IRRIGATION SUITABILITY LAND CLASSIFICATION AND EXISTING AND POTENTIAL AGRICULTURAL LAND USES, SEBASTOPOL AND SOUTH COUNTY RECLAMATION STUDY AREAS

SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT

Prepared for

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

May 1996

Prepared by

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For

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1.0 INTRODUCTION

1.1 PURPOSE, EXTENT, AND DATES OF INVESTIGATION

Southern and western Sonoma County agricultural lands are currently utilized predominantly for dry-farmed hay production, or as dairy or grazing lands, largely because of the present unavailability of a developed dependable irrigation water supply. A potential exists for the irrigation of existing and newly established orchards and vineyards, field, row and forage crops in portions of Sonoma County due to the availability of highly treated wastewater from the City of Santa Rosa Laguna Wastewater Treatment Plant. Recognizing this potential, the City of Santa Rosa Board of Public Utilities (BPU) selected the South County and West County alternative study areas for an evaluation of the potential expansion of its existing reclaimed water irrigation program. The Sebastapol area, which operationally can be included in either the remainder of the South County area or the West County area, is discussed in this Report.

Not all lands are suited for irrigation because of soil, slope, drainage or other limitations. A land classification study is required to identify and characterize lands within the project area that are suited for sustained, economically viable irrigation with reclaimed water. As part of the project decision-making process, separate environmental analyses are then conducted to determine the effects of irrigation, including impacts on surface water, groundwater and biological systems. The purpose of this report is to describe the Irrigation Suitability Land Classification for the South County study area. A previous Technical Memorandum prepared by CH2M Hill in 1990 provided a similar report for the West County alternative study area. The West County report was updated as part of the present investigations and the results presented as a separate addendum. (See *Irrigation Suitability Land Classification and Existing and Potential Agricultural Land Uses, West County Reclamation Area [Addendum]*, Questa Engineering Corp., May 1996.)

In addition to an evaluation of land suitability for irrigation, information is also presented in this Report on existing agricultural land uses, irrigated crops that can be grown, and the water demand or consumptive water use of those potential crops. Potential crops consider water quality and climatic constraints in addition to soil and drainage conditions. Some restrictions will be imposed on the choice of crops that can be grown on sloping, erodible lands and poorly drained lands. Irrigation of some lands with manageable erosion hazards will require development and implementation of soil conservation measures.

Approximately 19,000 acres in southern and southwestern Sonoma County, California, are classified in this Report. The Report covers the agricultural lands along Petaluma Hill Road between Rohnert Park and Penngrove, lands along Adobe Road east of Petaluma, and along Lakeville Highway west of the Petaluma River. Apple orchards and vineyards in the Sebastapol area are also included in this Report. The results of the land classification and land use studies are portrayed on a series of 1”=1,000’ (1:12,000) topographic base maps that cover the South County project area. These maps use connotative map symbols to show soil and land suitability for irrigation and existing and potential agricultural land uses. Field work was conducted from November 1994, to April 1995. The report was prepared in June/August of 1995 and finalized in May 1996. A number of related technical reports were prepared during this time period which provide a more detailed analysis and evaluation of specific issues associated with irrigation of agricultural lands. These include topics such as irrigation water quality, salt management needs, soil erosion and metals loading. These technical papers are referenced at appropriate points in this document. For the convenience of the reader, a separate Technical Memorandum provides a glossary of technical irrigation, drainage and agricultural water quality terms that are used in these reports.

1.2 SUMMARY OF FINDINGS AND CONCLUSIONS

Dry-farmed hay lands, dairies and livestock production, with some vineyards, and orchards are the major agricultural land uses in the South County study area. Presently, the principal crops consist of non-irrigated pasture and dry-farmed winter grown legume/grass silage and oat hay. Apples and grapes are grown in the Sebastapol area with a small acreage of vineyards in the Lakeville area. There is also a small acreage of melons, fruits and vegetables grown for the fresh produce market along Petaluma Hill Road, east of Rohnert Park, demonstrating the agricultural feasibility of growing a wide variety of crops. The area is climatically well suited to crop and pasture irrigation; the estimated crop water requirement, or consumptive use, for improved pasture is estimated to be 29 inches during the approximately six-month irrigation season. Overall, for project planning purposes, an average annual crop consumptive water use of 28 inches per acre is estimated for the South County study area. An additional 20-percent water use is estimated to account for irrigation efficiency. This value includes water losses due to deep percolation, runoff, wind drift and other factors associated with application uniformity and management. This total amount of water use (about 33.5 inches per acre annually) will vary considerably depending on the crop grown and type of irrigation system (sprinkler versus drip) and actual irrigation efficiencies achieved.

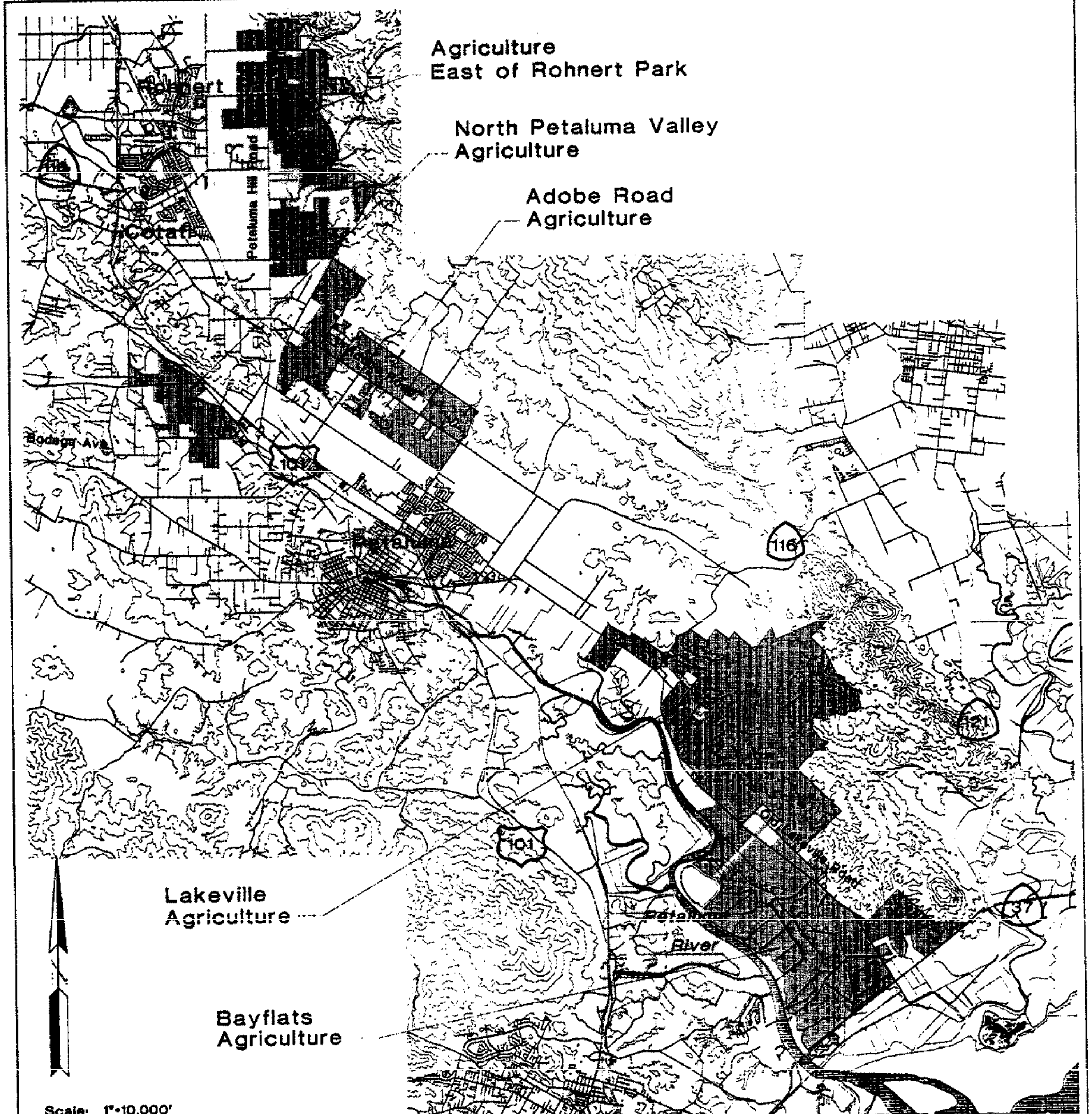
A summary of the land classification by class and acreage is shown in Table 1:

Table 1 Land Classification Summary

{PRIVATE }CLASS	ACRES	PROPORTION (percent)
Class 1	36	0.2%
Class 2	5,696	29.8%
Class 3	3,633	19.0%
Class 4	4,138	21.6%
Class 6	5,619	29.4%
Gross Survey Area	19,122	± 100%

The total arable area is approximately 13,500 acres.[1] Class 1 and 2 lands are the best suited for irrigation with virtually no limitations. Classes 3 and 4 contain some limitations that may restrict crop choice and yield, and require special management. Class 5 lands are marginally irrigable and best suited for forage and pasture crops, and Class 6 lands cannot normally be irrigated. (Note: Class 5

[1] Irrigable lands are Class 1 through 4, with Class 5 problematic, and Class 6 non-irrigable.



Source: Parsons Engineering Science
Questa Engineering
USGS quad maps

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Santa Rosa
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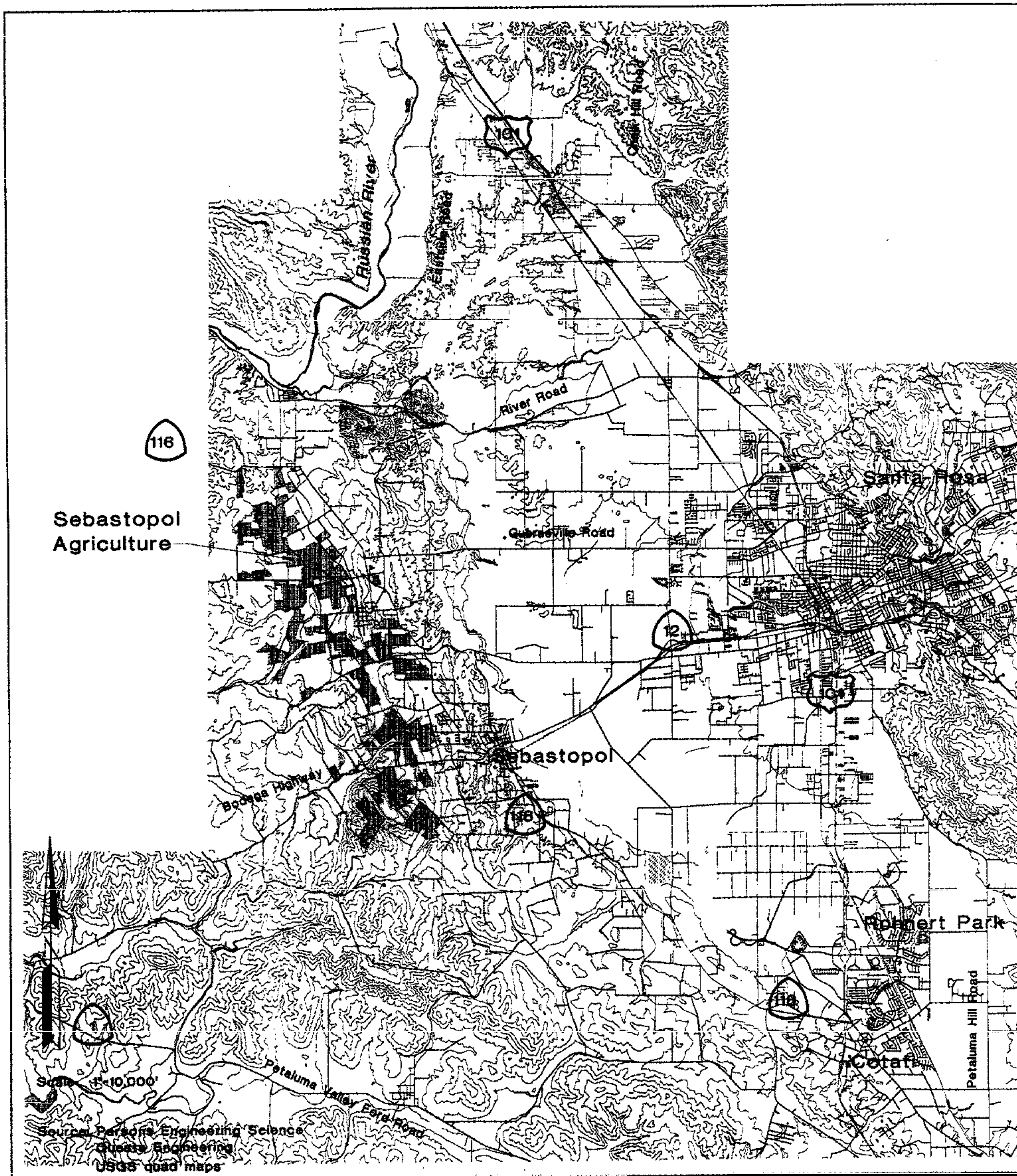
SOUTH COUNTY
AGRICULTURE

Figure 1



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SEBASTOPOL AGRICULTURE

Figure 2

lands were not recognized in the South County area.) Lands with observed wetlands characteristics are included in this acreage. Based on the project Water Balance Model completed by Parsons Engineering Science, approximately 3,900 acres of irrigable lands are required for land disposal for the one percent river discharge alternative. This assumes a project with a high amount of irrigated hay and pasture, crops with relatively high water demands. Irrigation land requirements could expand 30 percent or more (± 5,300 acres) if less water demanding fruit and vegetable crops predominate. The extensive planting of drip irrigated vineyards, which are very water efficient, may allow irrigation of virtually all arable lands in the South County (12,000 to 13,500 acres).

Given the favorable climatic conditions and good reclaimed water quality in the South County area, a wide variety of fruit, vegetable and forage crops can be grown. The fruit and vegetable crops are best suited for the flat valley bottom lands and gentle side slopes. Because of potential concerns over soil erosion, the more sloping lands are best suited for forage crops such as field corn or sudan grass, with the steepest slops (up to 15 percent) suitable for improved irrigated pasture. Drip irrigated specialty (fruit and vegetables) crops, such as strawberries, artichokes and vineyards, could also be grown on sloping lands, provided that soil conservation practices are developed and implemented. Over 6,000 acres are suited for fruit and vegetable crops (with proper management) with an additional 7,000 or more acres potentially suited for vineyards and orchards. All of these lands can also be used for forage crops and irrigated pasture, with markets readily available.

Many soils of the South County project area are clayey and difficult to work. Typically, they must be cultivated at the right moisture content to provide a good seedbed. However, the success of small organic fruit and vegetable farmers and vineyards demonstrate that a wide variety of fruit and vegetable crops can be grown under these soil and climatic conditions. The bigger challenge may be developing markets for the produce.

There appear to be some climatic and soil/drainage limitations to the general establishment of alfalfa throughout most of the South County area. Alfalfa is a high protein feed crop in great demand by the Marin-Sonoma dairy industry. From the perspective of the subregional system, alfalfa is also a desirable crop because it has a relatively high water demand, higher than irrigated pasture (34 inches of water use versus 29 inches for improved pasture). Substantial quantities of alfalfa hay are currently imported by the dairy industry from Central Valley growers. It may be necessary to select better adapted varieties and develop new cultural techniques (such as raised bed planting) for wide-spread cropping of alfalfa. This research could be conducted cooperatively with the University of California Cooperative Extension (U.C. Extension).

1.3 STUDY PARTICIPANTS

The land classification was authorized by the City of Santa Rosa. Harland Bartholomew Associates, Inc. (HBA) is the prime consultant. The work was administered by Anders Hauge of HBA.

Fieldwork, consisting of soils mapping, sampling, and hydraulic testing, was planned and conducted by Questa Engineering Corporation. Mr. Jeffrey Peters, CPSS/SC was the Project Manager for Questa, assisted by Ms. Nancy Dagle, Ms. Molly Brown, and Mr. Randall Smith.[2] Mr. Dennis Worrel of Parsons Engineering Science was involved in the early stages of the field work. Mr. Robert

[2] CPSS/SC stands for Certified Professional Soil Scientist/Soil Classifier.

Moore conducted the determination of consumptive water use. Vern Marble, PhD, Agronomist, and Lynn Brittan, Soil Scientist, provided consultation on soil suitability, potential irrigation management systems, existing agricultural management practices, and potential crops. Mr. Norman Hantzsche, P.E., assisted in preparation of the irrigation and drainage sections of the report.

2.0 STUDY AREA CHARACTERISTICS

The location of the survey area is shown in Figure 1. The survey area consists of 19,121 acres in southern and southwestern Sonoma County, California. The survey area lies approximately 40 air miles north of San Francisco. The Pacific Coast is roughly 16 miles west of the westernmost boundary of the study area. The area includes lands with slopes up to 20 percent, although by definition irrigable lands are less than 15 percent slope. The main part of the project area is roughly bounded by the Rohnert Park-Cotati area on the north, the Sonoma Mountains on the east, San Pablo Bay on the south and the Petaluma River/Highway 101/Stony Point Road corridor on the west. The Sebastapol area is also discussed in this Report. For project irrigation planing purposes, however, the Sebastapol area can be included and operationally managed with either the South or West County areas and is included in both the West and South County Reclamation Project alternatives.

2.1 GEOGRAPHIC REGIONS WITHIN STUDY AREA

The survey area has been sub-divided into six geographic sub-areas. These sub-areas include:

1. Sebastapol. This mostly upland area encompasses the orchards and vineyards along Atascadero Creek west of the City of the Santa Rosa. The northern extent of this area is the Town of Forestville and the southern limit is near the Town of Sebastapol.

2. East of Rohnert Park. This area includes the valley and foothill lands to the east and west of Petaluma Hill Road near Rohnert Park and Cotati along with lands bordering Adobe Road near Penngrove. The area borders the Sonoma Mountains to the east. Although some vegetables are grown, most of the area is used for dry-farmed oat hay production, or sheep and cattle grazing.

3. Adobe Road. The Adobe Road area extends from Corona Road on the west to Washington Road on the east. This area of mostly rolling topography is used for dry-farmed oat hay and sheep and cattle grazing.

4. North Petaluma Valley. This area encompasses a broad valley to the north of Petaluma, bordered by Stony Point Road to the north and east, Liberty Road to the west and Rainsville Road to the south. Current land use in the valley consists mostly of cattle grazing.

5. Lakeville. This area encompasses alluvial fans and rolling foothills along Stage Gulch Road between Lakeville Highway and Adobe Road in the north. It also continues south along Lakeville Highway to about one-half mile north of Highway 37. Most of this area is also used for dry-farmed oat hay production, with a few dairies and sheep and cattle grazing operations. One small vineyard has also been established.

6. Baylands. The Baylands include a small area of alluvial fans (Clear Lake soils) of the southern Sonoma Mountains along Lakeville Highway and the reclaimed tidal marshlands (Reyes soils) between Lakeville Highway and the Petaluma River. Much of this area is in oat hay production with one large (250-acre) vineyard.

2.2 PHYSIOGRAPHY

The South County irrigation lands are located in three watersheds (river basins). The Rohnert Park area is located near the southern headwaters of the Russian River on the northwestern flanks of the Sonoma Mountains. The Sebastapol area also drains into the Russian River. The Adobe Road, Lakeville and Baylands areas are located on the southwestern flanks of Sonoma Mountain, but in the Petaluma River watershed. The North Petaluma Valley area is separated from the Rohnert Park-Cotati area by Meacham Hill (a low divide), and drains into the coastal Stemple Creek watershed. The topographic divides between these three watersheds are quite subtle, and the majority of the irrigation area is on the foot slopes and alluvial fans of Sonoma Mountain, with a portion on the basin and floodplain deposits of the Petaluma River and the major creeks of Sonoma Mountain. Elevations range from about sea level along the Petaluma River to about 300 feet on the Sonoma Mountain foot slopes. The irrigation areas can be referred physiographically as the Sebastapol foot slopes and Rohnert Park-Cotati Plain (parts of the greater Santa Rosa plan), and the eastern portion of the Petaluma Valley.

The sub-areas are quite similar with respect to climate, soils, drainage and agricultural practices. However, because of the drainage divides, the South County-Sebastapol irrigation area is located within two different Regional Water Quality Control Boards; Sebastapol, Rohnert Park and North Petaluma Valley sub-areas are located within the jurisdiction of the North Coast Regional Board, while the remainder of the area draining into San Pablo Bay (along Adobe Road and Lakeville Highway) is in the jurisdiction of the San Francisco Bay Regional Board.

2.3 GEOLOGY AND GEOMORPHOLOGY

Many soil characteristics are strongly related to the land forms on which they occur and the geologic parent materials in which they develop. This is particularly important when considering the erosion potential and slope stability of more sloping irrigable lands, as well as drainage and hydrologic characteristics. The fate and transport mechanisms and subsurface travel rates of applied irrigation water, as well as their load of dissolved nutrients and metals, are determined by the characteristics of the subsoils and underlying geologic materials. Accordingly, both the surface soils and near surface geologic parent materials were investigated in the field and through literature reviews to develop an understanding of the probable behavior of the soil-water system upon irrigation. This background information and understanding was subsequently used to prepare the technical memorandum on irrigation drainage entitled *Baseline Hydrology and Irrigation Drainage Evaluation for West and South County Reclamation Alternatives*, Questa Engineering Corp., February, 1996. The geologic literature reviewed included:

- Blake, M.C., Jr., Smith, J.T., Wentworth, C.M., and Wright, R.H. (1971). *Preliminary geologic map of western Sonoma County and northernmost Marin County, California*, U.S. Geological Survey and U.S. Department of Housing and Urban Development, Basic Data Contribution 12, San Francisco Bay Region Environment and Resources Planning Study, 1:62,500.

- Blake, M.C., Jr. Bartow, J.A., Frizzell, V.A., Jr., Schlocker, J., Sorg, D., Wentworth, C.M., and Wright R.H., 1974, *Preliminary geologic map of Marin and San Francisco Counties and parts of Alameda, Contra Costa, and Sonoma Counties, California*, U.S.

Geological Survey and U.S. Department of Housing and Urban Development, Basic Data Contribution 64, San Francisco Bay Region Environment and Resources Planning Study, 1:62,500.

- California Department of Water Resources, Central District (May, 1982). *A Study of Nitrates in Groundwater, Petaluma Area, Sonoma County* (DWR Special Report).

- California Department of Water Resources (June, 1982). *Evaluation of Groundwater Resources, Sonoma County*, Vol 2, Santa Rosa Plain, Vol 3, Petaluma Valley (DWR Bulletin 118-4).

- California Department of Water Resources, Central District (July, 1979). *Meeting Water Demands in the City of Rohnert Park* (DWR Special Report).

- Caldwell, G.T. (1958). *Geology and Groundwater in the Santa Rosa and Petaluma Valley Areas, Sonoma County, California*, U.S. Geological Survey Water Supply Paper 1427, 273 p.

- Fox, K.F., Jr., Sims., J.D., Bartow, J.A., and Helley, E.J., 1973, *Preliminary geologic map of eastern Sonoma County and western Napa County, California*, U.S. Geological Survey and U.S Department of Housing and Urban Development, Basic Data Contribution 56, San Francisco Bay Region Environment and Rsources Planning Study, 1:62,500.

- Huffman, M.E. and Armstrong, C.F., 1980, *Geology for Planning in Sonoma County*, California Division of Mines and Geology Special Report #120.

- U.S. Geological Survey, *Flood-prone areas in the Petaluma River drainage basins and Cotati vicinity, Sonoma and Marin Counties, California*, U.S. Geological Survey and U.S. Department of Housing and Urban Development, Basic Data Contribution 17.

This information is briefly reviewed in this section. More detailed information on the geology and groundwater hydrology of the South County study area is presented in a separate technical memorandum prepared by Parsons Engineering Science.

2.3.1 Geology

1. Sebastapol

The predominant geologic unit of this area is the Wilson Grove Formation of Upper Pliocene age, which unconformably overlies rocks of the Franciscan Assemblage. The Wilson Grove Formation is a massive, fine to coarse grained marine sandstone with lenses of gravel and occasional interbeds of clay and silty clay. The Franciscan Assemblage was deposited in geosynclinal sink during Jurassic and Cretaceous time. Locally, this unit consists of consolidated beds of graywacke sandstone and siltstone, shale, chert, conglomerate, and serpentine. The most abundant kind of Franciscan rock in the study area is graywacke, a greenish-gray weathering to brown, firmly indurated sandstone and siltstone characterized by poorly sorted angular grains and restricted matrix. Sandstones are massive; siltstones may be bedded. Most of the water movement observed in the Franciscan rocks immediately beneath the soil layer typically occurs in a two to five-foot thick weathering zone at or near the soil-rock contact, or through fractures in the rock structure.

The Wilson Grove Formation is postulated to have been deposited in a subsiding embayment open to the ocean, on the irregular surface of the Franciscan Assemblage. Most of this unit is loose and poorly cemented, with well-sorted, rounded grains. The upper portion located immediately below the soil layer is usually highly weathered and permeable, although frequently the soil layers above the weathered rock are very clayey.

Pleistocene faulting has caused the Franciscan and Wilson Grove Formations to be uplifted and down dropped relative to one another. This faulting, together with Holocene erosion and the irregular surface on which the Wilson Grove was deposited, has caused the Wilson Grove to vary in thickness. Both younger and older Quaternary alluvium are also present in the area. These recently deposited, unconsolidated gravel, sand, silt, and clayey sediments unconformably overlie the Franciscan and Wilson Grove rocks in valley bottom areas. These alluvial soils are typically more permeable than the upland soils, but may have areas of poor drainage and winter ponding.

2. East of Rohnert Park

This area is underlain primarily by Quaternary alluvial fan deposits in areas of lower slopes and by the Pliocene age Sonoma Volcanics in upland positions on the Sonoma Mountain foot slopes. Both the younger alluvial fan deposits and older alluvium soils are very clayey with slow permeabilities. The older deposits occur on the elevated portions of the fans, above the modern floodplain. Some areas pond water in the winter and have high seasonal water tables within six feet of the ground surface. The Sonoma Volcanics originated during a period (Tertiary) of volcanic activity which included volcanic ash eruptions and lava flows. During the Pleistocene, these rocks were uplifted, folded and faulted to form the present day Sonoma Mountains. The rocks of the Sonoma Volcanics include andesite, basalt, rhyollite, and tuff. These rocks vary considerably in their hardness, induration, weathering and fracturing. The soils that occur on them are typically stony clay loams with moderately slow permeabilities. Water can move laterally along the soil-rock interface until more permeable zones or fractured rock is encountered. Landslides and springs are common along active faults which traverse the Sonoma Mountains.

3. North Petaluma Valley

This area has three predominant geologic units. The low lying valley positions contain Quaternary alluvium. The gently sloping hills to the west are underlain by the Wilson Grove Formation. Within the main valley floor there are small units of sedimentary rocks of the Tertiary age Petaluma Formation. The Petaluma Formation consists of Pliocene age sedimentary rocks which were deposited in a shallow marine environment. The formation was later folded and uplifted. Rocks of this group include claystone, siltstone, mudstone and tuff, with sandstone and conglomerate crossbeds. Most are lightly consolidated and highly weathered near the surface. The underlying geologic materials are most often more permeable than the clayey soils which have developed on them.

4. Lakeville Highway

The Petaluma Formation occurs east of Lakeville Highway, with Quaternary alluvium to the west. Quaternary alluvium is found on alluvial fans and interfluves. Quaternary alluvium is comprised of find sand, silt, silty clay, coarse sand and gravel, with gravel more abundant near the fan heads. Silty clay soils with slow permeabilities predominate in this area.

5. Baylands

This area consists of clayey sediments reclaimed from tidal marsh deposits (young bay muds). Permeabilities are very slow through the upper soil layers. Seasonal groundwater tables are often at or within two feet of the ground surface. Many areas are artificially drained by a surface drainage ditch system. It appears that a portion of the drainage of these lands is by preferential flow through old marsh channels or through more permeable interbedded deposits in the clayey strata.

6. Adobe Road

This valley area contains Quaternary Alluvium. These fluvial deposits are at the outer edge of alluvial fans and flood plain deposits. They form levees between basin deposits and are characterized by fine, but variable grain size. The composition of these soils is mainly clays. The soils are generally slowly permeable.

2.3.2 Geomorphology and Drainage

1. Sebastapol/Camp Meeker.

Atascadero, Parrington and Green Valley Creeks are the major drainages in this area. These creeks flow north into the Russian River. Tributaries are closely spaced and generally flow in a south to north pattern.

The creeks wind their way through moderate to steep hills until they reach the Russian River floodplain. The rivers have cut channels through the Wilson Grove formation and into the underlying Franciscan Formation. The sequence of alluvial deposition in this area are layers of stratified silt and clay.

2. East of Rohnert Park.

Crane, Copeland, Hindebaugh and Lichau Creeks are the major drainages in this area. These creeks flow west from the Sonoma Mountains and into the valley along Petaluma Hill Road. In the north, Crane, Copeland and Hindebaugh Creeks drain west to the Laguna de Santa Rosa. Lichau Creek and Willow Brook drain south into the Petaluma River. Nearly all of these creeks are spring-fed and perennial in the Sonoma Mountains.

3. North Petaluma Valley.

Several seasonal creeks flow through the valley and drain into the upper Petaluma River. The Petaluma River flows south and into San Pablo Bay. Tributaries are closely spaced and flow both from the east to the west from the Sonoma Mountains and from the north to the south from the Meacham Hill area.

The Petaluma River carries sediments that have accumulated on terraces and along stream channels. The north Petaluma valley is such a terrace and contains gravely deposits from the streams and soils with clay subsoils that are formed from soft sandstone, siltstone and shale.

4. Lakeville Highway.

The Petaluma River and Tolay Creek are the major drainages in this area and flow south into San Pablo Bay. Baylands and marshes border the Petaluma River. In the upper reaches, Tolay Creek runs through Tolay Valley, a former shallow lake bed that was drained for agricultural purposes in the 1870s. The tributaries for both the Petaluma River and Tolay Creek are closely spaced and flow both from east to west and from west to east, respectively. Most are unnamed creeks originating in the foothills and alluvial fans east of Lakeville Highway. The Petaluma River, Tolay Creek and their tributaries carry sediments of claystone, siltstone, mudstone, tuff and sandstone into San Pablo Bay.

5. Baylands.

The major drainage for this area is the Petaluma River. This tidal slough meanders through reclaimed marshland and tidal marsh before entering into San Pablo Bay. The tributaries are closely spaced and carry sediments of mudstone, tuff and sandstone. A number of agricultural drainage ditches have been constructed in the reclamation areas to permit farming.

6. Adobe Road.

Willow Brook, Corona Creek, Lynch Creek, Washington Creek and Adobe Creek are the primary drainages for this area. These streams originate in the Sonoma Mountains and flows south into the valley and cross under Adobe Road. They are tributaries to the Petaluma River. Willow Brook's tributaries are widely spaced and generally flow from north to south. The area around Adobe Road is a terrace whose soils have been formed from alluvial sediments, weathered sandstone and soft shale with occasional strata of weakly consolidated conglomerate. Irrigation drainage water from the Santa Rosa project would not be intercepted by Lynch, Washington or Adobe Creek.

2.4 CLIMATE

The climate of the study area is coastal Mediterranean, characterized by dry, moderately hot summers and cool moderately wet winters. Temperature readings range from highs occasionally exceeding 100 degrees to lows periodically falling below freezing. Nighttime temperatures typically drop into the 50s. Low clouds or fog persist during much of the summer in a narrow band offshore. Under typical summer conditions this cloudiness moves inland during the late afternoon and spreads across much of the South County during the evening. By mid-morning the fog starts to dissipate over inland areas of the county. By early afternoon most of the South County experiences sunshine.

2.4.1 Temperature

The temperature pattern within the South County area is profoundly influenced by the temperature of the Pacific Ocean with near coastal areas being influenced to a greater extent than more inland areas. Within the study area, summer temperatures range from a high of 100 degrees plus to lows in the 50s during the nighttime. The mean daily maximum for the Petaluma area during the month of July is estimated to be 90 degrees.

Winter temperatures are generally mild, although cold spells (below freezing) have been routinely reported. The mean minimum temperature in January for Santa Rosa is 39 degrees. All-time lows have been reported in the high teens to the low twenties. The January mean daily maximum temperature for the Petaluma area is 58 degrees.

2.4.2 Frost Free Days

The average date of the last 32 degree temperature reading in the spring extends through the month of March in most of the cultivated areas of the South County. When freezes of 28 degrees or colder are considered, these dates range from mid-December through February over much of the South County.

The average date of the first 32 degree temperature reading in the fall is around the middle of November over most of the South County. In the case of 28 degree readings, the dates range from early December to early January. These dates give a mean growing season length, as determined by the 32 degree temperature readings, of 230 to 260 days in the project study area.

2.4.3 Precipitation

The average seasonal precipitation ranges from less than 20 inches in the extreme southeast corner of the County through 30 and 40 inches over much of the central part of the County. Reported average rainfall for Petaluma covering the period of l961 to l990 is 24.02-inches. Rainfall totals vary from season to season with total rainfall in the southeast corner of the County being approximately 18 inches and increasing to 26 to 28 inches in the Penngrove-Rohnert Park area.

2.4.4 Winds

Winds are fairly light most of the time, though they blow persistently during the summer. Winds are usually not strong enough during the growing season to adversely affect crops, although some allowance in sprinkler design is recommended to accommodate wind drift and distortions in irrigation application uniformity.

2.5 FLOOD HAZARD

Mapping of flood prone areas is available for much of the survey area from the U.S. Geological Survey. Also available from the Federal Emergency Management Agency are 100-year flood-plain maps of major streams in urban areas. Lower lying alluvial lands adjacent to the active channels are subject to flooding whenever the capacities of the creeks are exceeded. In many areas, this is at frequencies between 1-in-5 and 1-in-20 years. Although there are levee systems to contain flood waters, the Petaluma River and its larger tributaries can overflow during larger storm events, causing flooding within the alluvial areas. Extensive low-lying areas are inundated in some years. Historically, flooding has not caused extensive crop damage and flood waters recede relatively quickly. The Baylands areas, in particular, are subject to prolonged ponding when rainfall amounts and run-off exceed the capacities of drainage pumps.

3.0 PRINCIPAL NATURAL LAND BODIES

3.1 SOILS

A soil survey was completed for Sonoma County by the U.S. Department of Agricultural (USDA) Soil Conservation Service in 1970 (now the Natural Resources Conservation Service [NRCS]), and was used as the source of much of the following taxonomic soil information. This information was supplemented by extensive project field investigations. Interpretations for irrigation suitability are presented in the next section. The irrigation study area is roughly one-third alluvial bottom lands and two-thirds gently to moderately sloping foothill uplands. A small part of the survey area consists of soils reclaimed from tidal marsh land along the Petaluma River after construction of levee and pump drainage systems around the turn of the century. As compared to the West County study area, soil conditions (texture, depth and drainage) are more uniform and predictable, and less complex over large areas.

The most commonly occurring alluvial soils recognized by the SCS in the survey area are the Clear Lake, Blucher, Pajaro, and Zamora series. These soils have developed in tidal and stream deposited materials weathered from basic and sedimentary rocks which include marine sandstones, siltstones and shales. Profile characteristics indicative of wetness can vary within series over short distances. Each of these series may meet hydric soil criteria depending upon local conditions. Clear Lake soils have a clay texture and are 60+ inches deep. Blucher soils have loam, clay loam or fine sandy clay loam texture and are 60+ inches deep. Pajaro soils have a fine sandy loam texture and are 36 to 60 inches deep. Zamora soils have a clay loam texture and have depth of 60 inches or more.

The most commonly occurring upland soils are the Cotati, Diablo, Haire, and Goldridge series. Cotati soils have a fine sandy loam texture with a clay subsoil and are 40 to 55 inches deep. They develop on coarse grained, weathered or weakly consolidated sandstones and tuff. Diablo soils have a clay texture and are 40 to 60 inches deep. Textures of the Goldridge soils are fine sandy loams with a sandy clay subsoil and are 40 to 60 inches deep. Haire soils have a clay loam texture with a clay subsoil and are 36 to 60 inches deep.

The Cotati soils are mainly underlain by the Sonoma Volcanic Group and older (Quaternary) uplifted alluvium. In the Lakeville Highway area, the Diablo soils are underlain by the Huichica Formation. In the Sears Point area, the Diablo soils are underlain by the Sonoma Volcanic Group and older (Quaternary) alluvium. On steeper slopes (15 to 30 percent) of the Cotati and Diablo soils, the soil depth ranges from 28 to 52 inches deep. The Goldridge soil is mainly underlain by the Wilson Grove Formation with inclusions of older alluvium and Franciscan rocks. On steeper slopes (15 to 30 percent) the soil depth ranges from 30 to 40 inches. The Haire soil is associated with the Petaluma valley formation and Quaternary alluvium.

Brief descriptions and the taxonomic classifications of the commonly occurring soils are presented in the following sections. The natural land bodies are grouped into three units for discussion purposes: 1) alluvial soils; 2) upland soils; and, 3) Baylands (Reyes soils).

3.1.1 Alluvial Soils

Blucher Series

These are somewhat poorly drained loams, underlain by mixed sedimentary alluvium of stratified silt and clay. These soils are in basins along stream bottoms and on alluvial fans. They are mainly in the south-central part of the county in valley areas west of Petaluma and Sebastapol.

Taxonomic classification: Typic Haploaquolls, coarse-loamy over clayey, mixed, noncalcareous, mesic.

0 - 9 inches	Dark gray loam; strong, coarse, angular blocky structure; very hard, friable, nonsticky and slightly plastic; medium acid.
9 - 20 inches	Dark gray silt loam that has common, fine, distinct, yellowish-brown mottles; massive; very hard, firm, plastic and nonsticky; neutral.
20 - 34 inches	Gray fine sandy loam that has common, fine, distinct, yellowish-brown mottles; massive; hard, friable, nonsticky and nonplastic; moderately alkaline.
34 - 45 inches	Dark gray heavy silty clay loam that has a few, fine, distinct, dark yellowish-brown mottles; massive; very hard, firm, sticky and plastic; moderately alkaline
45 - 57 inches	Dark gray silty clay loam that has common, fine, prominent, dark yellowish-brown mottles; massive; hard, friable, slightly sticky and plastic; mildly alkaline.
57 - 78 inches	Gray heavy silt loam that has common, medium, distinct, dark yellowish-brown mottles; massive; hard, friable, nonsticky and slightly plastic; mildly alkaline.

Clear Lake Series

This soil consists of clays that formed under poorly drained conditions. These soils are underlain by alluvium from basic and sedimentary rock. They are on plains and flat basin areas. They occur in an area that extends from approximately five miles south of Santa Rosa and east of Petaluma to north of the tidelands bordering San Francisco Bay. There are also scattered areas south and southwest of Sonoma.

Taxonomic classification: Typic Palloxererts, fine, montmorillonitic, thermic.

0 - 2 inches	Dark gray clay; fine and medium granular structure; hard, very firm, sticky and plastic; medium acid.
2 - 8 inches	Dark gray clay; massive and coarse subangular blocky structure; very hard, very firm, sticky and plastic; medium acid
8 - 25 inches	Dark gray clay; massive; extremely hard, extremely firm, sticky and plastic; medium acid.

25 - 39 inches	Dark gray clay that has common, fine, distinct, light-gray mottles; massive; extremely hard, extremely firm, sticky and plastic; many slickensides; slightly acid.
39 - 46 inches	Dark gray clay that has common, fine, distinct, light-gray mottles; massive; very hard, extremely firm, very sticky and plastic; many slickensides, moderately alkaline.
46 - 52 inches	Gray clay that has common, fine, distinct, light-gray mottles; massive; very hard, extremely firm, very sticky and very plastic; many slickensides, moderately alkaline.
52 - 60 inches	Light brownish-gray light clay that has white lime splotches; massive; very hard, extremely firm, sticky and plastic; moderately alkaline.
60 - 72 inches	Light gray to white sandy clay loam; massive; hard, firm, slightly sticky and slightly plastic; many moderately thick clay films in pores; moderately alkaline; disseminated lime; weakly effervescent.

Zamora

The Zamora series consists of well-drained clay loams that have a mainly clay loam subsoil formed in recent alluvium from mixed sedimentary sources. These soils are on alluvial fans. They are mainly in the large valleys and drainage ways of the county and along the immediate channels of the small creeks.

Taxonomic classification: Mollic Haploxeralfs, fine-silty, mixed, thermic.

0 - 5 inches	Grayish-brown silty clay loam; very hard, firm, very sticky and very plastic; slightly acid.
5 - 17 inches	Dark grayish-brown clay loam; strong, medium and coarse, angular blocky structure; extremely hard, firm, very sticky and very plastic; many thick organic coatings on ped faces; neutral.
17 - 29 inches	Dark grayish-brown clay loam that has common, fine, faint, dark yellowish-brown mottles; strong, medium and coarse, angular blocky structure; hard, friable, very sticky and very plastic; many thick organic coatings on ped faces; neutral.
29 - 41 inches	Dark grayish-brown clay loam; strong, medium and coarse, angular blocky structure; hard, friable, very sticky and very plastic; many moderately thick clay films in pores and as bridges; neutral.
41 - 55 inches	Dark-brown sandy clay loam; strong, coarse and medium, angular blocky structure; slightly hard, friable, very sticky and very plastic; many thick and moderately thick clay films in pores, as bridges, and on ped faces; neutral.

55 - 60 inches Dark-brown gravely clay; strong, coarse and medium, angular blocky structure; slightly hard, firm, very sticky and very plastic; many thick and thin clay films in pores and ped faces; neutral.

Pajaro Series

The Pajaro series consists of somewhat poorly drained fine sandy loams. These soils are underlain by mixed alluvial material derived from a variety of sedimentary sources. The soils are on low terraces and on alluvial flood plains and fans in valley areas. They are mainly in the south-central and southwestern parts of the county between Petaluma and Two Rock but are also in the vicinity of Sebastapol.

Taxonomic classification: Typic Haplaquolls, coarse-loamy, mixed noncalcareous, mesic.

0 - 4 inches Grayish-brown fine sandy loam; massive; hard, friable, nonsticky and slightly plastic; medium acid.

4 - 35 inches Gray fine sandy loam that has common, large, distinct, yellowish-brown mottles; massive; hard, friable, nonsticky and nonplastic; slightly acid.

35 - 54 inches Gray fine sandy loam that has common, fine, distinct, yellowish-brown mottles; massive; hard, friable, nonsticky and nonplastic, neutral.

54 - 72 inches Grayish-brown fine sandy loam; massive; hard, friable, nonsticky and nonplastic; slightly acid.

3.1.2 Upland Soils

Cotati

The Cotati series consists of moderately well-drained fine sandy loams that have a clay subsoil. They formed in weakly consolidated sand, gravel, and clay of old marine-terrace material and weathered siltstone and shale with occasional strata of weakly consolidated conglomerate. These soils are on undulating to hilly terraces. They occur mainly in the south-central part of the county between Petaluma and Cotati.

Taxonomic classification: Typic Haploxerults, clayey, montmorillonitic, mesic.

0 - 5 inches Light brownish-gray fine sandy loam; weak, fine, granular structure to a depth of one inch, massive structure below and apparent compaction by livestock; hard, friable, slightly sticky and nonplastic; strongly acid.

5 - 11 inches Grayish-brown fine sandy loam; massive; slightly hard, friable, slightly sticky and nonplastic, strongly acid.

11 - 19 inches Light brownish-gray sandy loam; massive; slightly hard, friable, slightly sticky and slightly plastic; strongly acid.

19 - 22 inches	Light gray sandy loam; massive; slightly hard, friable, slightly sticky and slightly plastic; strongly acid.
22 - 35 inches	Grayish-brown clay; moderate, coarse, prismatic structure; very hard, very firm, sticky and very plastic; continuous moderately thick and thick clay films on ped faces and in tubular pores; common compression faces and slickensides; very strongly acid.
35 - 48 inches	Light brownish-gray clay; strong, coarse, prismatic structure, prisms break diagonally along slickenside planes; very hard, firm and very firm, sticky and very plastic; extremely acid.
48 - 55 inches	Light-gray clay; massive; very hard, friable and firm, very sticky and very plastic; a few slickensides; extremely acid
55 - 68 inches	Light-gray clay; weak, medium and coarse, subangular blocky structure; very hard, firm with friable inclusions, very sticky and plastic; common moderately thick to thick clay films in pores and as bridges; very strongly acid; a few brittle zones in this horizon indicate irregular transition to weakly consolidated shale or siltstone.

Diablo Series

The Diablo series consists of well-drained clay soils. At a depth 60+ inches the soils overlie interbedded, calcareous, fine-grained sandstone, clayey shale, and weathered siltstone. These soils are on terraces and rolling uplands. They are mainly in the south-central quarter of the county on the open grass hills east of the Petaluma plains.

Taxonomic classification: Chromic Pelloxererts, fine, montmorillonitic, thermic.

0 - 7 inches	Dark-gray clay; strong, fine, subangular blocky structure that grades with depth to weak, coarse, subangular blocky structure; very hard, firm, very sticky and very plastic; slightly acid.
7 - 19 inches	Very dark gray clay that has common, fine, distinct, light-gray mottles; massive; extremely hard, extremely firm, very sticky, and very plastic; slightly acid.
19 - 30 inches	Dark gray clay; weak, fine, subangular blocky structure; extremely hard, very firm, very sticky and very plastic; moderately alkaline.
30 - 38 inches	Dark gray clay that has many, medium, distinct, white mottles; massive; extremely hard, very firm, very sticky and plastic; moderately alkaline.
38 - 46 inches	Light olive gray clay; massive; extremely hard, very firm, very sticky and very plastic; moderately alkaline; scattered lime blotches and a few slickensides.
46 - 56 inches	Light olive gray light clay; massive; extremely hard, firm, sticky and plastic; moderately alkaline; a few large streaks of lime mixed with black material; fragments of weathered siltstone which break to medium subangular blocky structure.

56 - 73 inches Light olive gray clay; massive; extremely hard, firm, very sticky and very plastic; moderately alkaline; large blotchy lime areas; many slickensides; small fragments of weathered siltstone.

Goldridge Series

The Goldridge series consists of moderately well-drained fine sandy loams that have a sandy clay loam subsoil. At a depth of 40 to 60+ inches, the soils are underlain by coarse-grained, weakly consolidated sandstone. These soils are on uplands. They occur along the coast from the Freestone-Sebastapol area north to the vicinity of Annapolis.

Taxonomic classification: Typic Hapludults, fine-loamy, mixed, mesic.

0 - 7 inches Light brownish-gray fine sandy loam; moderate, very fine, granular structure; soft, very friable, nonsticky and nonplastic; very strongly acid.

7 - 20 inches Light brownish-gray fine sandy loam; massive; soft, friable, nonsticky and nonplastic; strongly acid.

20 - 24 inches Light brownish gray fine sandy loam; massive; slightly hard, friable, nonsticky and nonplastic; strongly acid.

24 - 28 inches Light gray fine sandy loam; massive; slightly hard, firm, slightly sticky and slightly plastic; very strongly acid.

28 - 41 inches Pale yellow sandy clay loam that has common, fine, distinct olive-yellow mottles; massive; very hard, firm, sticky and plastic; very strongly acid.

41 - 57 inches Mottled, very pale brown and light yellowish-brown sandy clay loam; massive; very hard, firm, slightly sticky and slightly plastic; strongly acid.

57 - 72 inches Very pale brown sandy clay loam that has common, fine, distinct brownish-yellow mottles; massive; slightly hard, firm, on sticky and slightly plastic; very strongly acid.

Haire Series

The Haire series consists of moderately well-drained clay loams that have a clay subsoil, and are underlain by old terrace-alluvium from mixed sedimentary and basic rock sources. These soils are on terraces and rolling hills. They are mainly scattered as small, localized soil bodies in the southern part of the county.

Taxonomic classification: Abruptic Palexerolls, fine, montmorillonitic, thermic.

0 - 7 inches Grayish-brown clay loam that has common, fine, distinct brown mottles; massive; slightly hard, friable, nonsticky and plastic; neutral.

7 - 12 inches Grayish-brown clay loam; massive; slightly hard, friable slightly sticky and plastic; slightly acid.

12 - 24 inches Grayish-brown clay loam; massive; slightly hard, friable, sticky and plastic; slightly acid.

24 - 36 inches Pale-brown clay; weak, medium, columnar structure, lower part is massive; thin, discontinuous, bleached capping on columns; extremely hard, very firm, sticky and very plastic; continuous thick clay films as bridges; upper 2 or 3 inches of peds have black colloidal stains on faces; strongly acid.

36 - 60 inches Pale-yellow and pale-brown very gravely and cobbly clay loam; massive; sticky and plastic; strongly acid.

3.1.3 Baylands (Reyes Soils)

The Reyes series consists of poorly drained silty clays that formed in mixed bay and stream alluvium. These soils are located in areas reclaimed from tidal marsh by levee systems. They are mainly in the southeastern part of the county next to San Pablo Bay at the southern ends of the Petaluma Valley. A separate technical memorandum discusses the unique hydrology and soil and water chemistry of the Baylands. (See *Hydrologic/Water Quality Evaluation of Irrigation of Baylands (Reyes Soils)*, Questa Engineering Corp., March 1996.)

Taxonomic classification: Fluventic Haplaquepts, fine mixed, sulfurous, acid, thermic.

0-7 inches Light brownish-gray silty clay, strong, fine, granular structure; strong, fine, granular structure; slightly hard, friable, sticky and plastic; extremely acid (pH 4.0).

7-14 inches Grayish-brown silty clay; strong, fine, granular structure; slightly hard, friable, sticky and plastic; extremely acid.

14-22 inches Light brownish-gray silty clay that has common, fine, distinct, brownish-yellow and light-gray mottles; many very dark-brown and strong-brown root channels; weak, coarse, subangular blocky structure; extremely hard, firm, sticky and plastic; very strongly acid (pH 4.5).

22-31 inches Light-gray silty clay that has common, fine prominent, strong-brown and black mottles and a few streaks of very dark grayish brown; weak, very coarse, prismatic structure; extremely hard, firm, sticky and very plastic; very strongly acid.

31-51 inches Gray silty clay that has common, fine prominent, strong-brown mottles; moderate, very coarse, prismatic structure; extremely hard, firm, sticky and plastic; very strongly acid.

51-63 inches Mixed gray and black silty clay, muck, and plant remains that have a few, fine, distinct, yellowish-brown mottles; massive; extremely hard, firm, sticky and plastic; hydrogen sulfide odor; extremely acid to medium acid.

3.2 SOIL CHEMISTRY AND FERTILITY

Representative soil samples were collected from selected soil profiles to document the chemistry and fertility of the soils found in the South County study area. Laboratory analyses were completed following U.C. Cooperative Extension test procedures by Environmental Technical Services (ETS) Laboratories, Petaluma, California. A summary of the significant characteristics are shown in Tables 2, 3 and 4. From the laboratory analyses, the following observations can be made:

3.2.1 Salinity and Sodicity

Soil salinity refers to the concentration of soluble salts present in the soil-water solution. As plants extract water from the soil, most of the salt is left behind, which potentially increases the concentration of salt in the remaining soil-water solution. The water molecules are held more firmly preventing the diffusion of water from the external solution into plant roots. Soil salinity can adversely affect crop production, especially in areas with inadequate subsurface drainage. Existing soil salinity concentrations were determined by laboratory analyses of 25 soil samples taken at 7 sites within the survey area. These data were supplemented by field investigations conducted as part of the *1990 South County Irrigation Feasibility Evaluation* completed by CH2M Hill, and by soils data collected for the proposed Bio-Solids Beneficial Use Program.

In the samples collected for analysis, salinity levels expressed as millimhos per centimeter (mmhos/cm) of the saturated paste extract range from 0.09 to 1.75 in the surface 20 inches, from 0.06 to 0.53 in the underlying 20 inches, and from 0.09 to 0.59 in the lowest 20-inch increment of the 60-inch soil profile. Salinities in the 0 to 2 range indicate that most plants will have little or no adverse effects to their survival or growth rates, while a range from 2 to 4 would restrict the growth of very salt sensitive crops, 4 to 8 would reduce the yields of many crops, 8 to 16 would allow only salt tolerant crops a satisfactory yield, and above 16 only a few very tolerant crops would have satisfactory yields. Salinity is expected to be a problem only on some low-lying areas of Reyes soils in the Lakeville area.

Sodicity is a special type of salinity and refers to situations where sodium is present in high concentrations relative to other soluble salts. Soils may be saline, sodic, or saline-sodic. The sodium absorption ratio (SAR) is used in estimating the exchangeable sodium percentage of a soil and indicates the need for amendment application. Sodic conditions are considered to adversely affect soil structure, intake rates, or permeability when the sodium absorption ratio of the soil exceeds 8. Conditions of this nature were not found in the soils that were sampled for this survey.

Reyes soils along Lakeville Highway and the Baylands region are included in the project. In a 1990 Irrigation Expansion Feasibility Memorandum for South Sonoma County prepared by Don Fox, Janet Cherry, and Jim Thayer (CH2M Hill) the Reyes soils that were sampled were found to have strongly calcareous, saline subsoils, with high electrical conductivities (EC) below approximately 18 to 28 inches. Salinity levels at these depths (along with seasonal drainage problems) are significant enough to preclude the establishment of most deeper rooted horticultural crops (orchards and vineyards) along with most fruit and vegetable crops. Installation of drainage structures and use of salt and wetness tolerant forage and pasture grasses, such as fescue, can overcome some of the inherent limitations of Reyes soils. Salinity is further discussed in the technical memorandum entitled *Irrigation Water Quality and Salt Management Leaching Requirements, South and West County Reclamation Alternatives*, Questa Engineering Corp., February, 1996.

3.2.2 Acidity

There are wide differences among plants in response to acidic and alkaline soil conditions. This is usually expressed as soil pH (Table 2). In strongly acid soils (pH~4), excess soluble or exchangeable manganese (Mn) and aluminum (Al) may produce toxicity in many crops. Below pH 4.2 the acidic conditions are too severe for most crops to do well, between pH 4.2 to 5.5 certain acid tolerant crops may grow, between pH 5.5 to 8.4 most crops grow well, and above 8.4 there is a probable sodium problem. The evaluation of soil pH and crop choice will determine the success and amount of crop yields.

Clear Lake Clay and Pajaro soils are representative of soils found on alluvial fans and basins. These soils were moderately acidic to neutral with soil pH ranging from 5.5 to 7.3. Subsoils were also near neutral in their surface layers with ranges from 6.3 to 7.3. Goldridge and Diablo soils are representative of soils found on upland areas. Their surface layers were moderately acidic to near neutral with soil pH ranging from 4.7 to 6.7, and their subsoils also moderately acidic to near neutral with soil pH ranging from 5.0 to 6.9.

Data from the 1990 South Sonoma County Irrigation Expansion Feasibility Memorandum confirm that the Reyes soils have extremely acidic surface soils with pH values ranging from 3.9 to 4.4. Typically, pH levels in such soils are adjusted with applications of agricultural lime. The associated lime requirement to bring the surface 6 inches of soil to pH 7.0 ranges from 13.2 to 17.6 tons/acre, a very high amount. The sulfide levels of the Reyes soils confirm the relatively high level of sulfur in these reclaimed tidal soils. The sulfide levels indicate that with drainage, these soils will continue to acidify and necessitate periodic liming to maintain soil pH levels in a range suitable for most hay and forage crops.

3.2.3 Trace Elements

Trace elements are metals that are needed by plants in small amounts. Acidic soil conditions increase the availability of many heavy metals such as copper, molybdenum, and zinc for plant absorption and for transport in the soil-water solution. In large amounts, these metals may be toxic to plants. The pressure of abundant native soluble metals in the soil also has implications regarding the potential leaching and transport of these elements in irrigation drainage waters (percolate) to surface water courses or shallow zone groundwater.

Laboratory analyses were conducted to determine the levels of soluble (DPTA extractable) metals found in the survey soil samples. Concentrations of soluble Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Molybdenum (Mo), Nickel (Ni), Selenium (Se) and Zinc (Zn) were found in most samples in very small quantities. The results are provided in Table 3. The concentration levels of these metals do not constitute a need to institute special drainage management measures to avoid leaching and transport of soluble metals in irrigation drainage waters. The potential accumulation of metals in the soil from metals contained in the applied irrigation water is discussed more fully in the technical memorandum, *Trace Element Loading Analysis for the South and West County Reclamation* Alternatives, Questa Engineering Corp., October, 1995. The quality of the irrigation drainage water is discussed in *Evaluation of Metals in the Irrigation Affected Percolate, West and South County* Alternatives, Questa Engineering Corp., March, 1996.

3.2.4 Soil Fertility

Mineral elements such as nitrogen and phosphorus are required by plants for their development and growth in varying amounts. An extreme deficiency of the element makes it impossible for the plant to complete the vegetative or reproductive stage of its life (produce fruit), while lesser deficiencies can affect the yield and quality of the crop.

Soil fertility levels were determined through laboratory analysis of representative soils. The concentrations of Nitrate ($N0_3$-N), Ammonia (NH3-N), Phosphorous (P), Potassium (K), Calcium (Ca), Magnesium (Mg), and Sodium (Na) were found to be within acceptable ranges on all samples tested. However, most crops will respond to nitrogen, phosphorous and, to a lesser extent, potassium applications to the soils. Some of these plant nutrient needs can be supplied by the reclaimed water. Additional fertilizers and sources of nitrogen (such as animal wastes) will still be required for some high nitrogen demanding crops, such as field corn and sudan grass, while phosphorous fertilization may be required for many of the fruit and vegetable crops.

The results of the fertility testing are provided in Table 4. A discussion of fertilizer and manure management is provided in the *Irrigation Management Plan*, Questa Engineering Corp., October, 1995, while an evaluation of the fate of applied nitrogen is contained in the report *Estimation of Nitrogen, Salt and Herbicide/Pesticide Concentrations in Surface Water, West County and South County Reclamation Alternatives*, Questa Engineering Corp., March, 1996.

4.0 IRRIGATION LAND CLASSIFICATION AND LAND USE

4.1 GENERAL DESCRIPTION

The results of the land classification and land-use investigations are portrayed on a series of six map sheets, each with a scale of 1" = 2,200'. Four kinds of information are contained on the mapping symbol within each polygon:

1. Irrigation suitability land classification.
2. Existing land-use.
3. Potential crop category.
4. Consumptive water use for that crop.

The Irrigation Suitability Land Classification methodology that was utilized was developed by the U.S. Bureau of Reclamation to identify and characterize lands suitable for sustained, profitable irrigation. Irrigation suitability land classification is an interpretative and predictive classification system which identifies and groups lands with similar irrigation potential on the basis of physical, chemical, and environmental characteristics. Soil (texture, coarse fragments and depth to restrictive layer), drainage, and slope gradient are among the most important factors considered.

The agricultural land-use classification system utilized was developed by the State of California Department of Water Resources (DWR) to identify existing agricultural land use. Much of the existing land use mapping was completed by interpretation of 1990 aerial photography with field checking in accessible areas. In some cases, current land use may have changed but not been detected. This land use information can then be utilized to estimate crop water use and irrigation water requirements for large areas. Agricultural, native vegetation, urban, recreational, and irrigation use symbols from this land use classification system were combined with the Bureau of Reclamation's Irrigation Suitability Land Classification rating, along with an indication of potential future crop uses (crop choice), and consumptive water use (the irrigation water demand of the crop) to form the informational symbol found on project maps. Crop water requirement was calculated based on methods presented in the State Water Resources Control Board Guidance Manual, *Irrigation with Reclaimed Municipal Wastewater* (Pettygrove, S. and T. Asano, 1984). This is further discussed in Section 6.0.

Mapping Symbol

The following is an example of the four-part mapping symbol which occurs within each polygon:

2(NV/P8) 15"

where:

2 = Irrigation land classification rating (ranges from 1, the highest, to 6, the lowest, non-irrigable).

NV = current land use symbol (see Section 4.2.3 for complete list).

P8 = potential or future crop choice symbol

15" = consumptive water use for future land use

The gross survey area for this classification was initially identified by the BPU and project team management. The study area boundary was then refined and finalized based on a Phase I Irrigation Feasibility Study completed by the project team in October, 1994. Study boundaries were approved by the BPU in November, 1994. Landowners and operators were contacted to obtain permission to enter private property to make the necessary field investigations. Some owners and operators refused to authorize entry. In these cases land classification and existing land use boundaries were photo interpreted without the opportunity for field verification. Checking and field verification of these areas was made by road-side observations, and extrapolations from nearby areas.

Additional soil drainage and wetland investigations may be needed for some parcels, particularly those to which access was denied, for confirming land class suitability and identifying wetlands. These investigations would be conducted as part of future planning/permitting and irrigation design studies as specific parcels are considered for inclusion within the reclamation system. Procedures for this are discussed in the *Irrigation Management Plan.*

4.2 LAND CLASSIFICATION SPECIFICATIONS

4.2.1 Irrigation Land Classification (Bureau of Reclamation)

Irrigation suitability land classification is based on the field appraisal of physical land characteristics and on the interpretation of laboratory results. The characteristics considered in irrigation suitability land classification are soils, topography, and drainage and the interrelationship of these with climatic conditions.

The classification numerical rating defines ranges for land characteristics that influence irrigation suitability and allows for the consistent grouping of lands with similar capacity to produce revenue to offset those project costs borne directly by the water user.

Land class specifications for this study are provided in Table 5. The classification assumes the use of sprinkler or drip irrigation. Arable Land Classes 1, 2, 3 and 4 are recognized. Class 5 lands were not mapped in the South County, although some very poorly drained or saline areas of Reyes soils, not inspected in this investigation, may be Class 5 lands. Such areas would be identified during the required irrigation design level planning inspections, as outlined in the IMP. Lands that are not considered arable are placed in Class 6.

Subclasses, deficiency modifiers, and degree of deficiency modifiers are included in the symbols. However, subclass symbols are only provided on the field copy maps. To simplify the mapping legend and its ease of use, only the overall land classes (1 through 6) are shown on the reproducible project maps.

4.2.2 Field Sheet Mapping Symbol

The following is an example of the complex mapping symbol placed on the field sheets:

$$\frac{2std\,(k_2 g_2 w_2)}{C21Y}$$

where:

Top Line Symbols:

2=	land class
s=	soils deficiency
t=	topography deficiency
d=	drainage deficiency

Bottom Line Symbols:

C=	land use
2=	productivity
1=	land development
Y=	substratum permeability

Deficiency Modifiers:

k_2=	shallow depth to coarse sand, gravel or cobble
g_2=	gradient
w_2=	subsurface drainage- water table

4.2.3 Agricultural Land-use (California Department of Water Resources)

The Department of Water Resources uses a breakdown of land use according to class symbol. More detail is obtained by adding the subclass number to the class symbol, or by use of a special condition symbol. The classification system is subdivided into agricultural crops, native rangeland and pasture, dairies and farmsteads, urban, and recreational classes. Land areas are also designated as irrigated or unirrigated (note: as used in this context, native rangeland means unimproved volunteer grasses, both introduced Mediterranean annuals and native grasses and forbs). Table 6 identifies the symbols of the land use classifications used in this report. These symbols are used to denote both the existing land use and where there are soil and slope limitations for future land use. In general, the highest, most intensive land use is shown for soils with few limitations. This is further discussed in Section 5.2.

Table 6 Department Of Water Resources Land Use Classification

{PRIVATE }Symbol	Definition	Symbol	Definition
D1	apple orchard	P1	alfalfa & alfalfa mixtures
D8	prune orchard	P4	native pasture
D13	walnut orchard	P8	improved pasture
F6	corn	S1	farmstead
G6	miscellaneous mixed hay and grain	S3	dairy
NR1	riparian - marsh	SR	suburban residential
NR3	riparian - trees & shrubs	T9	melons, squash, cucumbers
NR5	riparian - duck marsh	T18	miscellaneous truck crops
NV	native vegetation	U	urban
NV-P	park	U12	extractive industries
NW	water surface	UR	urban residential
		V	vineyard

4.3 METHODS

Bureau of Reclamation Series 510 Techniques and Standards were followed in completing this investigation. The Bureau's land mapping symbols and the DWR land use legends were combined with a future crop symbol and the future consumptive water use to produce the mapping legend.

The gross survey boundary was determined by considering previous irrigation feasibility studies, by locating 15 percent slope breaks on 7.5 minute USGS topographic maps, and aerial photography.

USGS topographic maps were enlarged to 1:12,000 scale and were used for field work along with 1985 1:12,000 aerial photography. The Bureau of Reclamation symbols, soil symbols, and investigation/observation sites were marked on these sheets. Land use polygon areas were drawn on 1:12,000 scale lot line topographic maps obtained from the Sonoma County Planning Department, by interpretation of the aerial photography and by field observations. The final composite mapping symbol was then placed inside these polygons.

Well over 150 soil borings and observations were completed and described during the field investigation. These were undertaken to verify soil characteristics in the study area. Soil borings were conducted using a tile spade and hand auger to depths of 40 to 60 inches (or deeper) or refusal due to bedrock or subsurface restrictive layer. Groundwater observations and depth to mottling/gleyed soil were also noted during the field investigations. Hand auger borings permitted observation of soil and shallow water table conditions from 40 to 60 inches deep or to bedrock or seasonal groundwater. The existing agricultural land use symbol was also plotted on the photo or field map at the time of the field investigations.

Arable and non-arable lands with observed wetland characteristics were identified in a reconnaissance fashion according to procedures prescribed in the 1987 U.S. Army Corps of Engineers Wetlands Delineation Manual. The U.S. Fish and Wildlife Service National Wetlands Inventory Maps, the NRCS hydric soils list, and the soil survey for Sonoma and Marin Counties were consulted. Candidate wetlands were also delineated by viewing aerial photos. The preliminary map of potential wetlands was then field verified by a separate wetlands survey team. This information is contained in a separate technical memorandum on wetlands prepared by Parsons Engineering Science. (Parsons Engineering Science, *Proposed Agricultural Irrigation Areas Wetland Determination for the City of Santa Rosa Subregional Long-term Wastewater Project*, May 1996).

4.4 RESULTS OF THE LAND CLASSIFICATION

The land classification maps are included as separate plates to this report. A summary of the results of the land classification is provided in Table 7.

Principal subclasses are described in the following paragraphs. In some cases, the listing of subclasses may appear redundant because, for brevity, deficiency modifiers have been omitted from this general description.

Class 1

These lands are the best suited for irrigation and have no limitations for crop choice. The soils are deep; medium textures are the most common. Topographic, soil, and drainage limitation are not present, although a few oxidation mottles indicative of high seasonal groundwater may be observed in the subsoil. Class 1 lands occur primarily on stream terraces and alluvial fans. Goldridge and Pleasanton clay loam soils are mapped in these positions. Inclusions of lands with observed wetlands characteristics occur infrequently in Class 1 delineations.

Class 2

These are lands with minor soil, drainage, and/or topographic deficiencies. Limitations on these lands are slight and include infiltration, fine textured clays, and slope gradient. There are few restrictions to crop choice, although some additional management may be required. Soils are deep and the textures range from fine to medium. The most common soils are clays and clay loams. Clear Lake clay, Haire, Raynor, Spreckels, Goldridge, Cotati, and Sebastapol soils are in Class 2. These lands occupy terraces, alluvial fan surfaces and gently sloping foothill lands. The slopes are smooth and gently sloping. Inclusions of lands with observed wetlands characteristics occur occasionally and are usually localized as springs, wet spots and low areas and along stream corridors.

Class 3

These lands have soil, topographic and/or drainage deficiencies that may reduce crop yields and require additional management. Limitations on these lands are moderate and include infiltration, ponding, fine textured clays, slope gradient, moderate depth to coarse sand, gravel, or cobble, subsurface drainage, moderate depth to impermeable or root restricting bedrock or substrata, very coarse texture, and irrigation pattern difficulties. Depending on the limitation and the crop, conditions may constrain some crop choices. The soils range from moderately deep to deep and the textures range from fine to coarse. The most common soils are clays, clay loams, and sandy/gravely loams. Haire, Diablo, Raynor, Cotati, Alluvial land sandy, Goulding, Clear Lake Clay ponded, Blucher and Goulding soils are in this class. Alluvial lands (sandy) and Clear Lake Clay-ponded soils appear along stream bottoms and on alluvial fans. The remaining soils are found on older upland terraces and hilly terrain. The slopes range from gently sloping alluvial fans and stream beds to slopes up to eight percent. Wetland characteristics may be found along streams and in ponded or low lying areas.

Class 4

Lands in this class have soil, topographic and drainage deficiencies that will reduce crop yields and crop choice if not improved or managed correctly. Most are primarily suited for forage production and irrigated pasture. In addition, they typically have moderate to high soil erosion hazards which will require management considerations. Limitations on these lands are moderate to severe and include shallow depth to coarse sand, gravel, or cobble, shallow depth to impermeable or root restricting bedrock, slope gradient, subsurface drainage, very fine texture, infiltration, and irrigation pattern deficiencies. The soils range from moderately deep to deep, and the textures are clays and silty clays. Diablo and higher lying, better drained Reyes soils are the principal soils mapped. Diablo soils are found on terraces and rolling uplands. Slopes are from 10 to 20 percent. Reyes soils are found in low-lying areas of reclaimed tidal marsh along the Petaluma River. Wetland characteristics are generally found along stream courses and in ponded areas of Reyes soils.

Class 6

These are lands that do not meet the minimum requirements for irrigation as defined in the land classification specifications. Included are slopes that are steeper than 15 percent; soils shallower than 30 inches to bedrock or to other slowly permeable material or restrictive layer; extremely wet areas; and lands that have combinations of soil, topographic, and drainage deficiencies that, in the aggregate, are not correctable. Lands with observed wetlands characteristics commonly occur in these subclasses on flatter slopes, and along drainage areas. An approximately 100-foot stream setback zone or buffer strip is also shown on the land classification maps, as described in the *Irrigation Management Plan*. These areas are labeled as 6NW (native wetlands). The need and specifications for buffer width will be determined on a farm level, case-by-case basis during irrigation suitability design. Urban areas, water bodies, farmsteads and other miscellaneous land uses are also shown on maps as non-irrigable.

5.0 EXISTING AND POTENTIAL AGRICULTURAL LAND USE

5.1 CURRENT LAND USE

Currently, most of the South County project areas are not intensively farmed. Irrigated cropland accounts for less than five percent of the total project acreage. The South County areas are predominantly used as hay lands and pasture lands for beef cattle and sheep grazing with a few dairies.

Dry-farmed oat hay, either bailed and stored in hay barns or put-up as silage in plastic silage bags or bunkers, is the most extensive land use. Oat hay production accounts for approximately 3,000 acres, or about 19 percent of the land use in the South County study area.

In addition to the oat hay lands, there is an extensive acreage in native (unimproved) range land and pasture grazed by beef cattle, sheep and dairy animals.[3] There are approximately 7,900 acres of pasture or rangeland or 48 percent of the South County project area (exclusive of Sebastapol). Native rangeland and pasture can be found along Lakeville Highway, Adobe Road, East of Rohnert Park along Petaluma Hill Road, North Petaluma Valley along Rainsville Road, and small parcels in the Sebastapol area. Also along Lakeville Highway there are several large horse ranches and equestrian centers with non-irrigated pastures.

Due to good soil conditions and favorable climate in the South County, truck and specialty fruit and vegetable crops, orchards and vineyards are grown. Even so, the acreage is relatively small; less than 600 acres in truck (vegetables, melons, etc.) and specialty crops and about 2,200 acres in orchards and vineyards (including the Sebastapol area). The favorable climatic conditions in the South County potentially allow for a much wider range of crops to be grown with a dependable irrigation water supply of suitable quality. Much of the South County project area, particularly in the Rohnert Park-Penngrove areas, is underlain by an extensive, deep groundwater aquifer. High capital costs have apparently prevented extensive construction of the deep production wells necessary for developing this as an irrigation water source.

Although most dairies and livestock operations have developed small, on-farm water storage reservoirs which divert and store winter and spring runoff, the water is primarily utilized for the management of animal wastes in dairy and feeding enclosures. The wastewater from dairy maintenance operations may be used to irrigate small pastures in the vicinity of the dairy operations, but the forage produced is largely insignificant to the dairy's feed needs. There is currently less than 200 acres of irrigated pasture{PRIVATE } in the South County area.

3 "Native rangeland" is an imprecise agricultural term for unimproved grazing areas. Vegetation consists of both introduced annual grasses and forbs with some areas of native plant grasslands. It is not to be confused with "native grasslands," which are predominantly native, non-introduced grasses. Pastures consist of small fenced off grazing areas. "Native pastures" are similar to native rangeland, with a mix of introduced and native species. In addition, pastures an be "improved" by removing trees and brush and/or seeding to more desireable forage plant species. Improved pastures can be either "non-irrigated" or "irrigated."

5.1.1 Oat Hay, Silage Production and Grazing

Nearly all of the oat hay and silage grown in the South County project area is used directly on the farms by ranchers and dairy operators; only a small percentage of the crop is sold locally.

The two dairies within the South County project area are located along Lakeville Highway. (Several other dairies are located just outside of the immediate South County irrigation study area, mainly along Adobe Road and Lakeville Highway.) Oat hay production supports this industry.

However, despite the large oat hay production and extensive acreage of unimproved rangeland, most livestock and dairies are heavily dependent on imported feeds, since a dairy cow must be fed high protein feeds (such as alfalfa and grain) to insure continued good milk production. Approximately 60 to 70 percent of the required feed is purchased by a typical South County dairy. Beef and sheep livestock operations are much more self-sufficient, producing an estimated 50 to 60 percent or more of their feed requirements.

In addition to oat hay, a small acreage of dry-farmed sudan grass or field corn is occasionally grown for green chop or silage. Acreages of these crops typically total less than 200 per year throughout the South County study area.

The necessity to purchase large quantities of supplemental feeds from growers in the Central Valley is a reflection of the inability of most ranchers under current dry-farmed agriculture to produce the kind of high quality feeds necessary for lactating cows and for putting weight on beef cattle, particularly during the summer and fall months when the range grasses are dried and not as nutritious, and the stored dried oat hay or silage cannot meet the protein needs of the animals.

Oat hay may be seeded and harvested on slopes up to 20 percent, but is most commonly grown on slopes less than 10 percent. Both annually seeded oat-vetch and oat-rye grass mixes may be mowed and harvested. The steeper lands may only be grazed, and not mowed, particularly following drier than normal winters.

The oat-hay lands are most often cultivated and seeded in the fall, relying on early winter rains to germinate and establish the crop. Some spring planting is also practiced on wetter valley bottom lands. The hay is then cut and cured in the spring, and the bailed oat hay or silage is used to feed the dairy, beef cattle or sheep livestock during the remainder of the year. As defined in the Sonoma County Soil Survey, typical oat hay yields range from over three tons per acre (dry weight basis) on better lands in the wet years, to less than two tons per acre on poorer lands in dry years.

The oat-hay stubble may also be grazed by cattle and sheep in the early summer, in addition to grazing the unmowed native grass pastures. Most native rangeland areas are not intensively managed by rotation systems through cross-fenced pastures, but the cattle are allowed to graze throughout large field enclosures. On well managed lands, the dryland native grasslands typically support up to four animal unit months (AUM) per acre, with poorer lands supporting about 2.7 AUM. An animal unit month is the amount of forage or feed required to maintain one animal unit (one cow, or two sheep) for a period of 30 days.

Most of the more gently sloping land (up to 10-percent slopes) currently utilized for dry-farmed oat hay can be converted to summer irrigated hay and silage, potentially allowing double cropping on some lands. Two summer cuttings of hay and silage are common on the irrigated lands. Yield increases of two to four times current dry-farmed yields can be expected from irrigation of these lands. Irrigated sudan grass and field corn also can potentially be grown throughout most of the South County area.

Some of the gently sloping lands and steeper native pasture areas (up to 15-percent slopes) can be converted to permanent irrigated pasture. The carrying capacity of well managed permanent irrigated pasture is expected to be in the range of 10 to 12 AUM's per acre.

5.1.2 Orchards and Vineyards

Orchards and vineyards are located on the flat valley bottoms and slopes up to 30 percent in the South County-Sebastapol area. Extensive apple orchards and vineyards (approximately 1300 and 900 acres, respectively) can be found in the Sebastapol area, with a few small walnut and one small declining prune orchard located east of Rohnert Park. Several hundred acres of drip irrigated vineyards are grown along Lakeville Highway in the southern portion of the project area.

In the early part of this century, apple orchards and vineyards in Sonoma County were largely dry farmed. In recent years, most vineyards have been converted to drip irrigation. The largest area of vineyards is approximately 400 acres on both sides of Frei Road. Typically, grape yields are 15 tons per acre on better lands to a low of three to five tons per acre on poorer lands. For the most part, apple orchards have remained unirrigated. Most of the apple orchards and vineyards are on smaller parcels of less than 40 acres. Apple yields range from about 30 tons per acre on better lands to a low of 20 tons per acre on poorer lands in a typical year. Orchard yields can be increased in most cases by application of irrigation water or by replanting with new dwarf varieties.

Much of the oat hay land in the South County-Sebastapol area is potentially suited to drip irrigated vineyards, but local microclimates, clayey soils and market conditions must also be considered. Other than the immediate Sebastapol area, soil conditions (poorly drained, clayey soils) are not as well suited for orchards in many other South County areas.

5.1.3 Fruit and Vegetable Crops

Truck crops (fruit and vegetable crops) grown in small quantities in the South County-Sebastapol project areas include potatoes, lettuce, carrots, tomatoes, melons, strawberries, squash, corn, pumpkins, and other row crops.

Currently, the majority of truck crops in the South County are grown in the Tolay Valley and immediately east of Rohnert Park along Petaluma Hill Road. A variety of crops are produced on about 100 acres in Tolay Valley, including pumpkins, corn, and safflower. The flat valley floor and deep soils of this area have the potential, with additional irrigation water, to allow a wider variety of crops to be grown. Much of the South County area consists of very clayey, adobe soils; cultivation at the right moisture content, as well as management for tilth, proper moisture and aeration is very important.

The lands immediately to the east of Sonoma State University and north of Penngrove are relatively flat and the soils are of a good quality. Along Petaluma Hill Road crane melons, strawberries, lettuce, beans, peppers and pumpkins are grown for the local fresh markets and organic fruit and vegetable stands. About 200 acres are in truck and row crop production in this area. Approximately 5,700 acres of flat valley bottom land and gentle side slopes are suited for irrigated fruit and vegetable crops in the South County areas. Some of the gently sloping lands may require drip or micro-irrigation water applications.

More than three thousand additional acres of gently to moderately sloping lands (up to 10 percent) are potentially suited to such drip or micro-irrigated specialty crops as cut flowers, boysenberries, strawberries, and artichokes in the South County-Sebastapol project areas. However, soil erosion is a significant concern with conversion to these crops. This issue is addressed further in the *Soil Erosion Evaluation Technical Report,* Questa Engineering Corp., September, 1995 and the *Irrigation Management Plan*.

5.2 POTENTIAL CROPS[4]

A wide variety of crops including fruit and vegetable crops, vineyards, orchards and forage and pasture potentially can be grown with irrigation water in the South County-Sebastapol area. No restrictions on crop choice are imposed by the state on use of reclaimed water for this level of treatment and quality (California Administrative Code, Title 22). From an agricultural perspective, the water is also of high quality with no restrictions on land-use (see *Irrigation Water Quality and Salt Management Leaching Requirement*, Questa Engineering Corp., November, 1995). Constraints on the selection of crops (crop choice) are imposed by soil, slope, drainage and, to a lesser extent, micro-climatic conditions. Successful sustained production means that the planted crops have a favorable yield and return on investment at least four years out of five (80 percent) and can be grown over a prolonged period of time without damaging the soil resource due to soil erosion, significant loss of fertility, water table build-up, or salt or metals accumulations. Occasional diminished harvests or crop failure can occur due to unfavorable weather conditions, such as late frosts, high winds, or late spring and summer rains. These can be particularly damaging to hay crops.

In the South County-Sebastapol area, there is a good correlation between soil limitations, soil erosion hazard and slope class. *The Soil Erosion Technical Memorandum* (Questa Engineering, September 1995) describes the existing and potential erosion problems resulting from cultivation and irrigation of sloping lands; it also demonstrates the benefits of implementing conservation measures. Generally the deeper soils with few soil limitations are found on the younger alluvial fans and floodplain deposits with slopes less than six percent. The soils that occur on land areas with slopes from six to ten percent typically are on older fans and terraces and have some subsurface restrictions to water movement. The soils that occur on lands with slopes over ten percent are typically upland soils with moderate depths (30 to 40 inches) to restrictive layers; these areas have the highest soil erosion hazard if the cultivated, barren soils are exposed to fall and winter rains.

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4 This section on potential crops was developed based on information provided in a letter/report by Vern Marble, PhD, Agronomist.

This relationship between soil limitation and slope provides an easy and convenient way to outline restrictions the City could place on delivery of reclaimed irrigation water to avoid development of drainage, erosion, and irrigation water quality problems. These possible restrictions are discussed more completely in the *Irrigation Management Plan* (IMP).

This is a general classification system for use in planning large land areas. The concept of slope limitations is readily understood and slope is easily determined in the field and from topographic maps and soil surveys. More detailed, site specific information collected at the time of individual irrigation system designs will override the suggested restrictions shown on the land classification maps. For the restricted cultivation category, a conservation plan should be developed to demonstrate how the restricted agricultural land area can be placed in cultivation and still avoid soil erosion and water quality impacts.

In the South County-Sebastapol area, slope and occasionally poor drainage or winter ponding provide the greatest limitations on crop choice. Although fruit and vegetable crops potentially can be grown on slopes up to 25 percent (e.g., with drip irrigation), the City may impose restrictions on the use of reclaimed water because of potential concerns over soil erosion and water quality impacts. Soil erosion problems were assessed in *Soil Erosion Evaluation of West and South County Reclamation Alternatives*, Questa Engineering Corp., September, 1995. Crop restrictions are also imposed on certain poorly drained lands (Baylands) to insure that extensive drainage projects are not constructed that could affect water quality. The limitations and restrictions are discussed more fully in the *Irrigation Management Plan*, Questa Engineering Corp., October, 1995.

Potential crops suitable for the South County-Sebastapol area (considering climate and soils) were identified in a consultant's letter/report to Questa Engineering Corporation prepared by Vern Marble, PhD, Emeritus Professor of Agronomy at U.C. Davis.

Based on the irrigation land classification mapping and the limitations and constraints imposed by soil, drainage and slope conditions, potential irrigated crop categories were identified for each land area and slope. These are based on the concept that those crops with the greatest economic return would be grown, and with the understanding that the fruit and vegetable crops would have a higher return on investment than forage crops, and irrigated pasture would have the lowest return.

Although the City can impose some restrictions on which general types of crops can be grown on sloping lands, the City cannot dictate which crops must be grown on private lands. This is the decision of the farmer/rancher. A technical memorandum on cropping scenarios was prepared by Questa Engineering Corp. (July, 1995) which outlines a variety of levels for farming intensity from "Low Tech" (most of the area used as pasture and forage lands) to "High Tech" (most suitable areas planted to vineyards, orchards or fruit and vegetable crops). This report provides an acreage basis for the evaluation of the economic and environmental impacts of conversion of dry-farmed haylands and pasture land to irrigated crop land.

Six groupings of potential crop types were utilized in this study. Because most of the Sebastapol area is currently planted to vineyards and orchards, separate symbols reflect existing land-use and likely consumptive water use patterns and were assigned to that area. The symbols used for the South County and Sebastapol areas and their explanations are as follows:

1. UC – Unrestricted Cultivated Crops.

Typically this designation was used for Class 1 and 2 soils, as well as for Class 3 soils on slopes of less than five percent. No restrictions would be imposed by the City on crop choice within these areas, and there are few inherent soil or drainage conditions which would limit crop choice. These areas are well suited for a wide variety of cultivated fruit and vegetable crops and horticultural crops. The average consumptive water use for this category of crops was determined to be 17 to 18 inches per year, although consumptive water use may vary widely according to the specific crop and irrigation practice. For instance, drip or micro-irrigation of crops uses about 60 to 65 percent as much water as that applied by sprinkler or surface applications.

2. RC – Restricted Cultivated Crops

This designation was used for lands with slopes of six to ten percent, and where there were significant soil constraints such as wetness or moderate depth to semi-permeable layers (Class 3 or 4 lands). The City may place some restrictions on growing cultivated crops on more sloping lands with significant erosion hazards because of concerns with soil erosion or development of drainage problems due to shallow barriers to water movement. Areas of Reyes soils were also given this designation because of the desire to preclude installation of extensive drainage measures and heavy use of soil amendments, which would be necessary to grow many cultivated crops other than forage or pasture. Horticultural crops can possibly be grown in many areas with drip or sprinkler irrigation, provided a perennial or winter cover crop is established. Generally, irrigated hay or forage crops (field corn, sudan grass) or permanent irrigated pasture can be easily established. The average consumptive water use for this category was determined to be 22 inches for the North Petaluma valley, Baylands and Lakeville Highway areas, and 23 inches for the Rohnert Park and Adobe Road areas. The average considers that some of the area would be vegetable crops with lower water requirements (17 to 19 inches) and some forage crops and pasture with higher water use requirements (23 to 28 inches). Baylands areas are also shown on the maps as having an irrigation water demand of 22 inches because of the shorter irrigation period from spring wet soil conditions. Other areas of irrigated pasture and forage crops have estimated annual consumptive water use rates ranging from 28 to 34 inches.

3. P8 – Irrigated Improved Pasture

Some lands were judged best suited for the establishment of permanent irrigated improved pasture because of steep slopes (10 to 15 percent) or significant soil and drainage constraints. Most of these lands were in Class 4 with the current land use predominantly non-irrigated pasture or native rangeland. An annual consumptive water use of 29 inches was estimated for these areas. This is similar to the water use requirements of the irrigated pasture lands of the Novato Sanitary District.

4. UTDV – Unrestricted Cultivated Crops

This symbol was used in the Sebastapol area to denote lands that were currently in fruit and vegetable production and the large acreage of orchards and vineyards. They consist of some Class 1 lands, primarily Class 2 and a few areas of Class 3 lands with slopes of less than five percent. These lands are well suited to a wide variety of fruit and vegetable and horticultural crops. For purposes of estimating consumptive water use, it was assumed that most areas in orchards would remain in fruit production with sprinkler irrigation, although some orchard lands would be converted to more productive new dwarf varieties. The average annual consumptive water use for orchard areas was estimated to be 26 inches (under tree-sprinkler irrigated) and about seven inches for vineyards (drip irrigated).

5. RTDV – Restricted Cultivated Crops

This symbol was also used for existing non-irrigated orchards and some vineyards in the Sebastapol area. Slopes are 6 to 15 percent, with some areas having slopes up to 20 percent. These are predominantly Class 3 lands, with a few areas of Class 4. It is assumed that these lands would remain in similar horticultural crops. The present concept and recommendation is that the City would provide winter irrigation water to these lands if erosion control measures, such as the establishment of cover crops, were implemented. This is further addressed in the IMP. The average consumptive water use for this area was estimated to be 26 inches. Drip irrigated horticultural crops may have water demands of 50 to 60 percent of sprinkler irrigation.

6. G6-P8 – Irrigated Pasture and Haylands

This designation was also used for sloping lands not currently in vineyards or orchards in the Sebastapol area. Only a few acres of this category were denoted. They consist of Class 3 or 4 lands currently in pasture and with moderate to high soil erosion hazards. These lands are well suited to irrigated pasture and forage crops. Orchards and vineyards can be established on these lands (in coordination with the City), provided that a conservation plan is developed and implemented. An average annual consumptive water use of 25 inches was estimated for these areas, reflective of a mix of hay and pasture crops.

The following sections describe the general kinds of crops which can typically be grown within each category.

5.2.1 Specific Crops Suitable for Flatlands (Unrestricted), With Slopes of 0-5 Percent

The flatter valley bottom soils of the project area have the potential for the production of most of the crops adapted to and currently grown in Sonoma County. Drainage problems in some areas will restrict crop selection to cultivated forages and irrigated pastures. Some of the better drained soils can produce high value crops, including selected varieties of alfalfa, forages, and most fruits and vegetables.

Agronomic crops that may be grown include cultivated oats, oat-vetch hay and silage, improved irrigated pasture containing components selected for the degree of wetness in the winter, such as perennial ryegrass, white clover, narrow leaf trefoil, fescue, strawberry clover; red clover, sudan grass, forage formulas, corn silage, and alfalfa for green chop, silage, grazing and hay (only on well-drained soils).

Vegetable crops that may be grown include tomatoes, lettuce, squash (summer, winter), melons (ambrosia, crane, watermelon), pumpkins, sweet corn and specialty corns, peas, broccoli, cauliflower, artichoke, fresh beans, and potatoes.

Horticultural crops that may be grown include apples, prunes, Bartlett pears, walnuts, Christmas trees, and grapes. Specialty crops include herbs (basil, dill, parsley, etc.), Kiwi, bushberries, blueberries and nursery ornamentals, bedding plants, cut flowers, etc., and Asian vegetables.

5.2.2 Crops Suitable For Slopes of 6-10 Percent (Restricted)

Some restrictions on crop choice are recommended for these lands. Erosion potential from cultivated land in the winter during the rainy season is high, and only in a few instances should winter cultivation be attempted. Therefore, the choice of crops, and crop sequence, should be designed to provide a crop cover during the winter rainy season for maximum reduction of erosion. Crops planted in the fall should be those that can establish a complete crop canopy, under irrigation, by early November. Summer crops must be able to be planted in mid to late May-early June, after the rainy season, and be harvested by late September or early October. Some summer vegetables could fit these requirements.

Agronomic crops that may be grown include irrigated, natural and improved permanent pastures; irrigated winter annual oat or oat mixtures, or irrigated annual or perennial ryegrass-legume pastures, silage, hay or green chop, followed by irrigated summer sudan or corn silage or green chop; and irrigated winter forages followed by rapid maturing summer vegetables such as lettuce, summer squash, sweet corn, potatoes, and broccoli.

Horticultural crops that may be grown (preferably with a winter cover crop), include grapes, and orchard crops such as apples, pears, and prunes. Local soil drainage problems should be assessed prior to planting these crops.

5.2.3 Crops Suitable for Slopes of 11-15 Percent

In general, lands with slopes over 10 percent have only a few alternatives to permanent irrigated pasture, because of concerns over soil erosion. Intensively cultivated crops are not recommended to be grown on these lands. These lands should only have crops that are either perennial and provide a permanent cover, or: 1) can be established in existing pastures using no-till procedures that do not eliminate the established plant cover; or 2) that can establish a plant cover by October 15, including annual forage crops. This may necessitate the use of sprinkler irrigation to germinate and establish annual crops.

Agronomic crops that may be grown include irrigated pastures, improved and native, and annual irrigated grass/legume forage crops. Horticultural crops that may be grown (with a permanent cover crop) include vineyards, and orchards (apples, pears, and prunes).

6.0 WATER USE AND WATER MANAGEMENT

6.1 CROP WATER REQUIREMENT

Crop water requirement, or consumptive water use, is defined as the depth of water required to meet the evapotranspiration rate of the crop (Etcrop) when soil water is not a limiting factor to plant growth and productivity.

The crop water requirement was determined for a variety of crops that potentially could be grown in several areas of the South County, as previously identified in this report.

The State Water Resources Control Board Report Number 84-1, *Irrigation with Reclaimed Municipal Wastewater, A Guidance Manual* (Pettygrove and Asano, 1984), was used as the basis for developing consumptive water use estimates for the project. The guidance manual offers three alternative approaches in determining normal year reference evapotranspiration (Eto): 1) the pan evaporation method; 2) area potential evapotranspiration (PET) method; and, 3) isoline map method. According to the guidance manual, the isoline map method offers the greatest accuracy in determining Eto and was the method selected for database development. Reference evapotranspiration (ET) isoline maps (by day and month) were used to develop daily reference documentation for crop coefficients. This was supplemented by other data on crop coefficients available from the California Department of Water Resources and U.C. Extension.

Average rainfall data developed by the U.C. Cooperative Extension, *Climate for Various Location in Sonoma, Napa, Mendocino, Lake and Marin Counties, California*, compiled December 1993, were used as the source of rainfall data for each of the geographic study areas. Where rainfall data were unavailable for any study area, the closest station to the study area that had rainfall data, as shown in the U.C. Extension publication for Sonoma County, was used. Table 9 summarizes, by geographic area, average reference evapotranspiration, rainfall data and net evapotranspiration. As indicated, evaporative demand throughout the South County is similar, averaging approximately 29 inches per year.

Average consumptive water use by crop was determined by taking monthly Eto data by area and adjusting them for rainfall to develop net monthly evapotranspiration. Crop coefficients (see Table 10) for typical growing season conditions were then adjusted against net monthly Etos (by area) to develop monthly and annual consumptive water use data. Total consumptive water use for each area and a representative cross section of potential crops are summarized in Table 11. This assumes an irrigation season extending from early April through September. A weighted average taking into account probable irrigated acreages, crop type and soil conditions was then developed. Based on this, 27.5 to 28 inches of annual consumptive water use is estimated for the South County study area.

Table 11 Annual Crop Water Uses

{PRIVATE }CROP	NORTH PETALUMA VALLEY	EAST OF ROHNERT PARK	LAKEVILLE	SONOMA VALLEY	SEBASTAPOL
Alfalfa	34.6"	27.8"	34.6"	29.6"	25.3"
Improved Pasture	29.3"	28.6"	29.3"	30.3"	25.3"
Vineyards	7.1"	7.2"	7.1"	7.8"	6.4"
Field Corn	20"	20.1"	20"	21.2"	18.9"
Apples	26.2"	25.7"	26.2"	27.2"	23"
Sudan Grass	22.4"	22.7"	22.4"	23.7"	20.1"
Tomatoes	19.8"	20"	19.8"	21.0"	18.0"

6.2 IRRIGATION EFFICIENCY AND FARM DELIVERY REQUIREMENT

Farm delivery requirement (FDR), or irrigation requirement, is the crop water requirement adjusted for irrigation system efficiency (SE), or:

RDR = Etcrop/SE

Based on a sprinkler irrigation system efficiency of 80 percent (as outlined in the Irrigation Management Plan) and an average crop consumptive water use of 27.5 to 28 inches per acre per year, the study area RDR is approximately 33 to 33.5 inches per acre per year, or about 2.9-acre feet per acre per year. Losses within the delivery system are not included in this figure, only irrigation system inefficiencies such as deep percolation, evaporation, runoff and wind drift that occur after water leaves the sprinkler head.

6.3 IRRIGATION MANAGEMENT

The proper use and management of applied irrigation water to avoid runoff and subsurface flows is critical to the success of the irrigation project and to avoiding adverse wetland and water quality impacts. 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. A high level of control can 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 will be overseen by the City’s reclamation staff. High efficiency irrigation management techniques are recommended for the South County-Sebastapol area. This subject area is discussed in more detail in the *Irrigation Management Plan*.

6.4 Water Quality and Salt Management Leaching Requirements

The quality of the reclaimed water for agricultural irrigation purposes is high, as summarized in Table 12. A separate Technical Memorandum discusses water quality in more detail (see Irrigation Water Quality and Salt Management Leaching Requirements, Questa Engineering Corporation, January, 1996). The analysis in this report concludes that additional irrigation water applications for leaching and salt management are not required because of the high quality (low total dissolved solids) of the water and the natural leaching provided by winter rains in this region.

6.5 Drainage Management

Farm drainage systems are not well developed throughout the South County area in part due to the small amount of irrigation acreage. Farm drainage systems are more abundant and important in areas relying on surface or furrow irrigation to handle irrigation tail water. Drainage systems are less important on sloping lands with well managed sprinkler irrigation systems because runoff is reduced and typically can be accommodated within the natural drainage systems of the landscape. However, many of the natural drainage systems (creek channels) have been modified by localized straightening, deepening and vegetation removal. In many areas this has resulted in streambank stability problems.

A more complex drainage system has been constructed in the Baylands areas, where drainage ditches remove surface runoff water during the winter and spring months and lower the groundwater table during the summer months. The drainage water from rectangular field ditches is typically collected in a master drainage ditch paralleling the Petaluma River levee, from which it is then pumped to the river.

A number of factors must be considered in determining the need for drainage improvements for the South County project area. These include depth of any soil zones restrictive to water movement, depth to existing or seasonal water table, water quality, soil permeability, soil infiltration rate, irrigation method and schedule, and the estimated quantity of deep percolation. Drainage requirements must then be balanced against possible hydrologic/water quality impacts.

Groundwater recharge under high rates of sprinkler irrigation follows a transient, or non-steady, flow condition. The water table may raise slightly in some areas during the irrigation season when any excess irrigation water passes below the crop root zone. The water table then recedes at the conclusion of the irrigation season in the fall and rises again with the onset of the winter rains. With good irrigation management this effect can be minimized. In general, large-scale drainage improvements, such as the installation of subsurface tile drain systems or construction of new surface ditches, will not be needed for the South County project area.

There are isolated, small pockets of Clear Lake soils and larger acreages of Reyes soils that may require local drainage and careful irrigation water application so that the root zone can be managed to avoid excessive moisture. Reyes soils along Lakeville Highway have some existing surface drainage improvements. As outlined in the Irrigation Management Plan, additional large-scale drainage structures generally will not be required. Other than small, localized drainage improvements, a drainage management system which relies on good water management, selection of drainage tolerant crops, and occasional summer fallowing, where water level monitoring and field observations indicate rising groundwater tables, is recommended in the Irrigation Management Plan. Existing drainage features will need to be monitored and maintained, and perhaps improved in some areas.

6.6 TRACE METALS LOADING

A separate Technical Memorandum discusses the potential build-up of toxic levels of trace metals in the soil from metals contained in applied irrigation water (see *Trace Metals Loading Analysis*, Questa Engineering Corporation, March 1996). The report concludes that there is no danger of toxic metal build-up in the soil from long-term applications of irrigation water throughout the life of the project (100+ years), because of the high quality (low metals content) of the reclaimed water.

7.0 SPECIAL CONSIDERATIONS AND RECOMMENDATIONS

1. Evaluations regarding drainage requirements assume a high degree of irrigation efficiency (80 percent) and farm management. Such high levels of efficiency can only be achieved with a carefully managed, coordinated sprinkler system. If careful water management is not practiced, water logging of the soils during the growing season, excessive runoff and deep percolation, and accelerated soil erosion may occur. These may result in water quality and biological impacts.

2. Irrigation should be scheduled using a soil moisture depletion inventory method. This may require continual soil moisture and climatic monitoring throughout the growing season. The services of a professional irrigation management service or staff irrigation specialist should be considered in this regard.

3. Even careful irrigation of some marginal lands may result in the development of drainage problems in bottom lands, and increased erosion and mass movement on steeper slopes. Extensive areas of soils with barriers to water movement less than 30 inches deep or on steeper slopes should not be irrigated. Small incidental acreages with these soil conditions could be included in an irrigation system layout as a practical matter so as not to overly dissect field boundaries.

4. Delineations of land classification map unit boundaries and composition, and representations regarding subsurface conditions, especially with respect to soil depth to barrier, are approximate. Unnamed inclusions of soils with more limiting properties occur in map units because of the complexity of natural systems and the assumptions that must be made in land classification mapping. Examples of these inclusions are shallower soils, wetter soils, and differences in slope relative to representations made on the land classification maps. For these reasons, the agricultural productivity of small areas within arable delineations may be diminished as a result of irrigation. Additional field investigations at the time of irrigation system design are warranted in complex soil areas and where field access was not allowed.

5. All significant wetlands and streams in the survey area should be avoided in the irrigation system layout. Stream and wetland buffers, riparian restoration and streambank stabilization measures should be considered in the irrigation design of farms and ranches. This issue is addressed further in the IMP and the *Wetlands Determination - Agricultural Areas Technical Memorandum* prepared by Parsons Engineering Science (May 1996).

GENERAL INSTRUCTIONS

SYMBOLS USED FOR THE IRRIGATION SUITABILITY LAND CLASSIFICATION MAPS CLASSIFY AND DESCRIBE DEFINED PARCELS FOR AGRICULTURAL IRRIGATION. EACH SYMBOL MAY BE PARSED INTO FOUR COMPONENTS DELIMITED BY A SLASH MARK (/). THE FOUR COMPONENTS ARE:

1) CURRENT LAND USE CLASSIFICATION – THIS PARAMETER DEFINES THE SUITABILITY OF THE INDICATED AREA FOR IRRIGATION. THERE ARE SEVEN SUITABILITY CLASSES; 1 IS THE MOST SUITABLE AND 5 IS THE LEAST SUITABLE. 0 AND 6 REPRESENT WATER COURSES THAT ARE NOT SUITABLE FOR IRRIGATION (0=PONDS; 6=RIPARIAN). SUITABILITY IS AFFECTED IN PART BY SLOPE AND COMPOSITION OF THE SOIL.

2) CURRENT LAND USE – THIS PARAMETER DEFINES THE LAND USE PRESENTLY OBSERVED FOR THE INDICATED AREA. ABBREVIATIONS FOR THIS PARAMETER ARE ADOPTED FROM THE CALIFORNIA DEPARTMENT OF WATER RESOURCES (DWR) STANDARD LAND USE LEGEND. AN EXISTING LAND USE LEGEND FOR THE SOUTH AND WEST COUNTY IS PROVIDED ON THIS SHEET.

3) POTENTIAL CROPS – THIS PARAMETER DEFINES THE HIGHEST AGRICULTURAL LAND USE POSSIBLE FOR THE INDICATED AREA. POTENTIAL CROP RESTRICTIONS ARE IMPOSED ON PROJECT LANDS, BASED ON SOILS AND SLOPES. THESE ARE DESCRIBED IN THE IRRIGATION MANAGEMENT PLAN. SYMBOLS AND EXPLANATIONS ARE PROVIDED ON THIS SHEET UNDER "POTENTIAL CROP LEGEND."

4) CONSUMPTIVE WATER USE – THE AMOUNT OF WATER, IN INCHES PER ACRE, ESTIMATED FOR APPLICATION TO THE INDICATED AREA ON AN ANNUAL BASIS.

EXAMPLE: 4/NV/RC/24 – THIS SYMBOL REPRESENTS:

1) CURRENT LAND USE CLASSIFICATION – LAND USE CLASS 4
2) CURRENT LAND USE – NV OR "NATIVE VEGETATION"
3) POTENTIAL CROPS – RC OR "RESTRICTED CULTIVATION"
4) CONSUMPTIVE WATER USE – 24 INCHES PER ACRE ANNUALLY

SYMBOL NOTES:

A) FOR ANY OF THE FOUR COMPONENTS, A POUND SIGN (#) REPRESENTS A BLANK OR NO AVAILABLE DATA.

B) SOME SYMBOLS HAVE ONLY ONE OR TWO COMPONENTS. SINGLE-COMPONENT SYMBOLS REPRESENT CURRENT LAND USE ONLY.

EXAMPLE: SR = SUBURBAN RESIDENTIAL

TWO-COMPONENT SYMBOLS REPRESENT BOTH CURRENT LAND USE CLASSIFICATION AND CURRENT LAND USE.

EXAMPLE: 0/NW = LAND USE CLASSIFICATION "0" FOR PONDS AND CURRENT LAND USE "NW" FOR WATER SURFACE AND WETLAND CORRIDOR

EXISTING LAND USE LEGEND

D1	APPLE ORCHARD
D8	PRUNE ORCHARD
D10	MISCELLANEOUS DECIDUOUS ORCHARD
D13	WALNUT ORCHARD
F6	CORN
F7	GRAIN, SORGHUM
F11	MISCELLANEOUS FIELD CROPS
G6	MISCELLANEOUS MIXED HAY AND GRAIN
I1	LAND CROPPED IN THE LAST 3 YEARS BUT NOT CURRENTLY TILLED
NR1	RIPARIAN HABITAT – MARSH
NV	NATIVE VEGETATION (RANGE LAND)
NV-P	PARK
NW	WATER SURFACE AND WETLAND CORRIDOR
P3	MIXED PASTURE
P4	NATIVE PASTURE
RT	RECREATIONAL VEHICLE-CAMP SITES
S1	FARMSTEAD
S2	FEEDLOTS
S3	DAIRY
SR	SUBURBAN RESIDENTIAL
T9	MELONS, SQUASH, CUCUMBERS
T12	POTATOES
T18	MISCELLANEOUS TRUCK CROPS
U	URBAN
U12	EXTRACTIVE INDUSTRIES
UR	URBAN RESIDENTIAL
V	VINEYARD

PREFIXES TO LAND USES FOR IRRIGATED OR NONIRRIGATED AGRICULTURAL CLASSES:

1) "i" DENOTES AN IRRIGATED CROP
EXAMPLE: "iV" = IRRIGATED VINEYARD

2) "n" DENOTES A DRY-FARMED CROP
EXAMPLE: "nD1" = NONIRRIGATED APPLE ORCHARD

POTENTIAL CROP LEGEND

SEBASTOPOL/CAMP MEEKER AREA:

UTDV	UNRESTRICTED CULTIVATED CROPS – NO RESTRICTIONS PLACED ON CROP CHOICE WITHIN AREA; MOST OF AREA IS IN ORCHARDS AND VINEYARDS
RTDV	RESTRICTED CULTIVATED CROPS – SPECIALTY, TRUCK, VINEYARDS, AND ORCHARDS CAN BE GROWN IN THESE AREAS; BUT WILL REQUIRE CITY APPROVAL AND A CONSERVATION PLAN
G6-P8	IRRIGATED PASTURE AND HAY – AREA SUITABLE FOR IRRIGATED HAY AND PASTURE CROPS; OTHER CULTIVATED CROPS WILL REQUIRE CITY APPROVAL AND A CONSERVATION PLAN

WEST COUNTY, EAST OF ROHNERT PARK, NORTH PETALUMA VALLEY, ADOBE ROAD, LAKEVILLE, AND BAYFLATS:

UC	UNRESTRICTED CULTIVATED CROPS – NO RESTRICTIONS PLACED ON CROP CHOICE WITHIN AREA
RC	RESTRICTED CULTIVATED CROPS – GENERALLY IRRIGATED HAY AND PASTURE CAN BE GROWN; OTHER IRRIGATED CULTIVATED CROPS WILL REQUIRE CITY APPROVAL AND A CONSERVATION PLAN
P8	IRRIGATED IMPROVED PASTURE – GENERALLY ONLY IMPROVED PASTURE IS SUITABLE FOR THESE AREAS; OTHER IRRIGATED CULTIVATED CROPS WILL REQUIRE CITY APPROVAL AND A CONSERVATION PLAN

GRAPHIC NOTE:

A) SOME RIPARIAN CORRIDOR BOUNDARIES HAVE BEEN EXAGGERATED SLIGHTLY FOR GRAPHIC PURPOSES. THE OFFSET FOR THE RIPARIAN CORRIDORS IS TYPICALLY 66-99 FEET AND WIDENS TO INCLUDE WETLAND BOUNDARIES.

NO.	DATE	REVISIONS	BY		
				PROJECT NO 723129	DATE
				DESIGNED BY QUESTA ENGINEERING	8/95
				DRAWN BY ALAN MARSHALL	8/95
				CHECKED BY QUESTA ENGINEERING	8/95

HARLAND BARTHOLOMEW AND ASSOCIATES
PARSONS ENGINEERING SCIENCE
PARSONS — OFFICES IN PRINCIPAL CITIES

SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT

ALTERNATIVES 2 & 3

IRRIGATION SUITABILITY LAND CLASSIFICATION SYMBOLS AND ABBREVIATIONS

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SHEET OF

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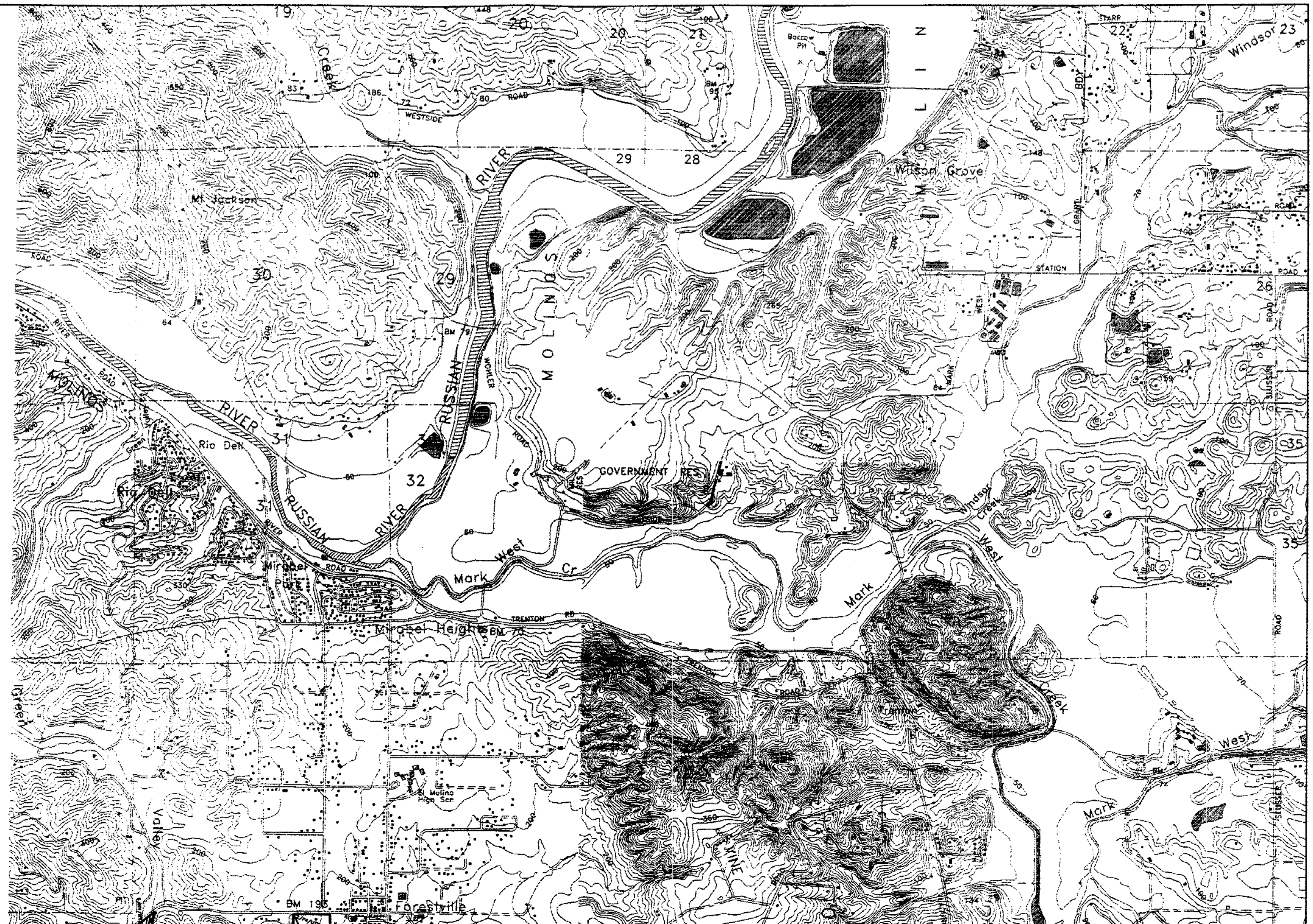

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SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT

1000' 0 1000' 2000'
SCALE:
CONTOUR INTERVAL: 40ft./20ft.

A B C D
SHEET LOCATION

ALTERNATIVES 2 & 3

IRRIGATION SUITABILITY LAND CLASSIFICATION

SCALE AS SHOWN
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SHEET of

AUG 29, 1995 - 12:26:11 ENG_DWG\STR\E-38_1

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SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT

SCALE: 1000' 0 1000' 2000'

CONTOUR INTERVAL: 40ft./20ft.

SHEET LOCATION: A B C

ALTERNATIVES 2 & 3

IRRIGATION SUITABILITY LAND CLASSIFICATION

SCALE: AS SHOWN

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SHEET OF

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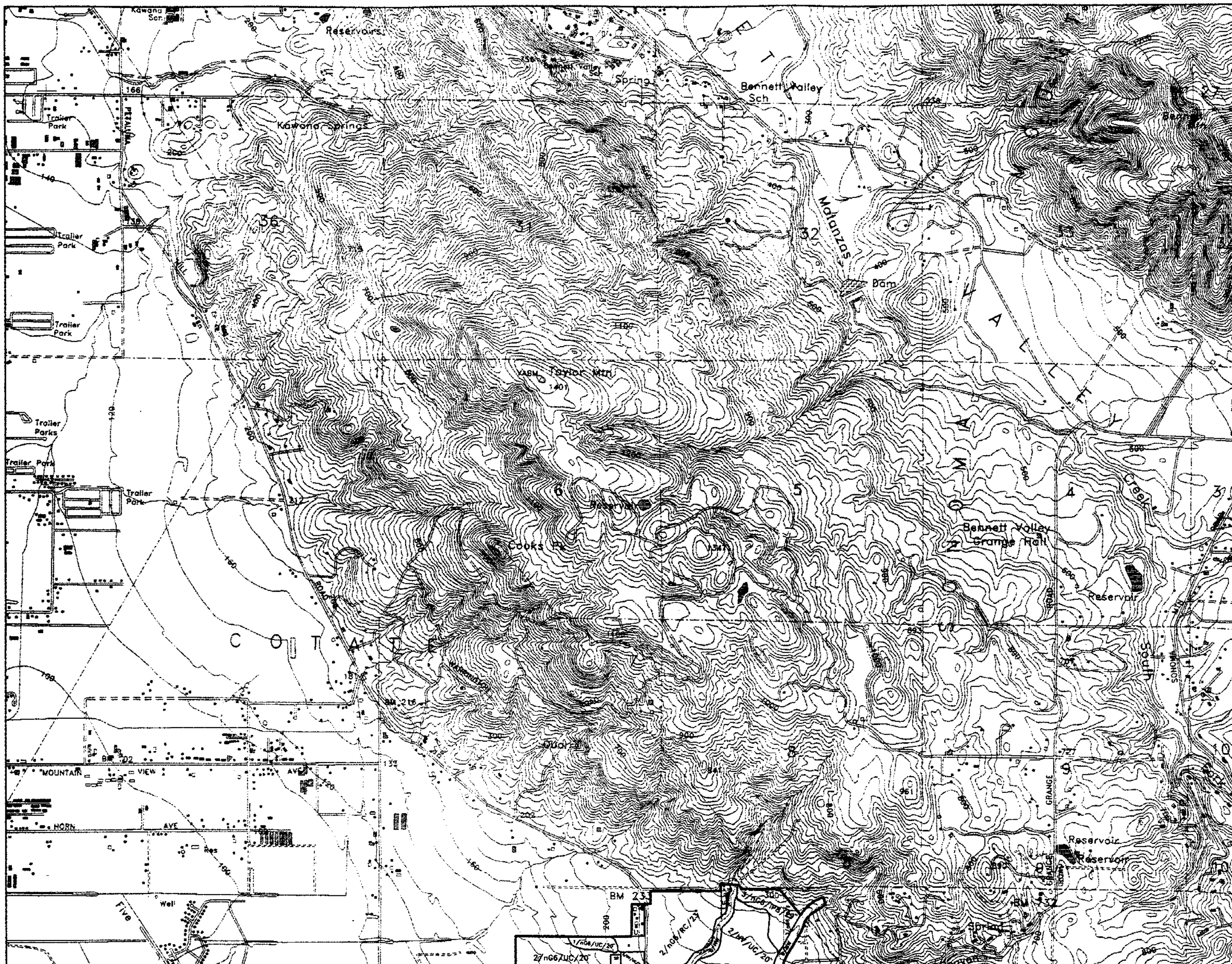

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SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT

1000' 0 1000' 2000'
SCALE:
CONTOUR INTERVAL: 40ft./20ft.

A B C D
SHEET LOCATION

ALTERNATIVES 2 & 3

IRRIGATION SUITABILITY LAND CLASSIFICATION

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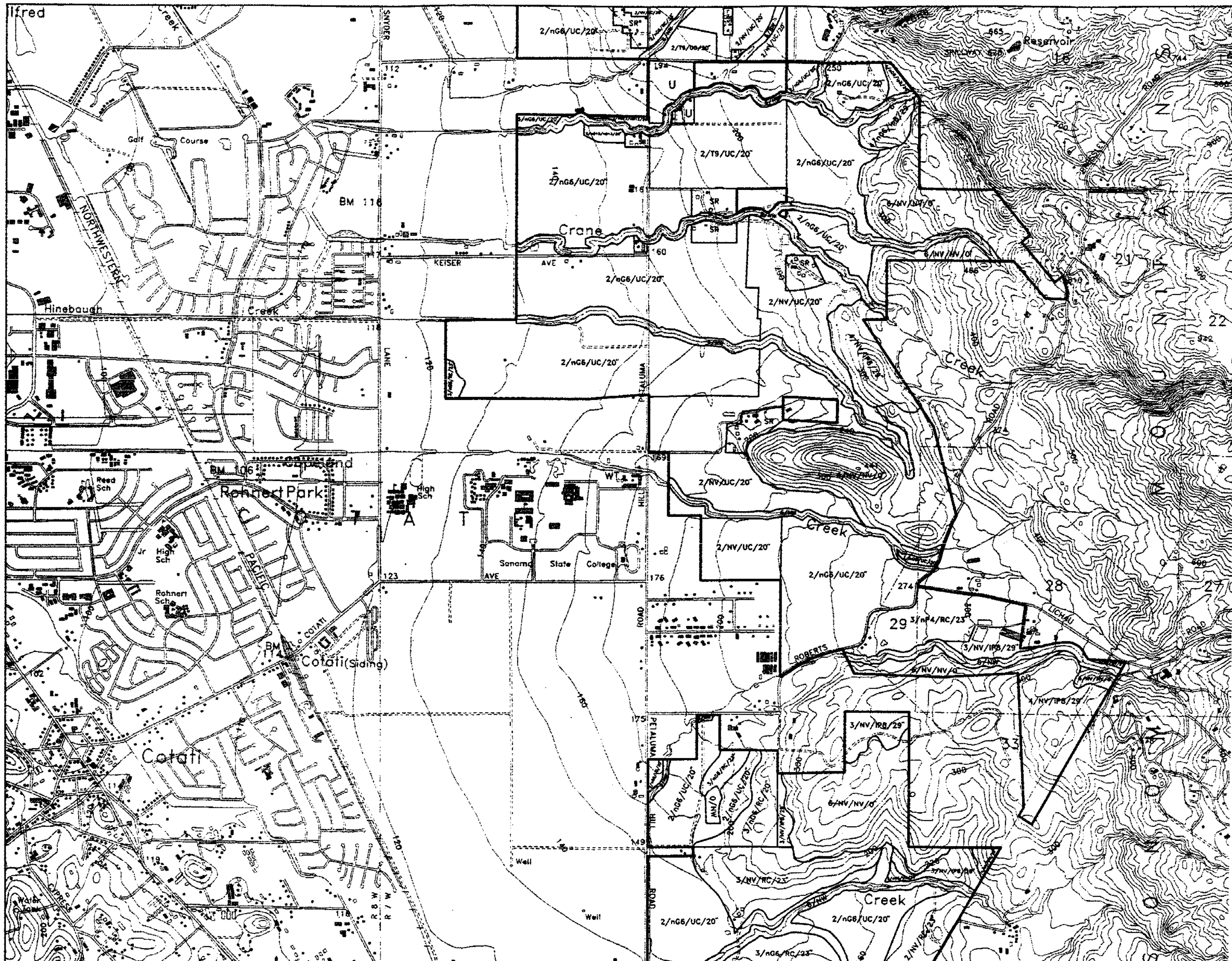

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SCALE: 1000' 0 1000' 2000'

CONTOUR INTERVAL: 40ft./20ft.

SHEET LOCATION: A B C

ALTERNATIVES 2 & 3

IRRIGATION SUITABILITY LAND CLASSIFICATION

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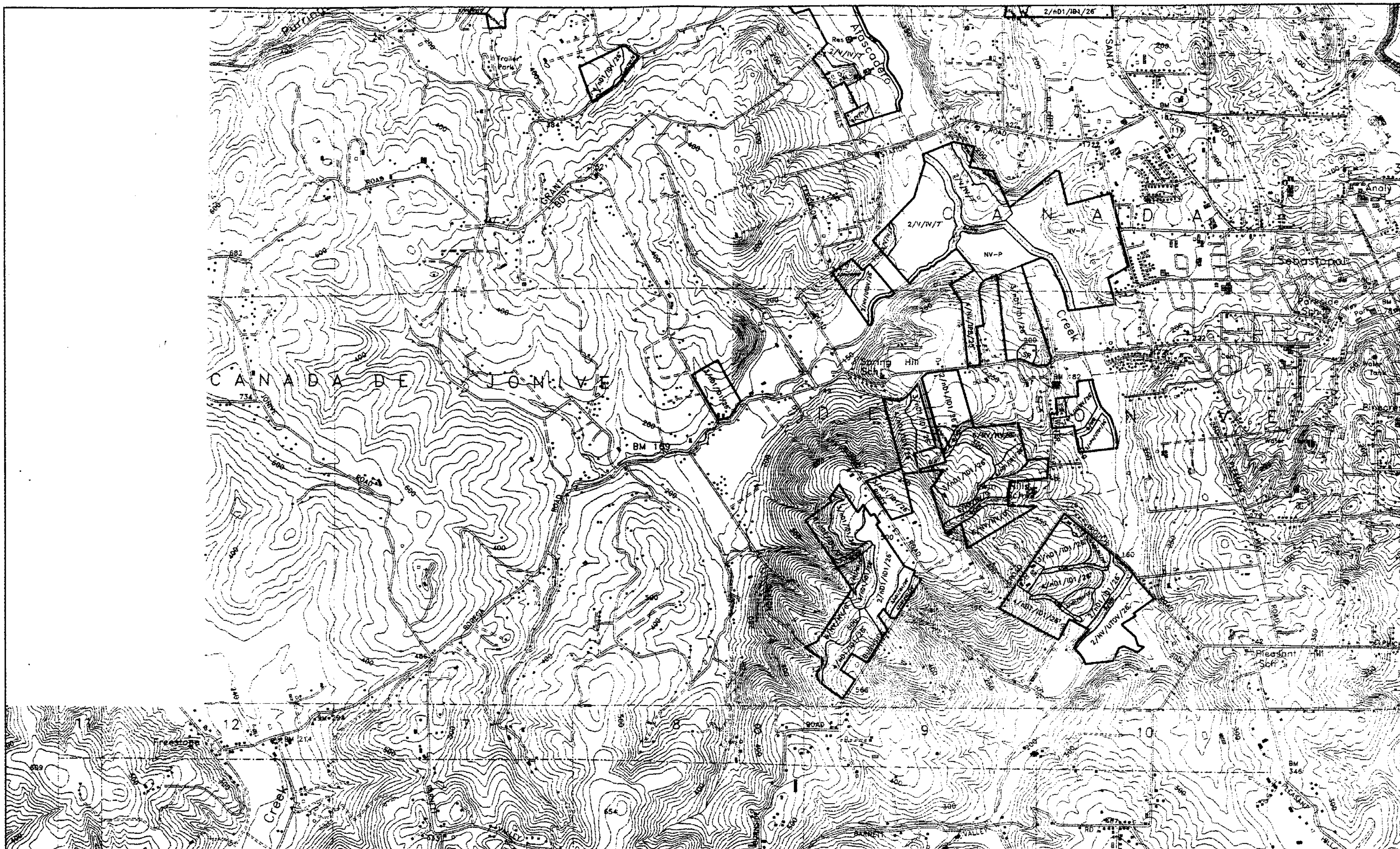

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SCALE:
CONTOUR INTERVAL: 40ft./20ft.

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SHEET LOCATION

ALTERNATIVES 2 & 3

IRRIGATION SUITABILITY LAND CLASSIFICATION

SCALE AS SHOWN
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SHEET OF

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SCALE:
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SHEET LOCATION

ALTERNATIVES 2 & 3

IRRIGATION SUITABILITY LAND CLASSIFICATION

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SHEET OF

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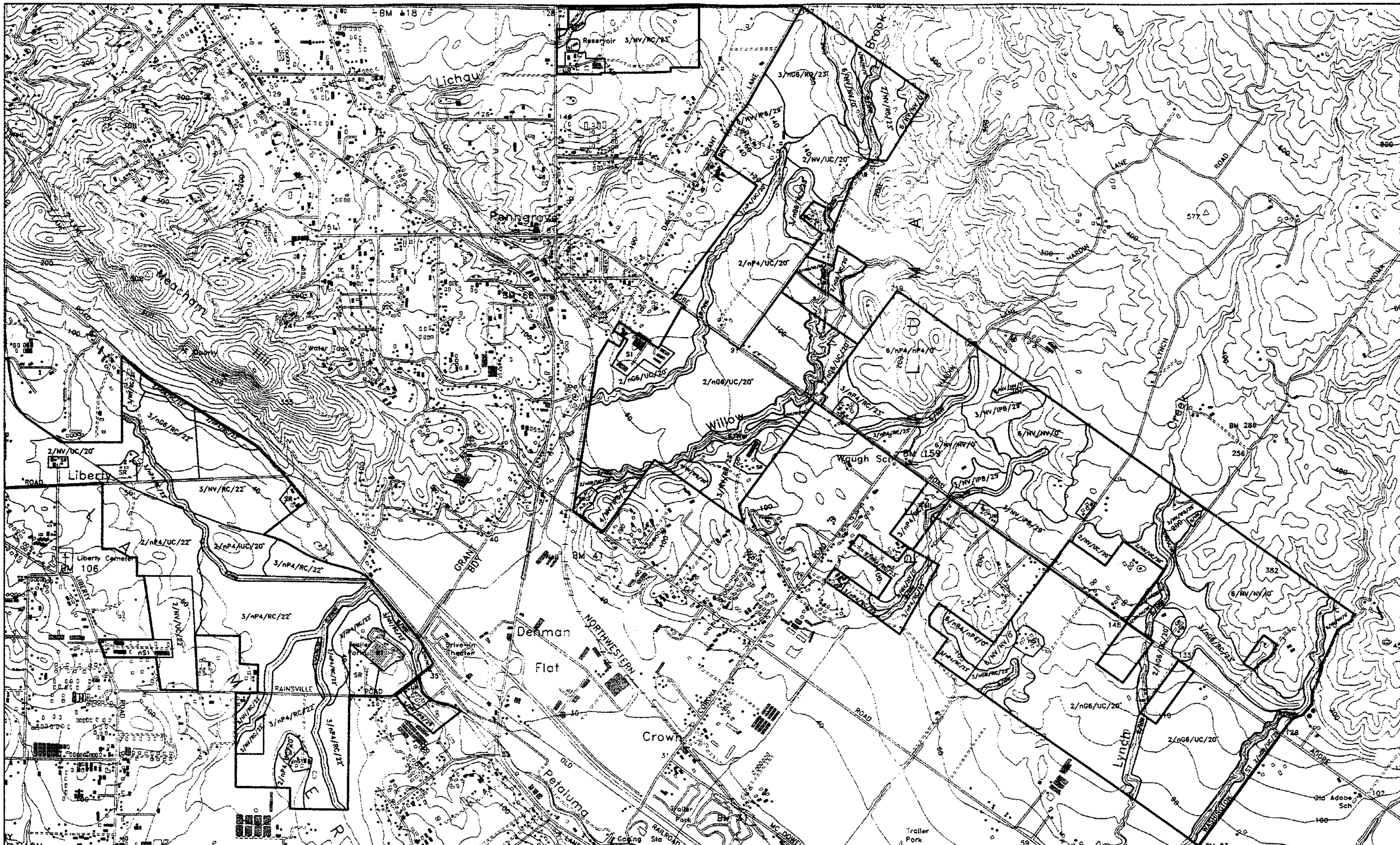

PROJECT NO. 723129	HARLAND BARTHOLOMEW AND ASSOCIATES	SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT	1000' 0 1000' 2000' SCALE: CONTOUR INTERVAL: 40ft./20ft.	ALTERNATIVES 2 & 3
DESIGNED BY QUESTA ENGINEERING 8/95	PARSONS ENGINEERING SCIENCE		SHEET LOCATION	IRRIGATION SUITABILITY LAND CLASSIFICATION
DRAWN BY ALAN MARSHALL 8/95	PARSONS			SCALE AS SHOWN
CHECKED BY QUESTA ENGINEERING 8/95	OFFICES IN PRINCIPAL CITIES			SHEET NO. G-2B-1

NO. DATE REVISIONS BY

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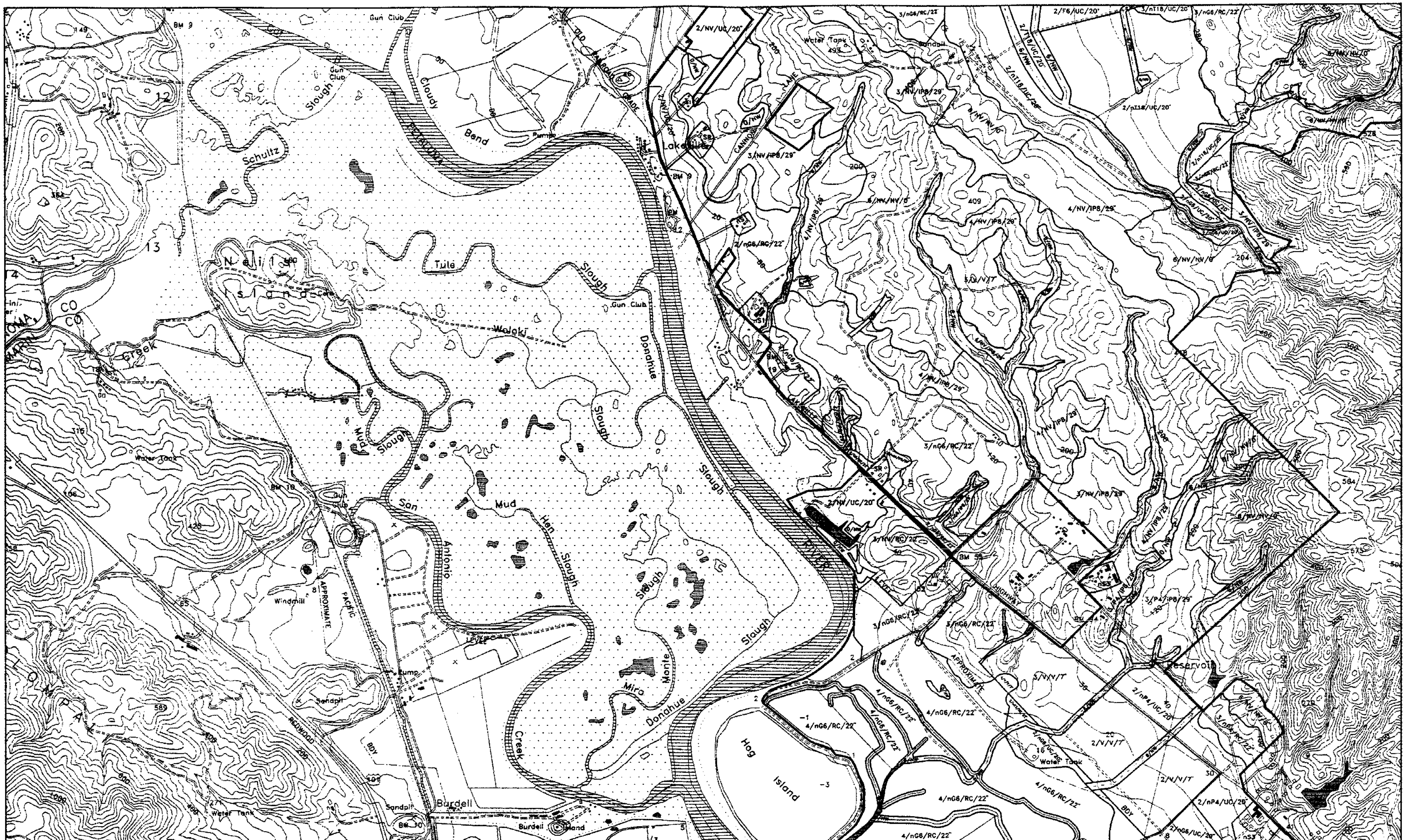

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SCALE:
CONTOUR INTERVAL: 40ft./20ft.

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SHEET LOCATION

ALTERNATIVES 2 & 3

IRRIGATION SUITABILITY LAND CLASSIFICATION

SCALE AS SHOWN
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SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT

1000' 0 1000' 2000'

SCALE:

CONTOUR INTERVAL: 40ft./20ft.

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ALTERNATIVES 2 & 3

IRRIGATION SUITABILITY LAND CLASSIFICATION

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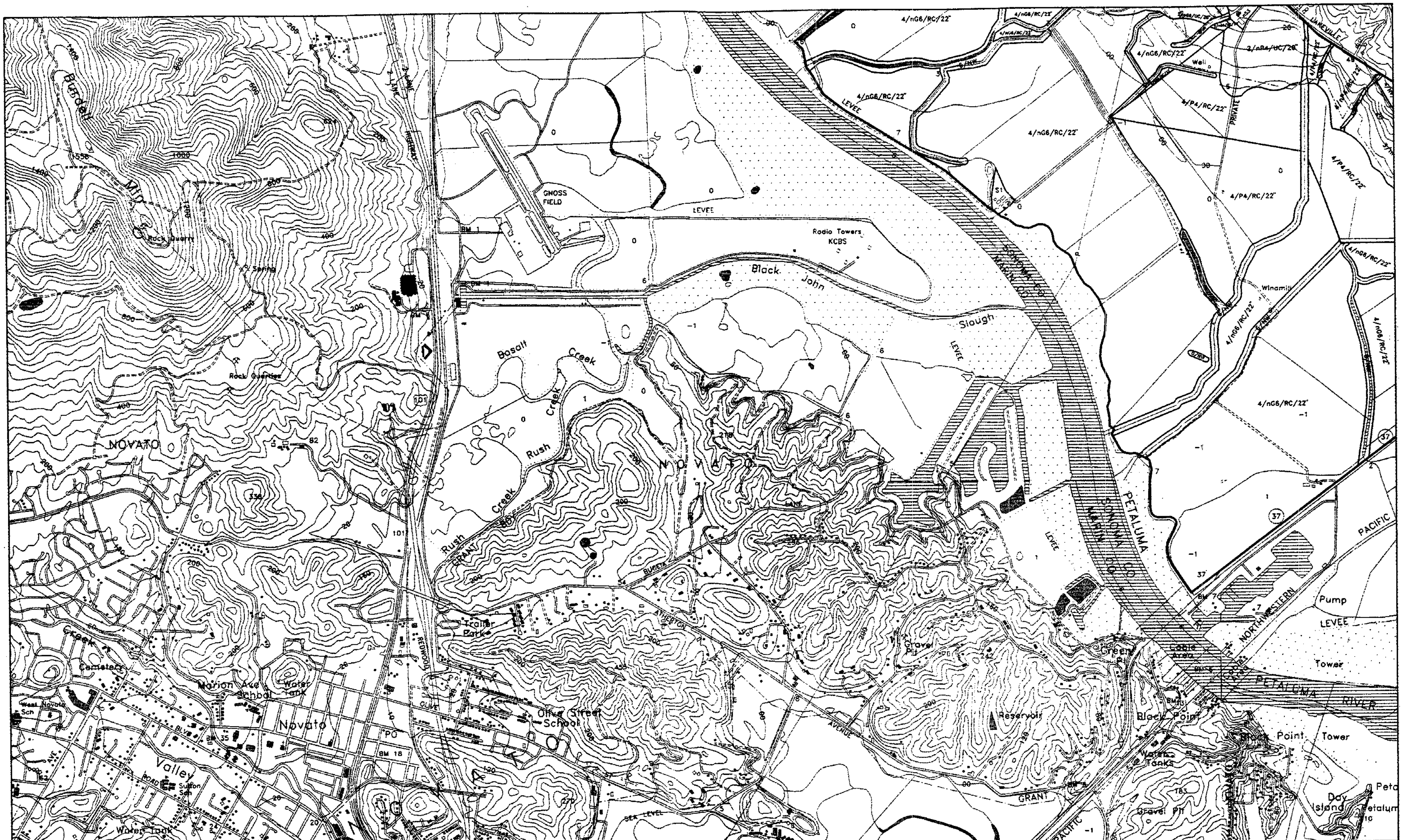

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1000' 0 1000' 2000'

SCALE:

CONTOUR INTERVAL: 40ft./20ft.

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SHEET LOCATION

ALTERNATIVES 2 & 3

IRRIGATION SUITABILITY LAND CLASSIFICATION

SCALE AS SHOWN

SHEET NO. H-1C-1

SHEET OF

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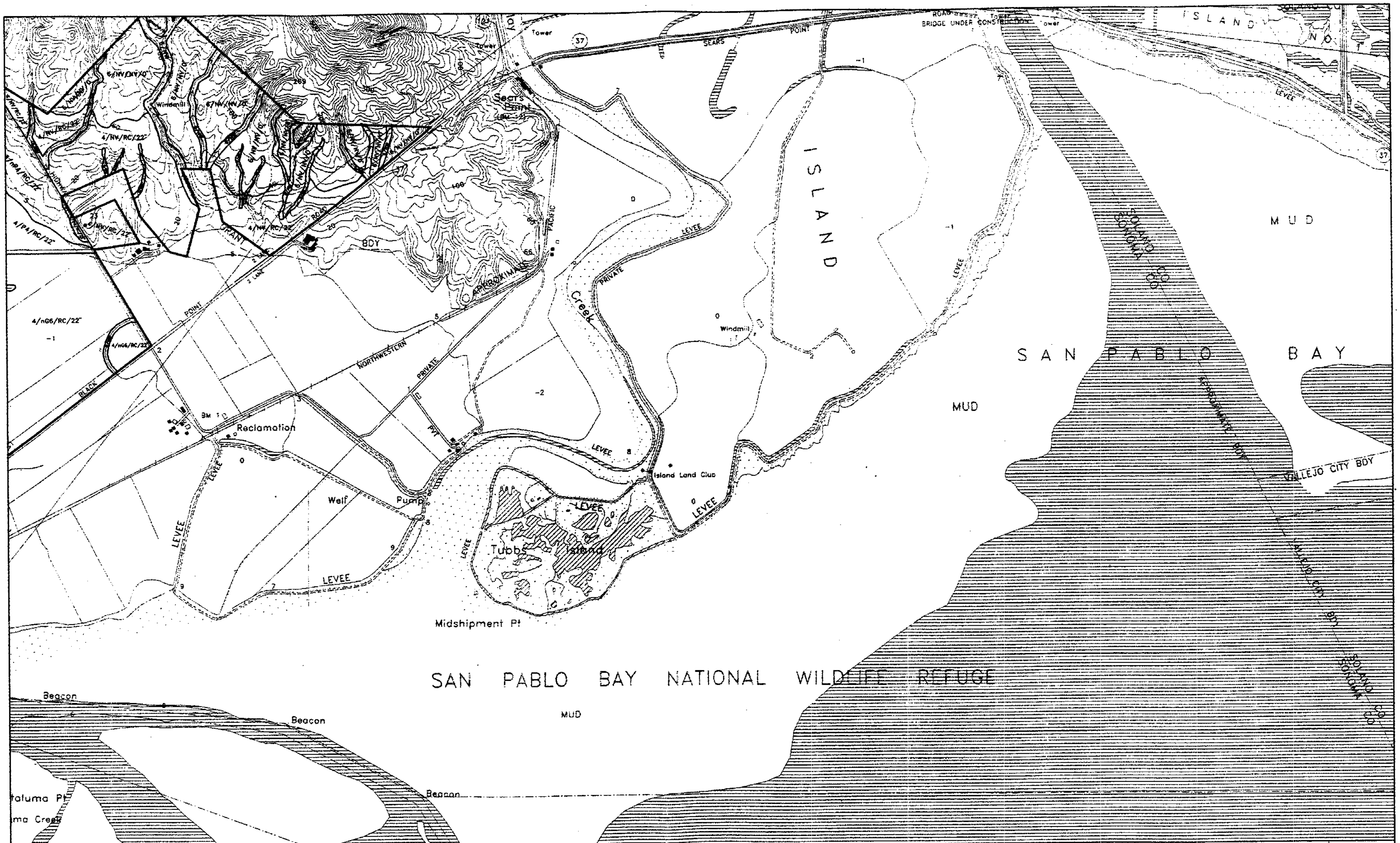

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SCALE: 1000' 0 1000' 2000'
CONTOUR INTERVAL: 40ft./20ft.

SHEET LOCATION: A B C

ALTERNATIVES 2 & 3

IRRIGATION SUITABILITY LAND CLASSIFICATION

SCALE: AS SHOWN
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