEMENTING THE IRRIGATION SCHEDULE

The required level of irrigation management is complex, and careful control over the irrigation applications must be maintained. In some cases ranchers and dairymen may not be familiar with the irrigation practices outlined. Because of these reasons, the City (or consulting irrigation professional) may develop and oversee the irrigation scheduling (or possibly delegate this responsibility to the RCD.) This responsibility may be assigned to the City's reclamation staff, or the City may contract for irrigation management services with professional irrigation specialists.

The irrigation professionals may work closely with each individual farmer, rancher or dairyman prior to the initiation of the irrigation season in developing an irrigation program and schedule unique to their site. The irrigation professionals may also be responsible for conducting periodic checks of soil moisture in representative fields. This may be completed, for instance, by installing an array of soil moisture access tubes in representative fields for measuring with a neutron probe. Other soil moisture monitoring devices may also be considered.

4 PLANNING AND DESIGN GUIDELINES

4.1 IRRIGATION SYSTEM DESIGN REVIEW AND APPROVAL

A number of guidelines and restrictions may be imposed on project irrigation operators (users) that will significantly reduce the potential for unwanted hydrologic, water quality, and biological impacts. Although some of the guidelines are related to operations, defining permissible crops or management for control of runoff from over irrigation, many are design criteria and requirements. These include setback requirements from streams and other sensitive features, as well as specific criteria for achieving coefficients of uniformity and application efficiency.

A high standard may be imposed on the technical design (plumbing) of the irrigation system. Good pressure distribution, layout of laterals based on environmental factors, and selection and sizing of sprinkler heads and nozzles must be achieved to provide even, uniform water application. Local variations in topography and soil conditions must also be taken into consideration. For instance, because of the generally slow water intake rates of clayey soils, low impact sprinklers with very low application rates will often be specified in the designs. Such sound technical designs will make the irrigation system easier to operate and manage, and will insure that major portions of a field are not over-irrigated just so that adequate water may be applied to the portions of a field that would normally receive lower water amounts.

To achieve the high standard of design required by the project, the City may either prepare the irrigation plans or require that they be prepared by a qualified civil or agricultural engineer experienced in agricultural irrigation systems. The City may occasionally require the designers to consult with professional soil scientists for detailed mapping and evaluation of soil and drainage conditions in some areas of complex landscapes, and to conduct additional infiltration and permeability testing. In some instances, the preparation of topographic maps may be required, but in most cases the designs may be shown on 1"=100' air photo enlargements.

Irrigation systems may normally be designed by the City's reclamation staff or consultants (working closely with the NRCS and RCD staff where applicable.) All proposed irrigation systems may be subject to review and approval by the City. In certain unusual situations, the City may seek consultation with U.C. Extension in design review. Staffing requirements and personnel needs for this assistance will be reviewed with the NRCS and RCD. The City may negotiate an equitable funding mechanism satisfactory to them (RCD, U.C. Cooperative Extension) for providing technical assistance.

4.2 SYSTEM LAYOUT CONSIDERATIONS

The design and layout of the sprinkler irrigation system involves sizing and arranging piping, control valves, pumps for pressurizing the system, and sprinkler heads in an integrated system that responds to the conditions of the irrigation site. Of particular importance in the design and layout is the recognition of differing soil and slope conditions that have contrasting water intake rates, moisture holding capacities, runoff, erosion and drainage characteristics. Sloping, upland areas cannot be irrigated in the same set or schedule with bottom-land areas that may collect runoff water. In recent years, irrigation system designs have been greatly improved to meet water conservation goals. Properly designed and installed irrigation systems, coupled with educated operators, may greatly increase irrigation efficiency and reduce incidents of over-irrigation and attendant runoff and percolation losses.

Many of the potential irrigation properties have variable and complex slopes, different soil conditions seasonally wet areas, and sensitive areas that need to be avoided. These areas may have differing irrigation application rates (intake rates) and scheduling requirements. A common cause of over-irrigation, and consequent runoff or subflow discharges to adjacent stream ways, is the failure to recognize differing site conditions within an irrigation area. In a traditional irrigation schedule, some wet or rapidly permeable areas may be over-irrigated to ensure that well-drained or slowly permeable areas receive adequate water. Instead, the layout plan, control valves and the sizing of heads and nozzles will take into account the locally variable site conditions so that large complex areas may be isolated and managed separately, and small areas may be managed through adjustments in the system.

To insure that irrigation layout and design reflects soil, slope and wetland conditions, the irrigation plans may be presented on a map or map overlay in which soils, wetland areas, gullies, stream setbacks and other conditions and restrictions are annotated. Typically these may be presented on a 1" = 100' topographic or air photo base map, so that the information is readily apparent to the engineer designing the system, to those reviewing the plans for approval, and to the operator of the irrigation system.

4.3 DESIGN HANDBOOKS

Formalizing design criteria provides a means of quality assurance so that all irrigation system planning, design and construction will be completed to a high standard. As noted in **Section 3.1**, poor system design may result in the need to over-irrigate the majority of a field to insure that small portions of a field receive adequate water. The following design criteria have been modified from the *NRCS Field Handbook of Conservation Practices*. Irrigation system design and scheduling may utilize the following design manuals:

1. Sprinkler Irrigation - NRCS National Engineering Handbook, No. 15, 1992, Washington, D.C.

2. Irrigation and Drainage - American Society of Agronomy Monograph #17, 1982, Ames, IO.

3. Sprinkle and Trickle Irrigation, Keller, J. And R.D. Bluesner, 1990, Van Nostrand Reinhold Publishers, New York, NY.

4. Irrigation System Design, An Engineering Approach, Cuenca, R.H., 1989, Prentice Hall, Englewood Cliffs, NJ.

5. Design and Operation of Farm Irrigation Systems, American Society of Agricultural Engineers, 1981, Monograph M0181, St. Josephs, MI.

6. Agricultural Sprinklers, Burt, C.M., 1993, ITRC, California Polytechnic University, San Luis Obispo, CA.

7. Undertree/Overvine Sprinkler Design, Burt, C.M., 1992, ITRC, California Polytechnic University, San Luis Obispo, CA.

8. Ag-Irrigation Management, Burt, C.M., 1992, ITRC, California Polytechnic University, San Luis Obispo, CA.

9. Management of Farm Irrigation Systems, 1992, CIT, California State University at Fresno, Fresno, CA.

10. Doorenbos, J. and W.O. Pruitt. 1977. Crop Water Requirements. FAO Irrigation and Drainage Paper 24. U.N. Food and Agriculture Organization. Rome.

11. Goldhamer, D.A. and R.L. Snyder (eds.) 1989. Irrigation Scheduling: A Guide for Efficient On-farm Water Management. U.C. Publication 21454. Oakland, CA.

12. Snyder, R.L., S.R. Grattan, and H.L. Sheradin. 1992. Selecting a Management Allowable Depletion (MAD). U.C. Drought Tips 92-62.

13. California Department of Health Services, Vector Biology and Control Branch. June 1983. Criteria for Mosquito Prevention in Wastewater Reclamation or Disposal Projects. California Department of Health Services, Sacramento, CA.

14. Bottcher, A.B. and L.B. Baldwin. 1986. General guide for selecting agricultural water quality practices. Publication SP-15, IFAS, University of Florida, Gainesville, FL.

15. Gustafson, D.I. 1989. Groundwater ubiquity score: A simple method for assessing pesticide leachability. Environ. Toxicol. Chem. 8:339-357.

16. Goss, D. 1991. Screening procedure for soils and pesticides relative to potential water quality impacts. In Using Computer Simulation Models in Pesticide Registration Decision Making. A Symposium/Workshop, Weed Sci. Soc., Louisville, KY.

17. Wauchope, R.D., T.M. Buttler, A.G. Hornsby, P.W.M. Augustijn Beckers, and J.P. Burt. 1992. Review of Environmental Contamination and Toxicology. Springer Verlag, New York.

4.4 IRRIGATION DESIGN CRITERIA

4.4.1 Sprinkler Irrigation

The net depth of application (i.e., inches of water) may be based on the available moisture capacity of the soil in the root zone of the crop to be irrigated, consistent with the land user's YTD or MAD values operation plan. The gross depth may be determined by using field application efficiencies outlined in **Sections 3.2 and 3.3**.

In High and Medium Priority irrigated areas, sprinkler irrigation systems may have either: (1) a design capacity adequate to meet the moisture demands of all crops to be irrigated in the design area; or, (2) enough capacity to meet the requirements of several selected irrigations during critical crop growth periods when deficit irrigation is planned. In computing capacity requirements, allowance may be made for reasonable water losses during application periods, consistent with design irrigation efficiencies.

The design rate of application may be within a range established by the minimum practical application rate under local climatic conditions and the maximum rate consistent with the intake rate of the soil and the conservation plan. If two or more sets of contrasting conditions occur in the design area, the lowest maximum application rate for areas of significant size may apply.

A combination of sprinkler spacing, nozzle sizes, and operating pressure that most closely provides the design application rate and distribution may be selected. The velocity of prevailing winds and other conditions may also be considered. If available from the manufacturers, uniformity coefficient data shall be used in selecting sprinkler spacing, nozzle sizes, and operating pressure. The uniformity coefficient may be not less than as shown below:

- 75% for orchards;
- 80% for deep-rooted (4 feet or more) field and forage crops; and,
- 90% for high-value or shallow-rooted crops and for any crop where fertilizer or pesticides are applied through the system.

In the absence of such data, sprinkler performance tables provided by the manufacturer may be used in selecting nozzle sizes, operating pressure, and wetted diameter for the required sprinkler discharge. The maximum spacing may comply with the following criteria.

1. For low, intermediate, and moderate-pressure sprinklers, the spacing along lateral lines (S) may not exceed 50 percent of the wetted diameter, as given in the manufacturer's performance tables, when the sprinkler is operating under optimum pressure. The spacing of laterals along the main line (S_m) may not exceed 65 percent of this wetted diameter. If winds that may affect the

distribution pattern are likely, spacing (S_m) shall be reduced to 60 percent for average velocities of 5 mph, to 50 percent for average velocities of 10 mph, and to 30 percent for average velocities greater than 10 mph.

2. For high pressure sprinklers, the maximum distance (diagonal) between two sprinklers on adjacent lateral lines may not exceed two-thirds of the wetted diameter under favorable operating conditions. If winds that may affect the distribution pattern are likely, the diagonal spacing may be reduced to 50 percent of the wetted diameter for average velocities of 5 mph and to 30 percent for average velocities greater than 10 mph.

Lateral lines may be so designed that the total pressure variation at the sprinkler heads, resulting from friction head and static head, does not exceed 20 percent of the design operating pressure of the sprinklers.

4.4.2 Drip Irrigation

The net depth of application shall be sufficient to replace the water used by the crop during the peak use period of critical growth stage without depleting the soil moisture in the root zone of the crop below the minimum level established for optimum growth. The net depth of application may be expressed as inches per day per unit of design area.

$$F_n = 1.604 \frac{QNTE}{AF}$$

Where:

F_n	=	net application depth, in inches/day
Q	=	discharge rate in gal/h/emitters
N	=	number of orifices or emitters
T	=	hours of operation per day
E	=	field application efficiency, expressed as a decimal
A	=	ft^2 of field area served by N (number of emitters)
F	=	the design area as a percentage of the field area, expressed as a decimal
1.604	=	units conservation constant 12 in/ft/7.48 gal/ft^3

Field application efficiency assumed for design purposes may be 90 percent.

The design capacity of drip irrigation may be adequate to meet moisture demands during the peak use period of the crops in the design area. The capacity may include an allowance for reasonable water losses during application periods (five percent). The system may have the capacity to apply a stated amount of water to the design area in a specific net operating period. The design area may be less than 100 percent of the field area but not less than the mature crop root zone area.

The design rate of application may be within a range established by the minimum practical discharge rate of the applicators (orifices, emitters, porous tubing, perforated pipe) and the maximum rate consistent with the intake rate of the soil. The application rate may be expressed in gallons per hour per emitters or orifice or per foot of porous tubing or perforated pipe.

The discharge rate of orifices, emitters, porous tubing or perforated pipe may be determined from the manufacturer's data relating to discharge and operating pressure. Emitters may be located to provide an overlap of the wetting pattern within the root zone. Lateral lines may be so designed that when operating at the design pressure, the discharge rate of any applicator served by the lateral will not exceed a variation of +15 percent of the design discharge rate.

Main lines and sub-mains may be designed to supply water to all lateral lines at a slow rate and pressure not less than the minimum design requirements of each lateral line. Adequate pressure may be provided to overcome friction losses in the pipelines and in all appurtenances, such as valves and filters consistent with the referenced design handbooks.

A filtration system may be used at the system inlet. If available, recommendations of the emitters manufacturer shall be used in selecting the filtration system. In the absence of the manufacturers recommendations, the net opening diameter of the filter may be not larger than one-fourth the diameter of the emitters opening.

All injectors, such as fertilizer injectors, may be installed upstream from the system filter, except for systems having injectors equipped with separate filters. The filter system shall permit flushing, cleaning or replacement as required without introducing contaminants or foreign particles into the trickle system.

4.5 IRRIGATION DESIGN AND MANAGEMENT SOFTWARE

Irrigation design and management software are available that may be used to increase irrigation application efficiency and uniformity through good design practices and, thus, allow better irrigation scheduling management. The following software or their equivalent may be utilized in irrigation system design and evaluation.

1. For sprinkler irrigation design:
   - Sprinkler irrigation coverage with the SPACE Program (available from CSU Fresno Center for Irrigation Technology [CIT]).
2. For drip/micro-irrigation of trees and vines (both available from California Polytechnic State University Irrigation Training and Research Center [ITRC]):
   - Drip/Micro-irrigation Evaluation Software.
   - DRIP Hose Hydraulics Program.
3. For periodic system evaluation:
   - AGWATER (available from ITRC).
4. For irrigation scheduling using real-time climatic information and soil moisture sensing data:
   - Roy Level 1 (available from Orange Software, Fresno, CA).

4.6 CROP ESTABLISHMENT AND MANAGEMENT PRACTICES

Since many dairymen and ranchers may be unfamiliar with the cultural and management practices for potential irrigated crops that may be grown, one element of the ICMP may discuss typical crop establishment, management, and harvesting systems. Some of this information is presented in the Irrigation Suitability Technical Report. The ICMP may include BMPs related to:

- cultivation and seed-bed preparation;
- seeding and planting;
- weed and insect control;
- harvesting; and,
- post harvest handling and marketing.

Much of this information is currently available in leaflets from U.C. Cooperative Extension (or extension services in neighboring states) and the U.S. Department of Agriculture. Several handbooks are available for specialty crops, such as vineyards and strawberries. Where available, these materials may be appended to or referenced in the ICMP.

As with other sections of the ICMP, the Crop Establishment and Management Practices section would have the dual purpose of insuring management practices that provide a feasible economic return, while protecting soil, water and wetland resources.

4.7 IRRIGATED PASTURE MANAGEMENT

Dairymen and ranchers may also not be familiar with some management practices for irrigated pasture. Typically, large, dry-farmed hayland fields or native grass pastures will need to be subdivided into several, smaller fenced fields to control the movement of sheep or cattle. Watering troughs may also have to be located in these fields. The pastures may then be planted to an improved grass-legume mix by conventional cultivation and seeding, or on steeper slopes by use of a no-till range drill. Sensitive environmental areas and gullies may also be fenced. An appropriate grazing management system may be developed.

For instance, in a rotational frazing management system a pasture is divided into multiple fenced fields, with similar forage production capabilities. Animals are rotated regularly through the fields allowing a period when the pastures are irrigated and regrown (rested) between grazing. As an example, in a four-field rotation system the animals are grazed in a field for seven days and the moved through progressive fields to return approximately 21 days later. The number of animals grazed is carefully matched with the capability of the land to produce the forage to support them (the Animal Unit Month Carrying Capacity).

4.8 EROSION CONTROL AND COVER CROPS

Cultivation and sprinkler irrigation of sloping lands will not necessarily result in increases in rates of erosion over existing conditions of dry-farmed haylands or intensively grazed grasslands. For instance, high amounts of soil erosion may occur on late fall planted or early spring oat haylands if intensive storms occur before the grass has had an opportunity to germinate, grow and provide a protective cover. The erosion problem may be severe if the planting pattern is oriented up and down slope. Existing orchards and vineyards, which are frequently clean cultivated and occur on steep erosive soils in the Sebastopol area, may also have high rates of soil erosion. Estimated existing and future rates of soil erosion for typical dry-farmed and irrigated crops in the South and West County areas are discussed more fully in the Soil Erosion Technical Memorandum. Erosion control practices such as contour farming, sprinkler use to grow fall seeded hay crops, and utilizing permanent cover crops in orchards and vineyards may be provided in sufficient detail for implementation in the ICMP. Most of these are included in the NRCS *Engineering Field Handbook of Conservation Practices*.

Because of soil erosion concerns from growing specialty (such as drip irrigated strawberries and artichokes) on sloping lands in the project areas, the City may request special assistance from the NRCS to develop cultural and conservation practices for these crops. The City may also cooperate with the NRCS and RCD to complete a field demonstration trial program of conservation practices for specialty crops. This trial program would be completed prior to their approval of agreements to deliver water to properties which propose to raise drip irrigated specialty crops on sloping lands.

4.9 MANAGEMENT OF AGROCHEMICALS

Currently, only very modest amounts of fertilizers, herbicides and pesticides are applied to dry farmed agricultural lands in the South and West County areas. More intensively farmed and irrigated lands will often require greater application of fertilizers to match increased plant growth and yields from water application. The various field and row crops that may be grown will also require management of weeds, disease and pest organisms which are of a much less serious concern in a dry-farmed operation. Unless properly managed, agrochemicals may begin to appear in increased amounts in the surface water, groundwater and air.

The State Water Resources Control Board Technical Advisory Committee (TAC) management recommendations for Irrigated Agriculture and Pesticides may be referenced by the project and may be incorporated into each ICMP. These include the following:

1. Control pollutants at their source.
    - Verify the need and amount of fertilizers through soil and plant tissue testing
    - Utilize Integrated Pest Management (IMP) procedures
    - Utilize the least toxic, least soluble, least persistent chemical
    - Carefully evaluate and apply the lowest amount that will achieve the management goal

2. Reduce the mobilization of pollutants.
    - Control soil erosion, irrigation runoff and subflow

3. Capture pollutants that are mobilized.
    - Utilize vegetated filter strips and grassed waterways
    - Utilize on-farm sediment detention structures where necessary

4. Utilize, dilute, detoxify, or dispose of excess pollutants correctly.
    - Proper handling (mixing and storage) and disposal practices

4.10 PLANNING AND DESIGN CONSIDERATIONS FOR MOSQUITO CONTROL

Mosquitoes are both pests and vectors of disease to humans and animals. There are 21 species of mosquitoes within the boundaries of the Marin/Sonoma Mosquito and Vector Control District (M/S MAD). Four of these have been implicated as vectors of Western Equine (WEE) and St. Louis Encephalitis (SLE). The primary vector of WEE in both Sonoma and Marin counties is *Culex tarsalis,* a mosquito that prefers higher nutrient loading in its larval habitat. Irrigation fields provide exceptional habitat for this species, as well as for *Cutlex stigmatosoma,* a secondary vector.

Mosquitoes exhibit exponential growth rates and as a result may reproduce to incredible population levels in a very short period of time, especially during the warmer summer months. Due to this process it becomes very important to properly design and manage irrigation projects with thought to reducing those conditions beneficial to mosquito production.

The California Health and Safety Code provides authority for abatement districts to advise and control mosquito production on private and public lands and to assess the land owner for the cost of that control. In addition, the districts have the authority to hold hearings and assess civil penalties to abate nuisance and potential health threats to the general public (Ref. California Health and Safety Code, 1987. Sections 2270-2294-2294).

Irrigation projects that minimize the amount of over irrigation, ponding or tail water will significantly reduce the need to treat these sites with larvicides or adulticidal materials and the subsequent need to provide M/S MAD with compensation for that control effort. Over many years, mosquito abatement districts have addressed the issues of mosquitoes and other biting arthropods associated with wastewater irrigation. Since many of these projects were implemented in the central valley of California, there is a history available to allow for proper design and management of these projects. Several documents have been produced addressing the concerns of M/S MAD and offer solutions to minimize and/or correct existing problems. Additionally, they provide information that will allow for proper management of an irrigation plan.

The use of proper design and subsequent management plans are instrumental in reducing the potential for mosquito production and the possibility of disease transmission (Western Equine, WEE and SLE) to humans and animals. The specifications for reducing the mosquito population in irrigated pastures are addressed in the referenced documents. Through awareness and utilization of Best Management Practices (BMPs) contained in these documents, irrigation projects may be implemented to satisfy all concerns for wastewater discharge, provide secondary and tertiary crops, reduce noxious odors, and minimize or eliminate vectors that may impact the health and well being of a growing urbanized community.

M/S MAD isolated WEE through the California Department of Health Services/California Mosquito and Vector Control Association combined with the arbovirus detection program in 1992-93 and 1993-94 in Sonoma County. However, no isolations were documents this year (1994-95). Viral activity in the area increases the probability of mosquito to human or animal transmission. Therefore, M/S MAD is required to minimize this particular mosquito species and not accept additional breeding habitat that may be supplied by the creation of new and/or poorly managed irrigation projects.

4.11 SETBACKS AND BUFFERS

Irrigation application setbacks and buffers from sensitive features are designed to provide additional protection by further isolating the feature and reducing the chance of impact from runoff, sub-surface water flow or animal and farm vehicle intrusion. The following recommended setbacks and buffers are intended as flexible guidelines which may generally be incorporated into each ICMP. Specific setbacks and buffers will be developed on a case-by-case basis using the guidelines, but taking into account the resource management needs unique to each site. The setback and buffer recommendations are drawn from the literature and the existing practices along the Illano Road irrigation lands. Potential setbacks and buffers for a hypothetical farm are shown in **Figure 1**.

- Residential and commercial buildings - 10 feet.
- Domestic well setback - 50 feet.
- Isolated medium and high quality wetlands - 25 feet (also, these may be fenced in most cases).
- Mature native trees, drip line plus 10 feet (mature trees are those having a diameter at breast height, or dbh, more than four inches).
- Grassed drainage swales and ditches - 25 feet.
- Gullied lands - 10 feet (gullies fenced and stabilized).
- Medium quality wetlands occurring as linear feature - 66 feet (fenced and restored as native vegetated filter strip).
- High quality wetlands and riparian stream corridors - 99 feet (fenced and restored as native vegetated filter strip).

- Endangered species habitat - minimum 50 feet (variable depending upon site and species issue, to be determined on a site specific basis in consultation with California Department of Fish and Game, and U.S. Fish and Wildlife Service).

  Note: medium and high quality wetlands may be defined and delineated prior to the design phase for each irrigation parcel. Standard methods acceptable to the regulatory agencies may be utilized to delineate wetlands and determine wetland function and value (i.e., WET2). Stream corridors requiring setbacks will be blue-line streams (dotted and solid) as shown on USGS. 7.5' topographic maps. Native trees may consist of the following species: Box elder, Oregon ash, big leaf maple, white alder, coast live oak, valley oak, Fremont cottonwood, black walnut, red willow and yellow willow.

4.12 VEGETATED FILTER STRIPS

Vegetated filter strips consist of strips of land located alongside stream courses or water bodies that are designed to passively filter sediment, nutrients and pesticides from runoff water. The filter strips may be planted to native grasses, shrubs and trees and may also provide important stream-side wildlife habitat and movement corridors.

As a general guideline, vegetated filter strips from 66 to 99 feet wide may be included in ICMPs along the major stream courses and linear wetland features. (Some flexibility needs to be provided in the development of ICMP designs. For instance, farm fields on level terraces incised streamways need to be accommodated. Buffers and setbacks from 66 to 99 feet may not be applicable in all cases.) Design criteria and procedures outlined in the USDA Conservation Resource Program (CRP) design manuals may be utilized by the project. Allowable widths for filter strips in the CRP program range from 66 to 99 feet. Typically buffer (Section 4.10) and filter strips may be designed to be between one and five percent of irrigable lands.

4.13 PROTECTION AND RESTORATION OF GULLIED LANDS

All gullied lands located within the general boundary of an irrigation area may be fenced (generally, 10-foot setback fence or as appropriate) and stabilization/restoration instituted, such as shaping and grading, installing check dams, lined and grassed waterways and placing willow cuttings. The irrigation systems may be designed to preclude sprinkler irrigation of gullied lands, except where desirable for establishing protective vegetation.

Site specific procedures for restoration of the gullied land, with an implementation schedule, may be included in the farm or ranch specific ICMP. Procedures may generally follow those listed in *Groundwork*, prepared by the Marin RCD and those outlined in the Stemple/Americano Creek Enhancement Plan.

Cost sharing and grant funding mechanisms for the fencing and stabilization work will be coordinated with the RCD, Regional Water Quality Control Board and the California Department of Forestry watershed enhancement and water quality programs.

4.14 PROTECTION AND ENHANCEMENT OF STREAM CORRIDORS

Stream corridors may be fenced with setbacks typically ranging from 66 feet (low and moderate quality) to 99 feet (high quality). Some flexibility may be provided so that stream restoration designs may accommodate the topographic and vegetative features, and existing road and building infrastructure unique to each site. Plans may be developed for stabilization, restoration and enhancement planting of the stream banks and adjacent buffer area using native vegetation materials, design and establishment techniques as identified in the Stemple Creek de Estero Americano Enhancement Plan and the Access and Enhancement Plan for the Petaluma River. Detailed stream restoration plans may be included in each ICMP. The bank stabilization and enhancement planting program will greatly reduce sediment from eroding stream banks and the planted phreatophytic vegetation (i.e., willows) will counter-balance any slight increase in subsurface flow and nutrients to the drainage ways from sprinkler irrigation water applications.

4.15 INTEGRATION OF ANIMAL / DAIRY WASTE MANAGEMENT

The ICMP may integrate the animal and dairy waste management needs of each ranch. Each ICMP may have a nutrient and manure management component that takes into account the individual problems and needs for disposal of solids and liquid wastes. The Plan may be based on the knowledge and experience gained by the Gold Ridge RCD in part from their 319H Manure Management Implementation Grant from the State Water Resources Control Board. In general, solids or manure from loafing barns, milking sheds and storage lagoons may be incorporated into the soil (i.e., by discing) prior to planting high nitrogen demanding crops such as sudan grass, field corn or other silage and hay crops. Animal wastes may also be surface applied at the correct time and rate during the irrigation and grazing cycle for irrigated pastures. The addition of solid and liquid wastes may be matched to the nitrogen and phosphorous demands of the crop and may be based on nutrient analysis of soils, liquids and bio-solids. Provided that the nitrogen demand of the crop is not exceeded, and that the bio-solids are applied appropriately, manure and solids from neighboring farms and ranches may also be utilized. Liquid wastes may be spray irrigated on standing non-vegetable crops, providing the application is coordinated with irrigation scheduling. The City's agronomist ~~will~~ may be available to work with the irrigator to perform sampling and testing, develop annual application recommendations, and coordinate waste management.

4.16 INTEGRATION WITH BIO-SOLIDS BENEFICIAL USE PROGRAM

Approximately 2,000 acres of potentially irrigable lands reclaimed from tidal marsh occur along the Petaluma River in the Lakeville Highway portion of the South County project alternative. However, the reclaimed soils (Reyes soils) have significant limitations associated with acidity, infertility and poor tilth and structure that make production of crops other than irrigated pasture or oat-ryegrass hay very difficult. It is expected that yields of the hay and irrigated pasture crops would be diminished without frequent application of fertilizers.

Yields may be increased significantly by application of bio-solids, which improve soil structure and fertility. The City's approved Bio-solids Beneficial Use Program provides for application of municipal sludge to areas of Reyes soils along Lakeville Highway. Since both the bio-solids and reclaimed water contain nutrients and low levels of metals, irrigation scheduling and application rates will need to be coordinated to consider both sources relative to plant needs and allowable regulatory levels.

4.17 TAIL WATER RETURN SYSTEM

Tail water, or runoff of reclaimed water from the irrigation area, may be minimized by detailed irrigation site planning and the level of irrigation scheduling and monitoring proposed. In addition, the use of vegetated filter strips may provide an absorbency capacity to capture and infiltrate runoff prior to entering drainage ways and stream courses. Tail water return systems may be included in the design of each parcel where needed. Typically, these will consist of 1.5 to 2.5 feet of earthen berm located within the vegetated filter strip that may impound a portion of the water flow. As a guideline, the detention may be designed to store about 10 percent of the distribution system flow capacity. Pumps and return piping may be carefully located to return and recirculate any ponded water that reaches a point where overtopping of the detention berm is anticipated. Any ponded or standing water may also be recirculated within two to four days for mosquito vector control.

4.18 DRAINAGE MANAGEMENT

Development or worsening drainage problems in poorly drained soils or soils with subsurface layers which restrict the downward movement of applied irrigation water (restrictive layers), are becoming common in many areas of California where intensive irrigation agriculture has been in use for a number of years. Over the long-term, the gradually rising groundwater table from the cumulative addition of irrigation water perching on subsurface restrictive layers may significantly impact the agricultural viability of such drainage effected farmlands. Generally, the initial development or on-set of drainage problems is dealt with by implementing drainage improvement measures. These measures include construction of new, additional or deeper/larger surface drainage ditches, or installing subsurface tile drain lines. Without drainage improvements, crop yields will begin to decrease, particularly in lower-lying or poorly drained portions of fields, or more widespread in wet years. Drainage problems may also cause a shift to growing more water tolerant and less intensive crops, such as pasture. In most case, drainage problems are slow to develop and are reversible, although costs and environmental impacts may preclude the necessary corrective actions.

Portions of the South County and a large percentage of the West County project areas have existing conditions of seasonal high groundwater or soil conditions (restrictive layers) that, unless irrigated carefully, may develop drainage problems. In general, because of undesirable impacts to surface water quality and aquatic biota, large scale drainage improvements may not be considered for the West and South County project areas. Drainage improvements may be considered on a small, localized basis (i.e., a portion of a field).

As outlined in the Irrigation Suitability Technical Report, the project may be designed and managed to preclude the development of significant drainage problems. Drainage problems are almost always slow to develop and progress; a well designed monitoring program may detect changes and trends so that remedial management measures may be implemented to prevent the on-set of drainage problems. The following management practices may be utilized to avoid drainage problems.

1. Existing very poorly drained areas, areas with shallow restrictive layers, or medium and high quality wetlands may be considered unsuited for irrigation and not irrigated. These designations may be confirmed at the design level of the project.

2. Crop choice generally may be restricted to irrigated pasture for: a) suitable lands with potential drainage problems; b) somewhat poorly drained areas; c) areas with deeper restrictive layers; or, d) prior converted or poor quality wetlands (i.e., Reyes soils). More water tolerant crops such as fescue trefoil-clover pasture mixes may be grown in these areas.

3. A high level of irrigation management may be achieved through technical innovations. Over irrigation, or application or irrigation water in excess of crop consumptive water demand may not be allowed. Over irrigation of lands with problem soils is the most common cause in drainage problem development. Such “source control” measures are often cited as the most appropriate Best Management Practice for drainage problems.

4. Water levels in fields may be closely monitored and irrigation management (irrigation scheduling) adjusted accordingly. Occasional summer fallowing (growing a dry-land hay crop, or crop with greatly reduced irrigation application) may occasionally be needed (say one year in five or seven) for problem sites which are developing drainage problems. This will allow the periodic re-establishment of the original water table and drainage condition.

5. Small scale drainage improvements (ditches and the drain systems) may be considered for portions of fields where the above management practices are insufficient to preclude localized development of drainage problems.

4.19 INDIVIDUAL OPERATIONS AND MAINTENANCE MANUAL

A site specific Operations and Maintenance Manual may be prepared to accompany each irrigation site design. The manual will be reviewed with the operator (farm or ranch irrigator) prior to initiation of irrigation. The Operations and Maintenance Manual may include the following:

1. A layout map of the irrigation area showing:

a) Field name or number, acreage, and crop;
b) Location of pipelines, sprinkler heads, and control valves;
c) Type and sizing of above (to facilitate replacement); and,
d) Utilities.

2. Summary of restrictions and enhancement goals; including:

a) Environmental setbacks;
b) Restoration and enhancement areas; and,
c) Crop choice and grazing restrictions.

3. Soils information:

a) Soil types, drainage, erosion, runoff and management problems;
b) Hydrologic properties of soils (infiltration, AWC);
c) Rooting depth, groundwater table, restrictive zones; and,
d) Soil fertility management needs.

4. Crop information (where applicable):

a) Cultivation and crop establishment techniques/practices;
b) Crop rotations;
c) Herbicide/pesticide application guidelines and IMG management practices; and,
d) Critical growth and harvesting periods.

5. Nutrient Management:

a) Systems for incorporation of animal wastes.

6. Vector Control:

a) Control of ditch water.
b) Avoid water ponding in fields.
c) Tail water management.

7. Erosion Control Practices:

a) Establishment of cover crops;
b) Gully and stream bank stabilization; and,
c) Use of other conservation practices.

8. Irrigated pasture management:

a) Carrying capacity estimates (Animal Unit Months);
b) Grazing and rest/rotation frequency; and,
c) Fencing, cross-fencing and other animal management methods.

9. Irrigation Scheduling Information:

a) Typical water budget and estimated monthly time, frequency and amount of application;
b) Soil moisture guidelines for determining when to initiate and stop irrigating; and,
c) Use of the CIMIS irrigation application forecasting model.

10. Irrigation operations:

a) Sequence to follow in starting/stopping irrigation;
b) Operating pressures, pressure checks, and flow control on pressure regulation; and,
c) Safety checks.

11. Maintenance and repair procedures.

12. Monitoring schedule.

13. Emergency response and notification:

a) Pipe rupture; and,
b) Over-irrigation and runoff response.

5 MANAGEMENT AND SYSTEM OPERATION

In coordination with the NRCS, RCD and U.C. Cooperative Extension, the City may provide on-going management support and technical consultation on agricultural, water use and water quality issues to its irrigation users. On-going management support may include the activities described in this section.

5.1 SOIL MOISTURE MONITORING IRRIGATION SCHEDULING AND DELIVERY

The City may be responsible for maintaining the CIMIS station, monitor soil moisture with a neutron probe for an array of representative sites, and assisting each farmer or rancher in irrigation scheduling (i.e., using a computer-based scheduling system). The scheduling system software may also allow the City to receive orders from growers for irrigation water (with 24-hour notice) and prioritize delivery during any periods of water shortages.

5.2 FLOW METERS

Flow meters measure the volume of water moving through a full-flowing, closed pipe and are a key component of a well managed irrigation system. A flow meter is essential to managing water precisely and efficiently, as well as for monitoring the performance, management, and compliance of an irrigation program. Precise water management requires:

1. Knowing how much water has been applied; and,

2. Applying only the amount of water needed to meet crop demands.

A flow meter provides the irrigation manager with the information needed to apply only the amount of water required, and gives the overall program manager a record of water usage to verify compliance with irrigation scheduling guidelines. Monitoring flow rates over the course of a season also makes it possible to identify changes in flow rates which may indicate problems, such as leaks in the system, which must be isolated and repaired. Flow meters may be installed on all mains serving irrigation parcels. The reclamation staff may monitor water usage periodically during the irrigation season to verify proper application amounts or to make scheduling and management adjustments, as necessary.

5.3 AGRONOMIC CONSULTATION

The City may make available an agronomist (potentially through U.C. Cooperative Extension) to assist farmers and ranchers in making decisions on crop management, including developing recommendations on crop varieties, planting dates, cultural practices, and harvest and post- harvest commodity handling.

5.4 MOSQUITO AND VECTOR CONTROL

The City may work cooperatively with Marin/Sonoma Mosquito Abatement District in implementing recommendations for irrigation management to reduce the incidence of mosquito pest and vector problems. This may include timely management of ponded tail water and management of standing water and vegetation in drainage ditches.

5.5 AGROCHEMICAL RECOMMENDATIONS

The City may also make available an Agronomist/Certified Pest Control Adviser (PCA) who may make recommendations on fertilizer needs and pesticide/herbicide applications. Fertilizer recommendations may be based on soil and plant tissue testing. For chemical means of pest and disease control, first consideration may be given to use of Integrated Pest Management approaches. When chemical means of weed or pest control are deemed necessary, the PCA may select the least toxic, least persistent, least soluble/leachable form, applied in the minimal quantity that may meet the management needs. The PCA may utilize a pesticide specifications software system, such as ACS, as an aid in developing his/her recommendations. ACS is a computer software system developed by Crop Data Management Systems Inc. (CDMS) to assist Pest Control Advisors (PCAs) in preparing written pesticide use recommendation reports. Several pesticide selection software models are also available to screen pesticides for mobility and toxicity. Screening models use physical and chemical characteristics of pesticides, in addition to toxicity and site information to determine the potential to leach or be lost through surface runoff. These include the GUS model (Gustafson, 1989) and the SCS rating model (Goss, 1991, Wauchope, et. al. 1992).

With screening and management software, the PCA may prepare pesticide use recommendations that are automatically checked against data contained in the pesticide label data base. Information on persistence, solubility and leachability are accessible in pesticide data bases for use in decision making and screening. As the PCA enters the proposed chemical and application rate, the software system checks to see that the recommended rate is within the range set by the manufacturer on the label. In addition, the system provides any restrictions, percentages, or limitations specified on the label as part of the recommendation. The recommendation may then be printed in a standard format with all the pertinent information attached as required by law. A PCA may access the label data base regularly to check for label changes, which are automatically updated by the system. The data base also provides information regarding treatment of specific pests. For example, the PCA may enter the name of the pest and receive a list of options that may be considered to control the pest. The system also provides current Material Safety Data Sheet (MSDS) information for commonly used pesticides for use by the applicators. It provides the applicator in the field with consistent up-to-date recommendations, label data and MSDS information critical to the legal application of herbicides and pesticides.

5.6 IRRIGATION SYSTEM CHECKS

Providing mobile technical services (a mobile irrigation laboratory) to check the efficiency and operating parameters of irrigation systems has become increasingly popular among irrigation districts in water short areas. This helps these districts maximize water conservation. The same principles for good irrigation water conservation also apply to preventing over-irrigation. A mobile irrigation laboratory (usually a small van) may be provided to check line pressures, application rates and uniformity, as well as to perform leak detection. Software monitoring systems such as **Agwater** may be used to evaluate system efficiency and optimize system operations. Recommendations may be provided in the field for modifying line locations and sprinkler nozzles, changing schedules, and improving the performance of vegetated filter strips and check berms.

5.7 MAINTENANCE

Good system maintenance is an important part of a well managed irrigation program; to work effectively an irrigation system must be maintained. Problems associated with over-applications to portions of fields and runoff from localized flows exceeding intake rates may result from unequal or inadequate pressure distribution in the line, broken pipelines or leaks at connection points, damaged valves, or clogged or broken heads and nozzles.

Most of these problems may be minimized by well designed and constructed systems using high quality materials. Timely, periodic inspection and routine maintenance may insure that problems are quickly spotted and corrected. The City may assist the irrigation manager in conducting an annual pre-application inspection of the irrigation system, prior to the start of irrigation. The inspection may include pressure checks; inspections of pressure regulators, valves and pumps; back-flushing lines; and, inspecting, cleaning and replacing of heads and applicators. Any necessary repairs to fencing, corrections to berms, and erosion control and replacement plantings in the vegetated filter strips and stream corridors may also be noted at that time and remedial recommendations developed.

6 MONITORING AND REPORTING PROGRAM

6.1 MONITORING

The monitoring of soils, irrigation input water, irrigation return flow (tail water), shallow and deep zone groundwater, and surface water receiving points is an important component of ongoing irrigation management. Monitoring is normally a requirement for an NPDES permit issued by Regional Water Quality Control Boards. Typically, changes in water levels or water quality from an irrigation project occur over a long enough period of time such that a well planned monitoring program may detect trends and allow timely adjustments in management practices. In fact, the monitoring database against which to evaluate future trends and changes was initiated with the environmental evaluation of project irrigation component alternatives. Existing water quality records have been collected and evaluated, and new shallow and deep zone monitoring wells installed. Surface water quality records are being compiled in a data base that may be maintained to allow for easy access and trend analysis by interested parties, as well as for an organized and consistent presentation.

A parcel specific monitoring program may be developed for each farm or ranch brought into the irrigation project. This may be an element of the parcel specific Irrigation Conservation and Management Plan. The design of the monitoring system must be based on consideration of regional surface and groundwater flow gradients and directions, and all data may be compiled and integrated for evaluation and reporting purposes. The monitoring program developed for the existing system may provide the basis for a formal monitoring and reporting program which will need to be prepared for the selected alternative.

A hypothetical monitoring plan is provided in **Figure 2**. Following are guidelines that are recommended in developing the monitoring activities:

1. Soils

- Conduct composite sampling along transects oriented parallel and perpendicular to irrigation field boundaries;
- Initiate first sampling prior to initial irrigation to provide a baseline;
- Typically samples will be obtained at 0-6 and 18-24-inch depths along 10 to 20 satellite stations spaced equidistant along the transects. These will be combined into one composite per transect;
- Additional transects may be required where contrasting soils occur within a field;
- Generally one transect network will be required for each 200 acres being irrigated;
- Additional sampling will be required in bio-solids application areas;

- Sampling will be completed on an annual basis in late March, prior to initiation of irrigation; and,
- Analyze samples for: pH, EC, SAR, B, NO_3, PO_4, K (UC Davis Extension Soils Lab Methods), cadmium, chromium, copper, lead, nickel, zinc; and,
- Monitor water levels in shallow zone or perched water table.

2. Surface Water

- Establish one permanent sampling station immediately upstream and downstream of any surface water course adjacent to the irrigation field and identifiable as a blue-line stream (solid and dotted) on 7.5' USGS topographic map;
- Initiate background sampling to establish a baseline prior to initiating irrigation.
- Sample first significant runoff producing event of water year (typically early to mid-November), a second runoff event following a winter storm (December to February), and any flow observed in May and August during irrigation season;
- Record field observations for (temperature, DO, pH, EC, turbidity, odor, flow, water level, and estimated discharge);
- Collect and analyze samples for: NO_3, PO_4 K, Cd, Cr, Cu, Pb, Ni, Zn.; and,
- Analyze for herbicides/pesticides that have been used on adjacent fields in watershed.

3. Groundwater

- Establish at least one shallow-zone monitoring well (less than 20-feet deep) for every 200 acres irrigated;
- Include vadose zone monitoring for soils with perching layers or barriers to water movement;
- Utilize existing domestic wells in and near irrigation sites;
- Consider groundwater subbasins and gradients in locating monitoring wells;
- Provide an upgradient or off-site well in a non-irrigated area, where possible; and,
- Record field observations and perform sampling on same schedule as for surface water; analyze for same parameters.

6.2 ANNUAL MONITORING REPORT

An annual monitoring report may be prepared by the City's reclamation staff summarizing the previous year's irrigation program. The report may be designed to meet the Regional Water Quality Control Board's needs, as well as to provide information to the possible CRMP or Irrigation Advisory Committee for on-going management planning. This information may also be available to the farmer or rancher to modify his farming and ranching procedures. The annual report may focus on the following topics:

1. Comparison of actual water application amounts with theoretical or justifiable amounts based on CIMIS data and other information. This will be obtained from individual farms and ranches, and analyzed collectively.

2. A discussion of incidents of runoff and ponding (if any), and an analysis of cause, impact/effect and recommended corrective actions.

3. Soil, surface water, and groundwater monitoring results and discussions. A multi-year trends analysis will also be prepared. Recommendations for management actions or investigations to remedy adverse trends will also be included. Particular attention will be paid to nitrate and TDS levels in surface waters and the detection of herbicide/pesticide compounds utilized in the watershed.

4. A progress report in achieving overall watershed water quality, riparian/wetlands enhancement and restoration, and gully control.

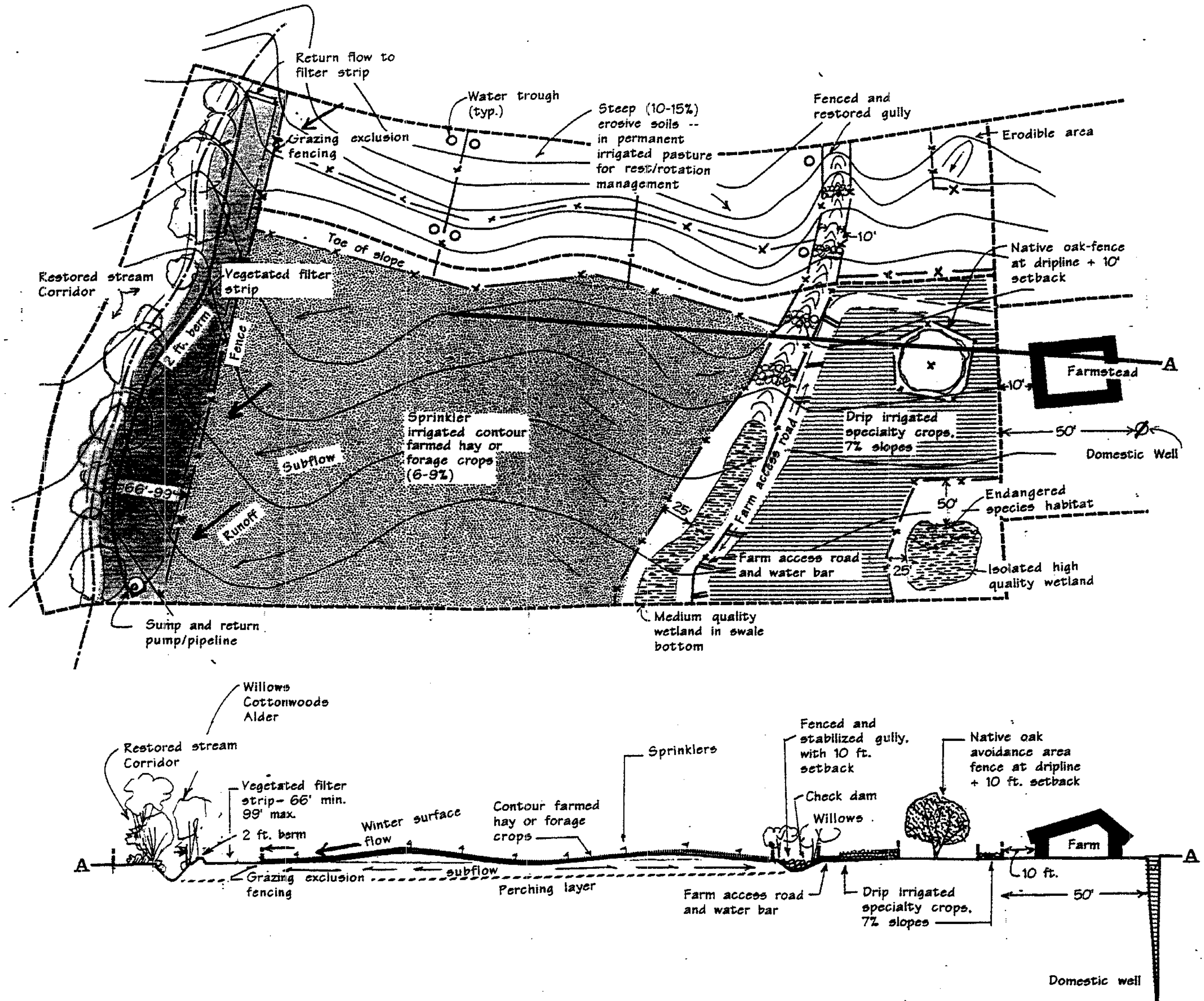
5. Discussions of crop acreage, commodities grown, yields and other agricultural issues.

6. A summary of herbicide/pesticide applications, including toxicity of compounds, detection in surface water or groundwater monitoring, and any recommendations regarding use and management.

7. A discussion of coordinating needs with other agencies and programs.

6.3 ANNUAL MANAGEMENT PLAN UPDATE

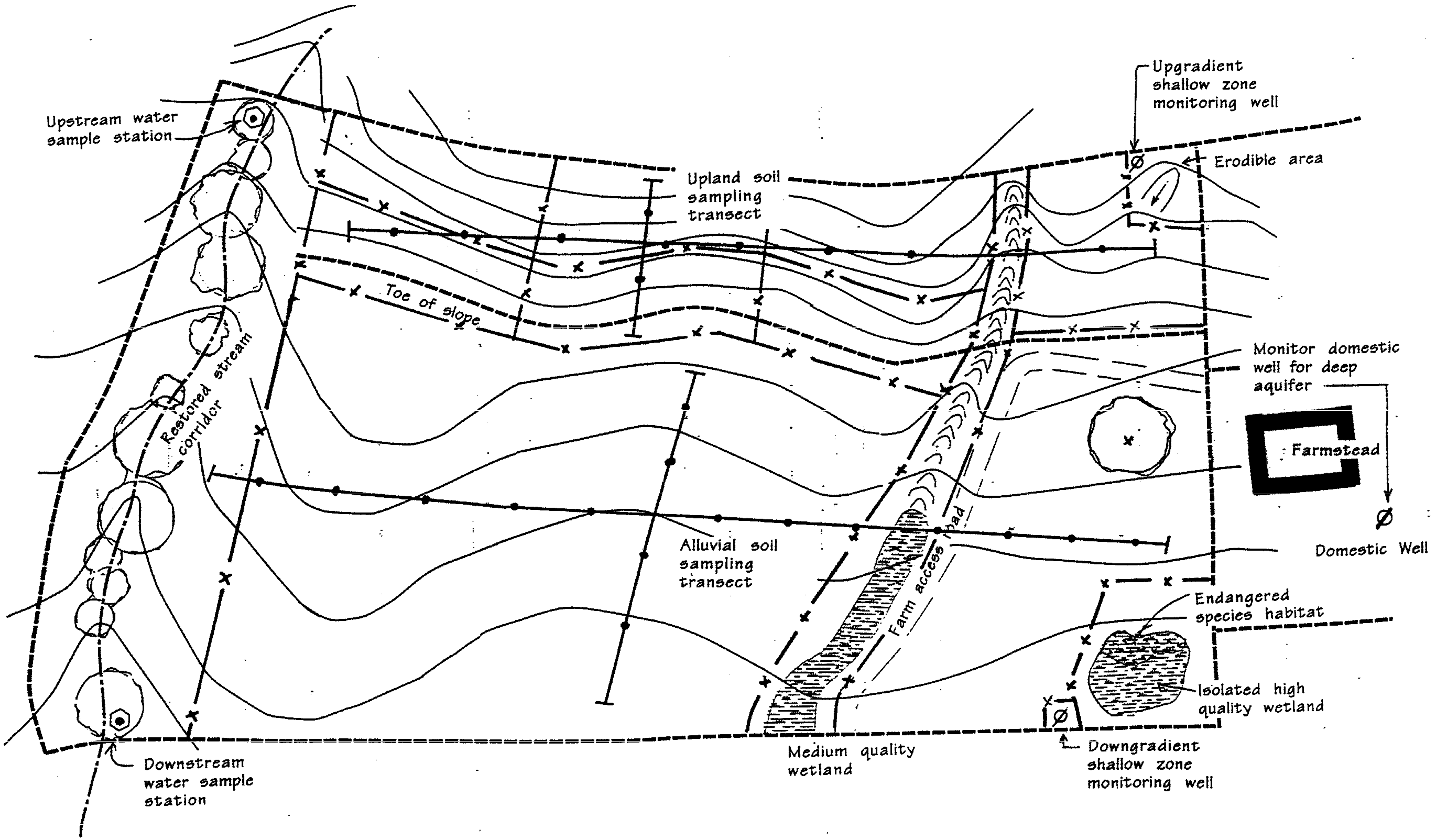
The IMG may be updated annually, where needed. The plan update may also include a summary of any additional acreage that will be added to the irrigation system. (This may be a discussion/summary of individual ICMPs.) Required revisions to the IMG may be based on field observations, monitoring data, and the experiences of City Reclamation staff, the RCD staff, and the CRMP team (or other Technical Advisory Committee). The CRMP may meet at least annually to: review the annual monitoring report; discuss planning for and progress in meeting overall watershed management goals; and, discuss the applicability of any new technologies. A major focus of the annual meeting may be to discuss the observed and measured flows, nutrients and organics in the surface water and groundwater. Depending upon the results of the monitoring, restrictions may be placed on the use of certain fertilizers and herbicides/pesticides on irrigation lands. This may be discussed with the Sonoma County Agricultural Commissioner’s office, which has the authority to impose additional restrictions on regulated compounds. Notes on the CRMP meeting may be included in the management plan update.



Santa Rosa Subregional Long-Term Wastewater Project

SETBACKS AND BUFFERS

Figure 1



Santa Rosa Subregional Long-Term Wastewater Project

PROJECT MONITORING GUIDELINES

Figure 2