ORIGINAL

WATER RESOURCES DEVELOPMENT PLAN FOR THE ISLAND OF LANAI LANAI, HAWAII

Prepared for:

Lanai Company, Inc.
Honolulu, Hawaii

Prepared by:

M&E Pacific, Inc.
Engineers and Architects
Pauahi Tower, Suite 500
1001 Bishop Street
Honolulu, Hawaii 96813-3497

March 1989

TABLE OF CONTENTS

FIGURES

APPENDICES

EXECUTIVE SUMMARY

Recent review efforts between the two hydrologists most familiar with the water resources of Lanai have led to a general consensus in terms of the hydrologic budget, the ultimate sustainable yield from high level ground water resources, and the initial phases of future water resources development on Lanai. This body of knowledge was distilled down to three average daily values: 1) the recharge to the high level aquifer is thought to be about 9.0 million gallons per day (mgd); 2) the ultimate sustainable yield from this aquifer is 6.0 mgd; and 3) the exploitable resource under good development practices is 4.8 mgd, of which the present system extracts 3.0 mgd, leaving a remainder of 1.8 mgd available for future high level water resources development.

Projections for water demand made during the plan preparation are based on plantation requirements (received from the plantation manager), existing domestic usage, and Maui County consumption factors (for new and future development). At the end of the 1991 planning horizon selected for this review, the usage is forecast as follows:

Domestic	1.36 mgd
Plantation	2.40 mgd
Landscape irrigation	2.08 mgd
Total	**5.84 mgd**

To meet this demand, we recommend initially two more high level wells with the estimated total yield of 0.8 mgd (see Figure 1, page 8). In addition, alternate sources are to supply 1.4 mgd, of which 0.4 mgd could be available from reclaimed sewage. A third high level well may be needed depending upon yields of the first two wells, and future demands. In comparison to the estimated 1991 total demand, projected supply capacity is 6.4 mgd, of which 5.0 mgd will be from the high level aquifer.

The principal alternate source is low level fresh or brackish water. This water, because it has leaked from the high level aquifer on its path to the sea, is unaccounted in the above estimates of sustainable yield. An exploratory well has been recommended as part of this program to evaluate the water table location and water quality condition of this alternate source.

We recommend that the initial phase of implementing this water resources plan consist of developing three new wells. Two wells should be located to tap into the high level aquifer and be completed as soon as possible for full scale production. A third exploratory well is recommended to develop the low level water resource.

After the initial phase and assessment of the drilling results, a complete system evaluation should be made to consider long-range lowering/replacement of existing pumps, additional low level well development, and system-wide improvements to main transmission capability.

INTRODUCTION

The hydrogeology of the island of Lanai has been studied by various investigators: Stearns (1940), Bartz (1972), Bowles (1974), Anderson and Kelly (1985), and Mink (1983). Recent work has been performed by Keith Anderson and John Mink, the principal hydrologists in contemporary studies and evaluation of the water resources available on Lanai.

Both hydrologists worked independently on recent projects until this year, when they collaborated in a review and evaluation of the water resources of Lanai to develop recommendations for development of the water resources on the island. The summarization of water supply and demand projections used during the review is shown in **Appendix 1.**

This joint effort is significant. The wealth of experience and expertise represented by both hydrologists are brought to bear on the formulation of the resource development plan in a collaborative effort to meet the projected needs of the future. The technical and professional basis underlying the water resource development plan is the most competent and relevant to the experience on Lanai. The summarization from the hydrologists is shown in **Appendix 2.**

The contribution made to the deliberations by M&E Pacific, Inc., is the demand assessment for the projected

water consumption and the engineering factors to be incorporated in the development and scheduling of construction of new sources of water.

SCOPE AND PURPOSE

The relevant hydrology was reviewed by Anderson and Mink based on most recent data and experience to ascertain the completeness of the data base. From this common data base, both hydrologists analyzed the sustainable yield of the existing well and shaft system and of the overall high level resource that the current system draws from. The conclusion drawn from both hydrologists, each following differing methodologies, agrees remarkably well considering the degree of precision of the data base itself. Based on the projected needs, the recommendation for the water resource development plan is formulated to meet the future demand.

The projection for pineapple irrigation was provided by James Parker, manager of Dole Company, Hawaii operations. The demand figures for the urban development were projected by M&E Pacific, Inc., following unit consumption rates specified by County codes. Landscape irrigation needs were projected by assuming typical values for pan evaporation rates applicable to this area and drawing from experience of other landscaped areas.

Altogether, expertise was brought to bear on developing a consensus on the estimates of the available supply for the projected demand for the future of Lanai. The formulation

status of the water supply system. For example, given the present setting of the pumps in the high level aquifer, both consultants (see Appendix 2) estimate the present sustainable yield at 3 mgd. If the condition of the system were to change, for example, the pumps lowered in the wells, the sustainable yield for that system configuration would change, but will never exceed the ultimate sustainable yield.

John Mink analyzes the sustainable yield based on the dynamics of the system with the aid of a mathematical model which has been demonstrated to work by experience with the Pearl Harbor and other aquifer systems. Keith Anderson bases his estimates on experience with the management of annual pumpage with respect to precipitation trends and economic factors.

The sustainable yield estimates agree well with experience and with hydrologic principles. Estimates of the ultimate sustainable yield by both hydrologists are as follows:

Mink	6.0 mgd	(per Appendix 2)
Anderson	6.2 mgd	(per Appendix 2)

The ultimate sustainable yield of the high level aquifer adopted for planning purposes is 6 million gallons per day (mgd).

The present system as it is configured can be counted on to provide 3.0 mgd (agreed upon by both hydrologists) on a sustained basis expressed as an average daily flow. This

represents about 50 percent of the current estimates of the ultimate sustainable yield from the high level aquifer.

Interconnected aquifer. The high level aquifer is envisioned to be an interconnected, compartmentalized media connected by fractures which permit hydraulic continuity within the dike complex. Over decades of time all sources of withdrawal will stabilize, provided the rate of withdrawal is not significantly changed before equilibrium levels occur between compartments. Due to varying irrigation demands and equipment operation, this is, practically speaking, difficult to achieve. Differences in the water levels will be noted in the transition periods which may take several years or decades.

There are two significant implications of this conclusion:

1) The use of a single value to represent the entire high level aquifer safe yield is warranted from a long-term planning point of view, and
2) The addition of new wells in the high level aquifer increases the flexibility in controlling short term water levels, but does not change the ultimate sustainable yield and will not prevent the water table from declining to its equilibrium level.

To what extent the withdrawal from new wells will contribute to the lowering of water level is an important

consideration to setting new pump intake levels and resetting existing pump intake levels. This would need some follow-up investigation by one or both hydrologists. But both hydrologists agree that it is prudent to establish a threshold limit for withdrawal in terms of sustainable yield. We propose that this limit be set at 80 percent of the estimated sustainable yield or 4.8 mgd from the high level aquifer.

The increase in sustainable yield that can be expected must always leave a margin of error for such uncertainties as natural leakage from the aquifer, the vagaries of drought occurrences, and the imperfect nature of the hydraulic connectivity of the individual dike compartments which constitute the high level aquifer zone.

Alternate sources. Alternate sources are considered here to mean water resources outside the high level aquifer, in particular, low level fresh and brackish waters believed to underlie the Palawai Basin and beyond. Alternate sources also include reclaimable sewage effluent suitable for landscape irrigation.

The alternate sources are a significant part of the overall water resources development plan, especially in anticipation of the fact that close to 80 percent of the demand for future water is estimated to be for irrigation. Domestic consumption is approximately 20 percent of the demand. This demand component requires the highest quality

water in any allocation scheme. By comparison, landscape irrigation can utilize brackish waters and reclaimed sewage effluent. The intermediary use is in pineapple irrigation. The water quality requirements for pineapple cultivation are also stringent. These are the considerations given to the future plan for alternate water resource development. Alternate sources will expand the availability of resources for Lanai's future.

The magnitude of the quantity of alternate sources, in particular, low level water has not been given much consideration by the hydrologists because the primary thrust has been to develop high level water. However, Anderson and Mink believe it to be a significant resource. One approximation of the minimum upper limit is the difference between the sustained recharge rate and the ultimate sustainable yield, namely 3 mgd. Some of this water will leak toward the coast. We know from geophysical surveys and early water development on Lanai that there is a hydraulic gradient toward the ocean.

We propose that an initial effort be made as part of the development program to drill an exploratory well in the southwestern sector of the Palawai Basin. This location is outside the range of influence of the wells in the high level aquifer. At worst, this well would be brackish. At best, it would be potable, but perhaps of low yield, considering estimates of the hydrogeology of the area.

Figure 1. Lanai Water Supply & Demand Projection

Summary of Resources

High Level Aquifer

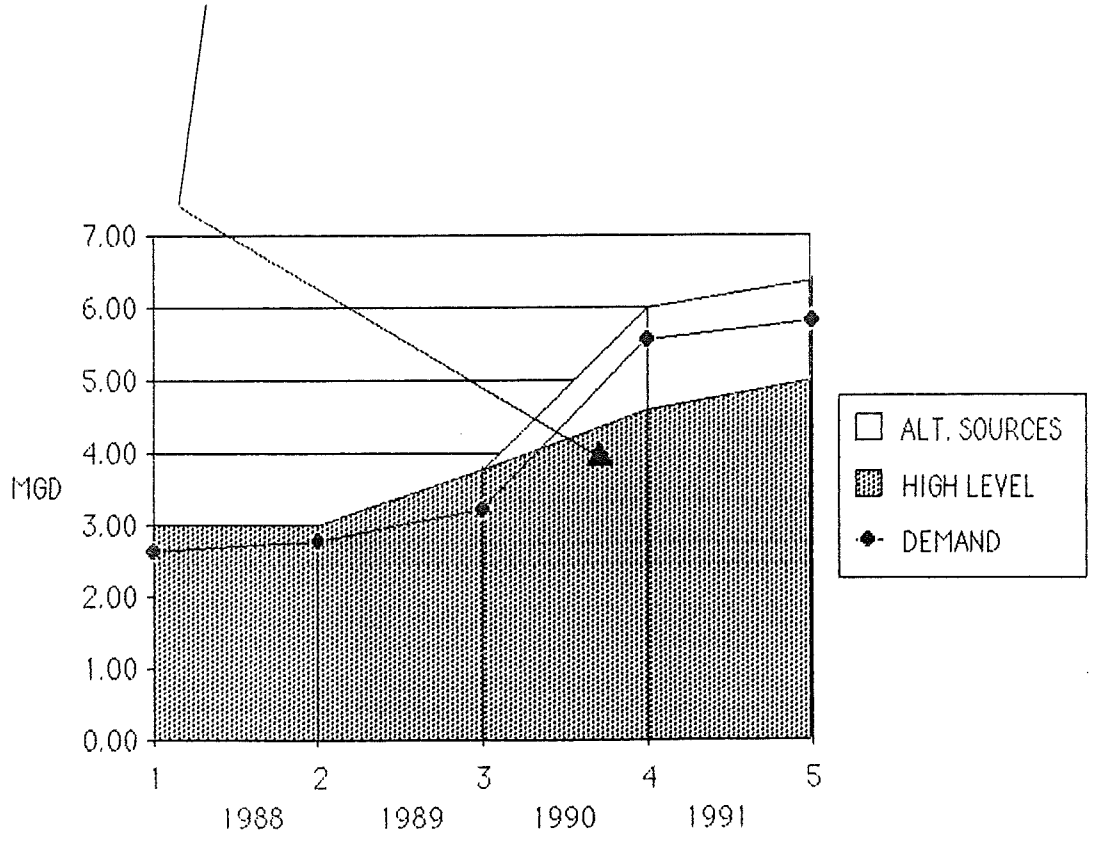
Wells 1-5 & Maunalei Sytem - 3.0 mgd
Wells 6-9 - 1.6 mgd
Optional High Level Well - 0.4 mgd

Subtotal - 5.0 mgd

Alternate Sources

Low Level Wells - 1.0 mgd
Reclaimed Effluent - 0.4 mgd

Subtotal - 1.4 mgd

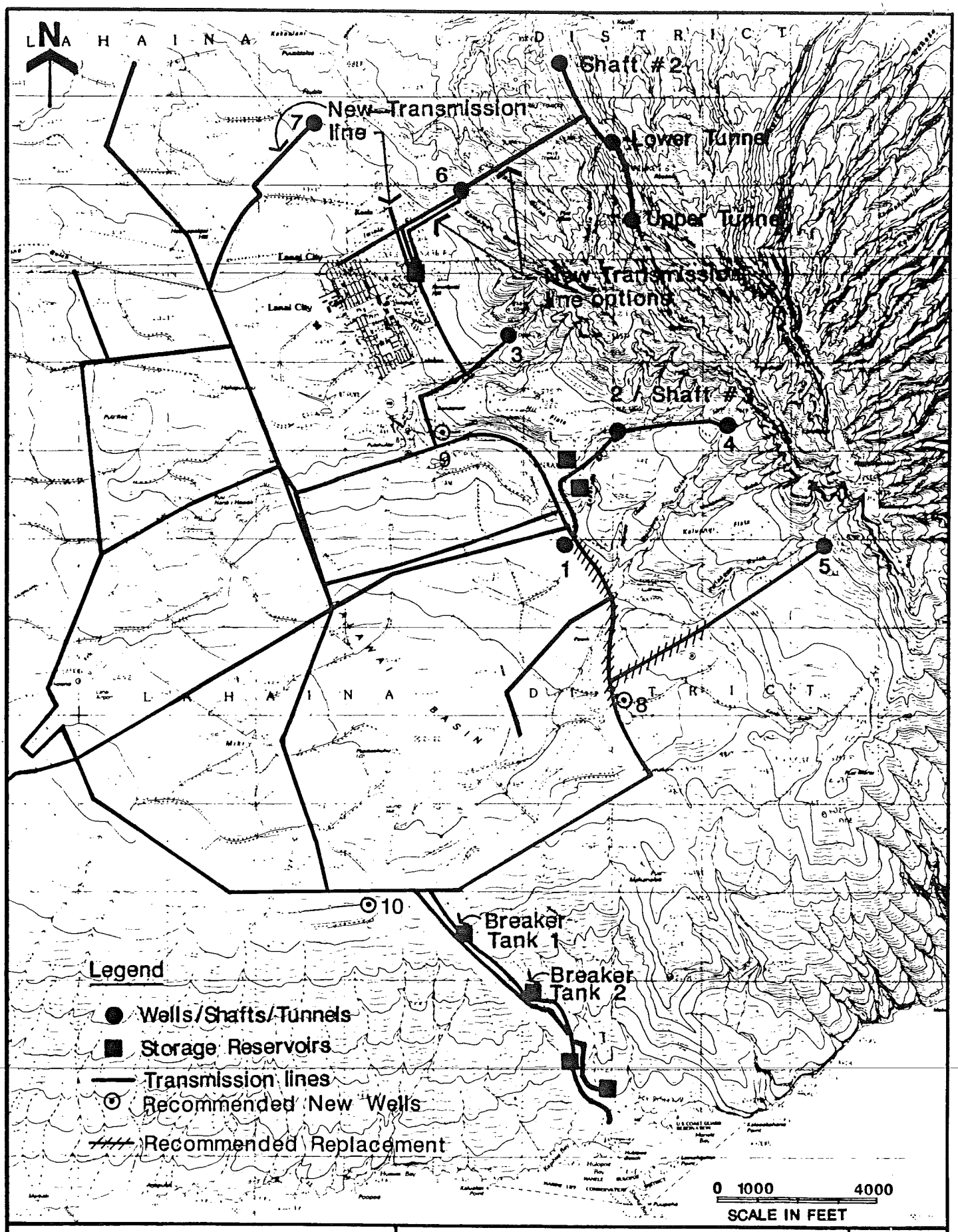


PROJECTED DEMAND AND SUPPLY

The water demand and supply projected for the future is summarized in **Figure 1.** Included in Appendix 1 is a breakdown of the anticipated water sources to be developed in tandem with the hotel and residential construction.

Projected individual yields for future wells are based upon judgement concerning the hydrogeology of the site and relevant experience from similar wells. The average of the yields of Wells 1 through 5 is 0.5 mgd. We believe 0.4 mgd is more prudent for well sites 8 and 9 given their location, the yield of Well 1, and pump test results from Well 7. At an average rate of 0.4 mgd, the well would pump at approximately 275 gallons per minute (gpm) on a 24-hour basis. A sustained period of operation of Wells 6 through 9 will be required before individual yields can be confirmed. Estimates of individual well yields from alternate sources are too speculative at this time. The significance of this point is that the exact number of wells needed to reach the threshold limit of ultimate sustainable yield is also a variable in the planning of water resource development.

Existing sources and consumption. The current supply to Lanai City other than pineapple irrigation is 0.38 mgd. Dole Plantation uses water up to 2.4 mgd and will continue at this rate into the future. The total average demand is 2.78 mgd. The sustainable yield from the existing sources at the present configuration is 3.0 mgd. The existing



Lanai Water Resources Development Plan	WELL LOCATIONS AND SERVICE AREA MAP	Figure 2

sources are the Maunalei shaft and tunnels, and Wells 1 to 5, and Shaft 3. These are located in **Figure 2.** Two additional wells have been drilled and will soon be hooked up into the water distribution network. These are Wells 6 and 7. The supply will increase to 3.8 mgd, which is sufficient to support the designated projects for 1989, as shown in Figure 1.

Future Sources and Consumption.

According to our plan, Wells 8 and 9 should be brought on line early in 1990. We estimate 4 months to drill and complete two wells; another 6 to 8 months to design and order the pumps, motors, controls and electrical substation equipment, and construct the transmission connection. The total supply with these wells is projected to be 4.6 mgd. Well 9 should be brought on line before the Koele Golf Course is placed in operation. In comparison to supply, the total projected demand on the high level aquifer is 4.16 mgd at that time (1990).

Another rationale for moving ahead with these wells, in particular Well 8, is the prospect that both Wells 1 and 2 will be down for major overhaul in the future (see Appendix 2, memo from J.H. Parker). During this overhaul Well 8 could furnish irrigation water and/or reduce the load on Well 4. Replacement of the first leg of the irrigation system could be programmed for that time frame (see Figure 2, replacement lines).

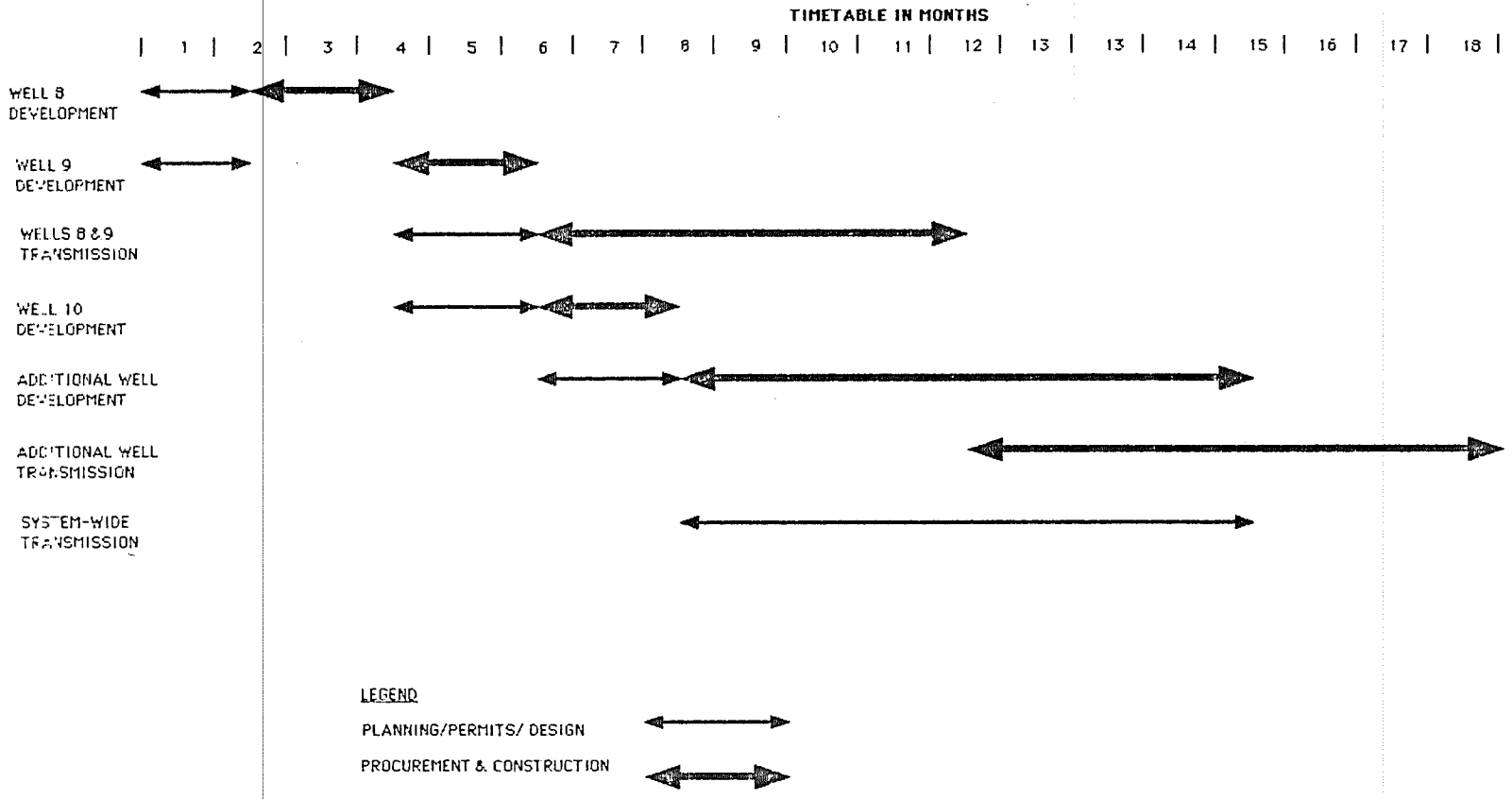


Figure 3. Estimated Timetable For Completion of Initial Water Resource Plan Elements

The plan to support the demand for landscape irrigation water is the exploration for and development of the brackish water sources, starting with wells in the southwestern sector of Palawai Basin. The desired quantities average 1.0 mgd, which would be equivalent to the anticipated demand of a golf course in Manele. The first step in this development is the exploratory Well 10. The total number of wells from this source could be estimated after the exploratory well tests were complete.

Reclamation of sewage effluent for landscape irrigation from the Lanai City's oxidation ponds and the Manele treatment plant can provide landscape irrigation water ultimately in quantities up to 0.4 mgd.

Figure 3 summarizes the projected water resource plan elements and preliminary planning, drilling permit application, design, and construction time tables needed to schedule the completion of the initial phase plan consisting of two production wells and a pilot exploratory well ahead of anticipated demands. The time for completion of wells to supply Manele Golf Course irrigation is also estimated. The total cost for the project would depend upon the yield of the new wells, the requirement for separate transmission supply to Manele Project District from the public health viewpoint, and the requirement for a separate transmission line for the Manele Golf Course irrigation water. The

latter depends upon the quality of water yielded from Well 10. At the time of this plan preparation, cost estimates were being prepared for the three new wells.

Figure 3 also shows the time to complete the source permit application, design and construction of transmission lines from new sources to points of demand. The critical time element for these plan elements is the scheduling of electrical substations for submersible well pumps. Diesel drive is an option, but the depths of these wells may limit the drive shaft capability.

The overall system transmission capability will need evaluation when the production capacity of Wells 6 to 9 and low level wells can be estimated. It would be prudent at that time to evaluate the requirements for resetting the existing pumps in light of future water table declines that are predicted concurrently with additional water withdrawal from the high level aquifer.

By 1991, one additional well in the high level aquifer may be needed. This will bring the total high level supply to 5.0 mgd. In comparison the demand supplied from the high level source is projected to be 4.44 mgd. In relation to the ultimate sustainable yield of the high level aquifer, the demand is 74 percent or approximately 50 percent of the estimated recharge rate of 9.0 mgd.

WATER RESOURCES DEVELOPMENT PLAN

In summary, the approach represents a prudent plan to develop all available resources commensurate with the

quality of use without over-committing the high level resources. Monitoring of the aquifer performance over time will provide more precise estimates for the supply and demand equation where adjustments can be made in the management of the water resources.

The total capacity of planned sources is given below:

High level water	5.00 mgd*
Reclaimed effluent	0.40
Alternate sources	1.00
Total	**6.40 mgd**

*Projected usage = 4.44 mgd.

The total usage of water by categories is as follows:

Domestic consumption	1.36 mgd
Pineapple irrigation	2.4
Landscape irrigation	2.08
Total	**5.84 mgd**

The projected installed capacity of the sources is 6.4 mgd. This will come from the future construction of three more wells at 0.4 mgd each in the high level aquifer. Wells 6 and 7 are already drilled and ready for hookup. Wells 8 and 9 must be constructed soon. The alternate sources anticipated amount to 1.4 mgd, of which 0.4 mgd is available from reclaimed sewage.

The total usage will vary. Experience will demonstrate the pattern of consumption. Irrigation water will depend on the rainfall pattern for the year. Domestic consumption is

projected according to the requirements of the County of Maui codes. For single family residences, the requirement is 600 gallons per day per unit (gpd/unit). For apartments, it is 560 gpd/unit. By comparison, the actual usage in the present Lanai community is about 276 gpd/unit, which is far below the allowance being provided.

Consumption patterns are expected to change in the future, but not beyond the levels being provided for in planning. It could well be that the pattern of usage would be less than projections. For this reason, the third well in the high level aquifer can be constructed later.

The alternate source can be a pilot well until it is demonstrated that a production well here would be worth the effort. Exploration should begin concurrently with construction of Wells 8 and 9.

It should be noted that the domestic consumption is 1.36 mgd out of the total projected at 5.84 mgd. Domestic consumption is but 23 percent of the total. The remainder (4.48 mgd) is for plantation use, golf course irrigation, and ornamental irrigation. Pineapple irrigation requires high quality water. Therefore, of the remainder, 2.08 mgd total non-domestic demand can utilize alternate sources. This provides considerable flexibility in the allocation scheme for irrigation water. In contrast, domestic and pineapple consumption do not have that flexibility.

CONCLUSION

The ultimate sustainable yield of the high level source is estimated at 6.0 mgd. The estimate is derived from two competent hydrologists, each with a wealth of experience and expertise. The projected demand from this source is 4.44 mgd, or 74 percent of the sustainable yield.

Construction of Wells 8 and 9 must begin now to provide additional water totaling 0.8 mgd, and plans for exploratory drilling in the southwestern sector of the Palawai Basin for an alternate water source must proceed concurrently. One mgd is desirable from this alternate source. In the future, another high level well will be necessary if the consumption pattern occurs as projected.

The projections of supply and demand for water show that the water resources on Lanai are adequate to meet future needs of domestic (urban) consumption, pineapple cultivation, and landscape development.

REFERENCES

1. Anderson and Kelly, 1985. **Lanai Water Supply Review.** Prepared for Dole Company, Lanai Plantation.

2. Ellwood Bartz, 1972. **Lanai's Water System.**

3. Stephen P. Bowles, 1974. **The Water Resources of Lanai, Summary.**

4. John F. Mink, 1983. **Lanai Water Supply.**

5. H.T. Stearns, 1940. **Geology and Groundwater Resources of Lanai and Kahoolawe, Hawaii.** Bulletin 6, Division of Hydrography, Territory of Hawaii.

APPENDIX 1

DETAILED WATER DEMAND

AND RESOURCE DEVELOPMENT

Lanai: Projected Water Demand and Resource Development

Time Line		Demand MGD	Cumulative Demand	Water Transmission Capability (MGD)	Source Wells/Other	New Well(s) Schedule
1988	Lanai City Dole Plantation	0.38 2.40	2.78	3.00	Maunalei Wells 1-5 Shaft 3	Wells #6 & 7 Complete
1989	Koele Hotel Lalakoa III Hulopoe Beach Park (Phase I) Lanai Industrial (Central Support) Community Gardens Assumes 27.5 ac. @ 4,000 gpd/ac. Lanai City Apartments	0.15 0.09 0.07 0.03 0.11 0.02 (0.47)	3.25	3.80	Wells #6 & 7 On Line (0.4 mgd each)	• Locate "Alternate Water Resources (1.5 mgd) Drill Test Well(s) • Start Well #8 • Start "Alternate Water Development • Start System to Utilize Treated Effluent
1990	Koele Golf Course Lower Waialua (122 units @ 600 gpd) Queen's Multi-Family (128 units) Manele Bay Hotel Manele Golf Course Other Landscape Clubhouse, Roadways Beach Park Phases II - IV Commercial Area (Downtown Redevelopment) Koele (SFR) assumes 35 units	0.40 0.07 0.07 0.20 1.0 0.5 0.05 0.02 (2.31)	(4.16 High level) (0.40 Effluent) (1.00 Alternative Source) 5.56	4.20 4.60 5.60	Well #8 - On Line (0.4 mgd) Treated Effluent System On Line (0.4 mgd) Alternate Water Resource On Line (1.0 mgd)	• Complete Develop Well #9 Develop Well (High level) subject to review of operating conditions of wells and demand
1991	Manele Residential (133 units) Koele Residential (200 units)	0.08 0.20 (0.28)	5.84	6.00 6.40	Well #9 - On Line (0.4 mgd) High level Well On Line (0.4 mgd)	
			4.44 High level .40 Effluent 1.00 Alternative	5.00 .40 1.00		

January 17-18, 1989

APPENDIX 2

MEMORANDA

Memo to Bob Oda, Vice President, Lanai Land Co.
From John F. Mink
Re Status and Sustainable Yield of the High Level Aquifers
January 23, 1989

The sustainable yield of the Lanai High Level Aquifers for the current configuration of the wells is approximately 3 mgd. Adding wells 6 and 7 does not change sustainable yield but allows more flexibility in controlling groundwater levels. The water levels are not yet at equilibrium with respect to continuous withdrawal of 3 mgd. It may take a few years before they stabilize.

The sustainable yield can be increased to 5 mgd by lowering the pumps in each well to 20 feet above well bottom. At total draft of greater than 3 mgd the water tables will continue to decline, but the rates are slow enough to allow time to lower the pumps.

Ultimately a sustainable yield of about 6 mgd is possible if wells are deepened to sea level and pumps set 20 feet above the bottom of each well. It may be less costly to drill new wells rather than deepen all of the old ones.

Total demand on the High Level Aquifers is expected to be 4.44 mgd in 1991, 0.56 mgd less than sustainable yield for the wells with pumps lowered to 20 feet above existing depths. Although the transient period of water level decay takes years before new equilibrium is reached, a plan should be formulated to eventually lower the pumps.

The new wells, numbers 6 and 7, will add 0.8 mgd to the system over the short term but will not prevent the water table from declining to its equilibrium head. Similarly, proposed wells 9 and 10 will contribute to the decline.

Exploratory well 10 has been located to test for the outer limit of high level water and to ascertain whether acceptable brackish is available if the site is outside the high level boundary.

Telephone
(208) 345 5665

1661 Mallard Drive, Boise,
Idaho 83706 3974

JMM James M Montgomery
Consulting Engineers Inc

January 25, 1989

Mr. Robert Oda
Vice President & General Manager
Lanai Company, Inc.
P. O. Box 2780
Honolulu, Hawaii 96803

Subject: Lanai Water Supplies

Dear Mr. Oda:

This letter report will summarize our conclusions and recommendations, stated in our January 17-18 meetings in your office, concerning the potential for additional development of water supplies on Lanai.

As you know, our study and evaluation of groundwater on Lanai goes back to 1957, with primary emphasis on the continuing evaluation of the capability of the existing water supply installations. From time to time we have made recommendations for the management of annual pumpage with respect to precipitation trends and economic factors.

Additional information gained from the drilling and testing of Wells 6 and 7, and from such studies as Ekern's investigation of fog-drip, allows for an updated estimate of additional water-supply that could be developed to accommodate the projected increased need for water on the island.

Our early estimate of recharge from rainfall was 0.41 mgd per square mile over a limited area. We believe this rate can be increased by 20 percent and the area increased to 14 square miles for a total of 6.89 mgd over the principal recharge area. We estimate that an additional 10 square miles receives recharge at a rate of 0.20 mgd per square mile from either direct precipitation or the infiltration of runoff from adjacent higher areas. Total estimated average recharge would then be:

Primary area 14 sq. mi. -	6.89 mgd
Secondary area 10 sq. mi. -	2.00 mgd
Total	8.89 mgd

We would estimate the sustainable yield from the high-level aquifers to be about 70 percent of recharge, or 6.22 mgd.

The experience with water use in recent years indicates that the present supply system (Maunalei side, Shaft 3, and Wells 1-5) can be managed to furnish an average

of 3.0 mgd. Additional water from Wells 6 and 7, completed and tested but not yet on-line, is estimated at 0.8 mgd for a total of 3.8 mgd.

An additional 0.8 mgd, for a total of 4.6 mgd, could probably be developed by drilling and equipping two—or possible three—new wells on the plantation side of the island.

With the additional development now taking place, and considering future planned development, it is recommended that the drilling of at least two new water-supply wells be started as soon as possible.

Several additional points should be kept in mind as plans and developments continue:

- A comprehensive program of monitoring pumpage, water levels, and precipitation must be continued.
- Some additional future costs should be anticipated for modifications or replacements at existing source facilities.
- Additional features related to the water-supply system will be required (distribution, storage, and power supply and transmission).

We would be glad to discuss any of these matters in more detail if you wish. Please let me know if you have any questions.

Sincerely,

Keith E. Anderson

Keith E. Anderson

/ln

cc: J.H. Parker
J. Kumagai

File: 2549.0010

Dole Packaged Foods Company
Lanai Plantation • Lanai, Hawaii 96763

Date: January 11, 1989

To: R. C. Oda

From: J. H. Parker

Subject: Lanai Plantation Water Distribution System

Per Mr. Murdock's request, the following summarizes the care, cost and condition of the water pumping and distribution system.

Wells:

1988 Cost	Maintenance:	$ 68,845
	Operation	$594,667

Well 1

This well is in the Palawai Basin and one of two diesel powered water sources. The pump was rebuilt and the drive line shaft replaced in 1987. The diesel engine was replaced in 1986, due for a routine major overhaul soon.

Well 2, Shaft 3

This complex above Kapohaku Gulch has been the Plantation's major source of irrigation water, but deliveries have declined due to the continuing drought. The Well has an electric powered line shaft pump that may require replacement in the near future. Capacity has been reduced, but water availability has also declined, and productivity has not been adversely affected.

Well 3

Above Kapano Gulch, east of Lanai City. Pump upgraded and replaced in 1979. Can deliver into either the 2 MM Gallon domestic tank or the Plantation irrigation system. No major problems.

Well 4

Above Field 5455, Puu Aalii, interconnects with Well 2/Shaft 3 to the 1 MM Gallon reservoir and the irrigation distribution system. Pump replaced and upgraded in mid 1980's. This well is most outstanding resource on the Island, carrying about 20% of the present withdrawal load. No major problems.

Well 5

Above Field 5451, Waiakeakua, has a direct feeder into the First Leg of the distribution system. Pump replaced and upgraded in the mid 1980's. This source has felt the impact of the extended dry period and produces well, but must be carefully managed. Due to the direct interconnect and elevation of the pump discharge, running this unit at critical times gives the Plantation's irrigation system a decided pressure and flow boost in the south slope fields.

Maunalei System

In the Maunalei Gulch, east of Lanai City, this system provides domestic water to Lanai City and excess can be diverted to irrigation through the Well 3 interconnect. Shaft 2 has a 500 Gallon Per Minute, electric line shaft pump at the shaft bottom. The pump could be lowered and capacity increased if greater flow required. There is probably some increased total water available, but significant investment in recovering more may not be warranted until the present pump fails. The booster was replaced and upgraded in 1987. The tunnels continue to contribute, but flows have been inhibited by the drought. Work is required on the tunnel lines, replacement is inevitable, but not justified until a normal rainfall and water recovery pattern return.

Distribution System:

1988 Cost Maintenance:	$ 46,284
System Depreciation:	$ 74,743

Major areas of concern:

First Leg, from Well 1 to Koala. A main feeder to the south slope irrigation and Manele Bay Projects, this exposed pipe is subject to frequent failures. Requests to Lanai Company, for approximately $75,000 for replacement of this section, have received no approval. Repairs to this section will contaminate the lines, causing continued Department of Health involvement and public relations problems - which will escalate as the hotel complex develops.

Well 5 feeder enters the system at this section of First Leg. Failures continue in Field 5409 and upgrading of this rather short section should be included with the above.

Extension to Field 5517, in west slope of Palawai Basin. This underground section has frequent breaks, may be caused by some faulty pipes in original 1964 installation. A unique situation, confined to a small area.

Overall condition. The complex, in years past, had a cathodic protection system. These installations fell out of favor with hydrologists and hydraulic engineers and the Plantation system was not maintained. The question of possible external corrosion has been raised again, and the Plantation has hired a consulting firm to make an evaluation of our system. We hope to receive firm direction regarding the possible need to reinstitute the cathodic protection system, or feel confident that it is not needed.

The internal corrosion was inhibited by addition of lime at each pumping station. We were required to stop this practice when the Manele withdrawal for the small boat harbor was declared potable. The above mentioned study should also answer the question of internal corrosion.

Well 7 has a direct feed into the irrigation system in the north end of the Plantation. This is in place and ready to go.

Well 6 was assumed to be tied into the Maunalei feeder, but Dr. Kumagai suggested a separate feeder to the Koele Lodge interconnect. A requested estimate for this by M&E Pacific appears to be out-of-line, with $55,000 engineering fees and an estimated cost in excess of $600,000 for the 3,200 ft. of piping required.

J. H. Parker

cc: R L Hawthorne
E T Oyama