THE WERI WELL ON TRUK:
A SOLAR PHOTOVOLTAIC PUMPING PROJECT

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Water and Energy Research Institute of the Western Pacific

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Partial Project Completion Report

for

Truk State Government

Federated States of Micronesia

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INTRODUCTION

Truk State is one of the four states in the Federated States of Micronesia. It consists of all the islands in Truk lagoon (hereafter referred to as Truk), the Mortlock Islands south of Truk, and a number of atoll islands to the west and north of Truk. All of these islands are located in the Eastern Caroline Islands roughly between 148° and 154° east longitude and 5° and 9° north latitude. The only high volcanic islands in Truk State are located within the Truk lagoon. All the other islands in the State are low and coralline and are generally situated on the reefs defining the various atolls.

Truk enjoys a tropical island climate with an average daily temperature of approximately 81° F. The average annual rainfall for Truk is approximately 145 inches; however, the rainfall is not uniform and distinct wet and dry seasons occur. The rainfall may vary significantly from year to year and droughts are common. The climate on the other islands in Truk State is similar, although accurate weather data are not available.

Most of Truk State is not served by central water supply and sewer systems. In these areas, traditional methods of obtaining potable water and disposing of wastewater must be used. Sources of potable water on high islands include streams, springs, shallow wells, and rainwater catchment systems. On low islands streams and springs are not available. Wastewater from washing clothing and kitchenware and from bathing is simply allowed to fall to the ground in the washing area. Toilet facilities consist of over-land or over-water benjos (outhouses) or water-sealed toilets.

Unfortunately, traditional methods of water supply in Truk State often do not provide water of adequate quality and in sufficient quantity. Surface and groundwater are often contaminated because of animal and human wastes. Rooftop catchment systems, which produce the highest quality water, generally are not functional during the dry season (January through March) because of insufficient catchment area and/or storage capacity. Perennial streams do not exist in all villages and, in the dry season, the yield of shallow wells may be seriously reduced or eliminated completely. The result is great inconvenience for the local people (i.e., carrying water for a long distance), compounded by increased consumption of water of marginal quality (i.e., no rooftop water available).

During the past year (1982) a cholera epidemic took place in Truk State. This emphasized the need for safe potable water supplies and, as a result, funds from the U.S.A. became available for assistance with a number of projects:

1. construction of water-sealed toilets

2. construction of ferro cement rainwater storage tanks

3. construction of shallow solar-powered (photovoltaic cell) wells

This report describes portions of the third project.

OBJECTIVES AND SCOPE

The Water and Energy Research Institute (WERI) was contracted by the Truk State government to perform a number of tasks:

1. Design a simple "standard" solar pumping system suitable for extracting ground water from low atoll islands or flat sandy coastal areas of high islands.

2. Provide an illustrated instruction manual for the installation of such systems.

3. Procure hardware required for the installation of a minimum of 150 such systems.

4. Install approximately 25 such systems.

5. Train Rural Sanitation Program personnel in the installation of such systems.

6. Design, procure hardware for, and install "special" solar pumping systems as required. Such systems might involve pumping larger quantities of water, pumping to higher elevations, pumping over longer distances, etc.

This report covers the design and installation of the "standard" solar pumping system (items 1 and 4 above).

DESIGN

Figure 1 is a photograph of a completed installation of a "standard" solar pumping system, hereafter referred to as a "WERI Well". Figure 2 is an assembly drawing for the "WERI Well" and Table 1 is a listing of all components of the well and their function. Figure 3 is the wiring diagram for the well.

The principle of operation of the "WERI Well" is quite simple. The solar panels, composed of photovoltaic cells, generate D. C. electricity at approximately 12 volts when they are exposed to sunlight. A small 12 volt submersible marine bilge pump is wired to the panels and operates whenever the panels generate sufficient power.

The "WERI Well" was designed to incorporate a number of features:

1. Simplicity/reliability. There is only one moving part in the system, the 12 volt marine bilge pump. There are no batteries, voltage regulators, switches, etc.

2. Ease of maintenance. It is probable that the only component of the system that may fail is the pump. Its cost is approximately $8; it is expendable and can be replaced in minutes.

Figure 1. A completed "WERI WELL" installation.

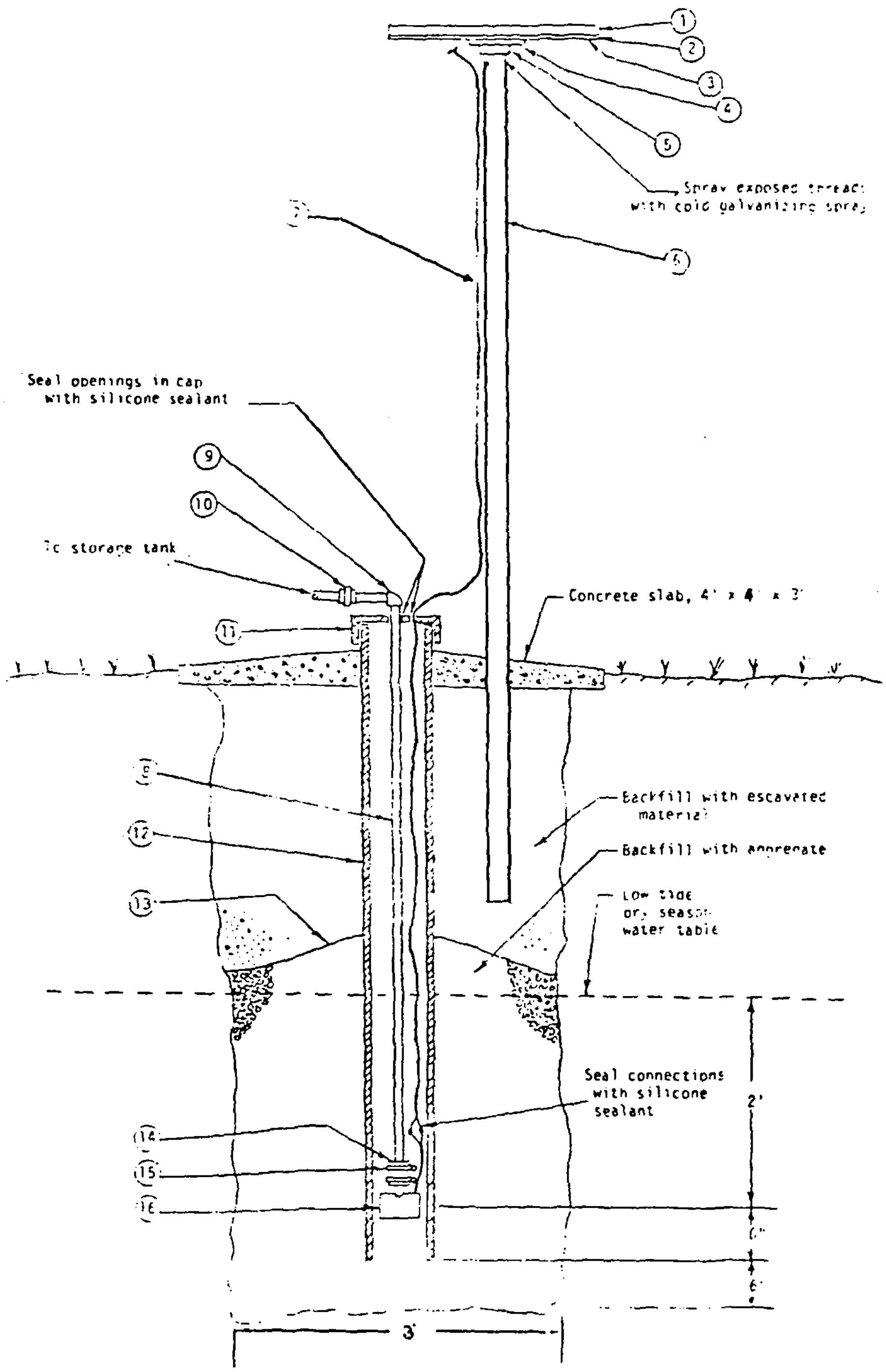

Figure 2. Assembly drawing of the "WERI Well." (not to scale)

Table 1. List of material for "WERI Well".

Item No.	Quantity	Description	Function
1	2	28 watt solar module, SPC LG160-12	generates 12v electricity from sunlight
2	1	2'x4'x½" marine plywood, treated & painted	mounting for solar modules
3	8	1/4" x 20 x 1" long, aluminum hex head cap screws, nuts, and washers	fastens solar modules to plywood mounting
4	5	1/4" x 20 x 1½" long glavanized carriage bolts, nuts, and washers	fastens plywood mounting to flange
5	1	2" galvanized steel floor flange	connects 2" pipe to solar module assembly
6	10' provided	2" galvanized steel water pipe (threaded on one end)	support for solar module assembly
7	20' provided	16-2 stranded wire	connects pump and solar module
8	40' provided	½" PVC water pipe	connects pump to storage tank (not shown)
9	6 provided	½" PVC elbow (socket ends)	provides for changes in pipe direction
10	1	½" PVC union (socket ends)	permits easy assembly and disassembly of well
11	1	6" PVC end cap	protects well from contamination
12	10' provided	6" PVC pipe	well casing
13	1	plastic sheet	prevents sand from entering aggregate
14	1	1" diameter x 6" long rubber hose	connects pump to ½" PVC pipe
15	2	1" stainless steel hose clamp	clamps hose to pipe and pump
16	1	Rule 400 gph pump	pumps water from well

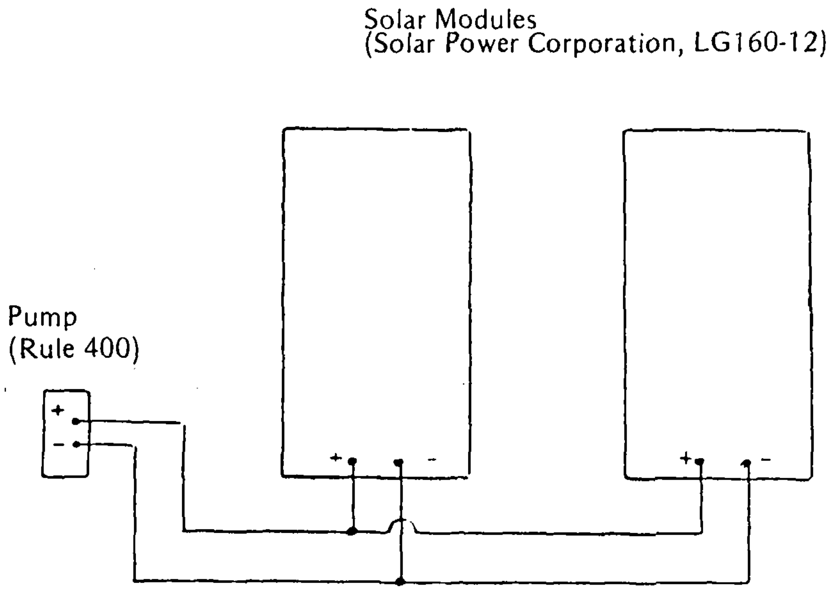

Figure 3. "WERI Well" wiring diagram.

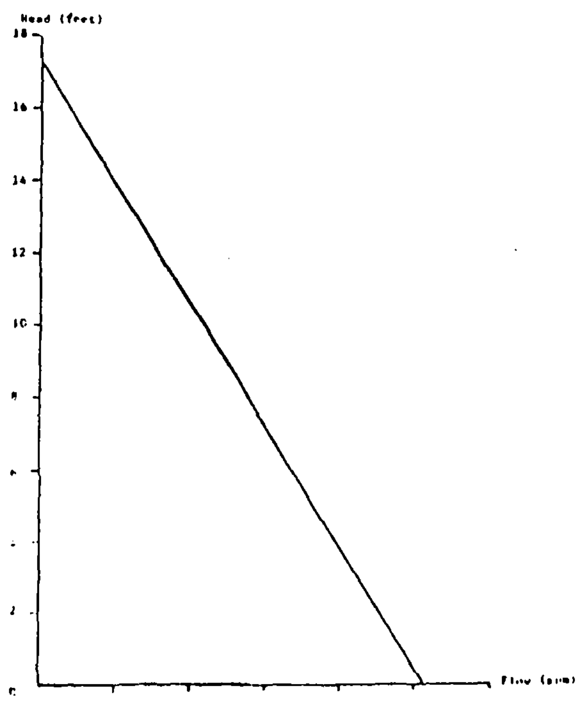

Figure 4. Pump curve for Rule 400 pump and two Solar Power Corporation LG160-12 solar panels.

3. Assistance to rainwater catchment systems. The system operates "at the will of the sun". It is intended to complement a roof top rainwater catchment system. The well will function on clear/dry days; rainwater catchment systems function on cloudy/rainy days.

4. Ease of construction. After the hole is dug and the required amount of aggregate gathered, the installation of the system takes approximately 2 hours.

5. Improved sanitation. The well is sealed from surface runoff which minimizes the risk of contamination from this source. However, it is emphasized that water from the well should <u>not</u> be used for drinking unless proved safe by bacteriological tests.

6. Low cost. The cost per system is less than $1,000.

7. Overpumping difficult. The pumping rate for the well at 14 ft head (from water table to top of tank) is approximately 1 gpm (400 gal per day). It increases to approximately 2 gpm (800 gal per day) at 10 ft head. Figure 4 is a pump curve for the well. At these low pumping rates, it is very difficult to cause sea water intrusion or to pump the well dry.

Sometimes special field conditions dictate that modifications to the design are necessary. Three common conditions are:

1. Installation of the solar panels on a roof top (Figure 5) or installation of the panels and galvanized mounting pole at a *location remote from the well (Figure 6) in order to maximize* exposure to sunlight. The length of wire from the panels to the pump should not exceed 100 ft. The following minimum wire sizes are recommended:

length of wire	wire size
less than 50 ft	no. 16 (supplied with "WERI Well" kit)
50 to 75 ft	no. 14
75 to 100 ft	no. 12

   In all cases, stranded wire should be used.

2. Use of an existing well. Sometimes it is convenient to place the pump in an existing well rather than dig a new one. The well can be back filled with aggregate and covered with a concrete slab as in the "WERI Well" design (Figure 7) or a reinforced slab can be poured elsewhere, cured, and laid on the well. Generally, a short piece of well casing (approximately 2 ft) is bonded to the slab to serve as a convenient location for mounting the ½ in PVC well pipe (Figure 8).

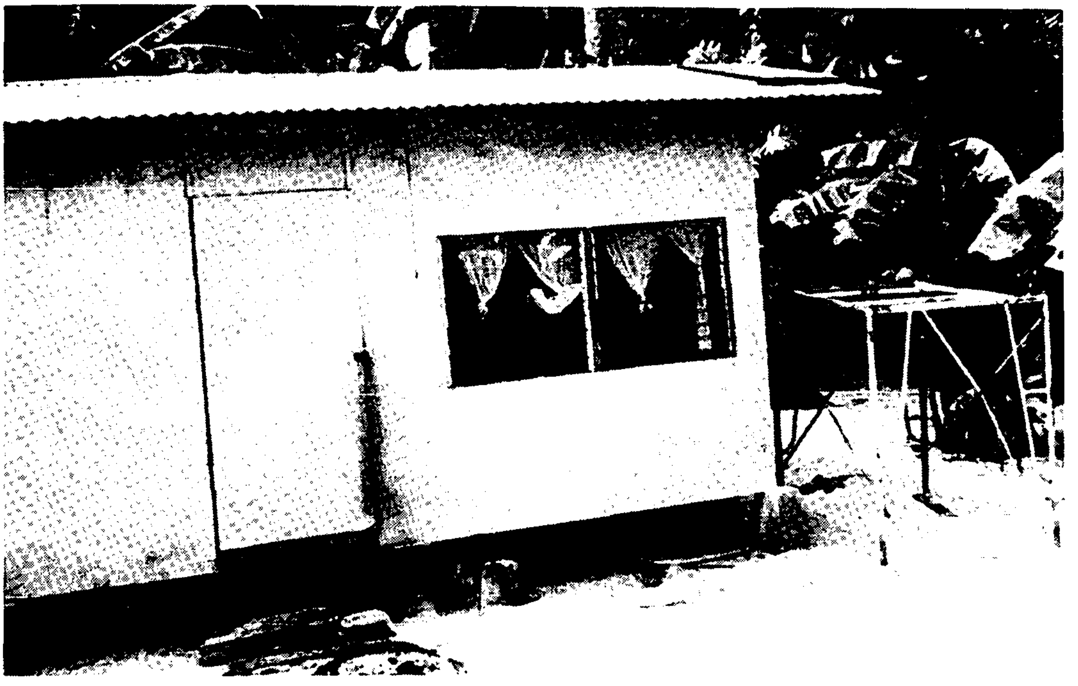

Figure 5. Solar panels on rooftop.

Figure 6. Solar panels on standard pole mount at a location remote from well.

Figure 7. Use of an existing well for a modified "WERI WELL" installation.

Figure 8. Pouring a slab to seal an existing well for a modified "WERI WELL" installation.

3. Installation of a 55 gallon drum below the water table. In areas where the sand contains little soil, root material, etc. to hold it together, caving can occur when digging below the water table. By digging from within a 55 gallon drum (with top and bottom removed) while gradually sinking it into the sand, caving will not occur (Figure 9). This adds to the safety of the digging operation and will probably increase the overall life of the well. This modification to the "WERI Well" design merits serious consideration in almost all installations.

This report does not specifically address storage tank construction. However, two factors related to well performance are important:

1. The water supply from the well to the tank should be to the top of the tank (Figure 10). If the supply is to the bottom, the head on the pump will decrease considerably and might cause overpumping of the well.

2. A faucet can be placed in the feed line to the tank (Figure 10). On partially cloudy days or when the sun is not too high, the pump may have sufficient power to pump water to the faucet. This will lengthen the period of operation of the well. The faucet should be left closed when not in use.

Of course, the storage tank should be equipped with a drain line, tap, and overflow line.

SITE SELECTION

The following criteria are used to select a site (Figure 11) for installation of a "WERI Well" (Figure 12):

1. Unavailability of public utilities (it is cheaper to use central power if available)

2. Flat sandy coastal area (so well depth will not exceed pumping capability of pump) (Figure 11)

3. Open area (accessibility of sunlight)

4. Government property (preferred) close to a village (so there will not be any land disputes)

5. Away from privys and taro patches (to prevent possible water contamination).

Figure 9. Digging below the water table from within a 55 gallon drum.

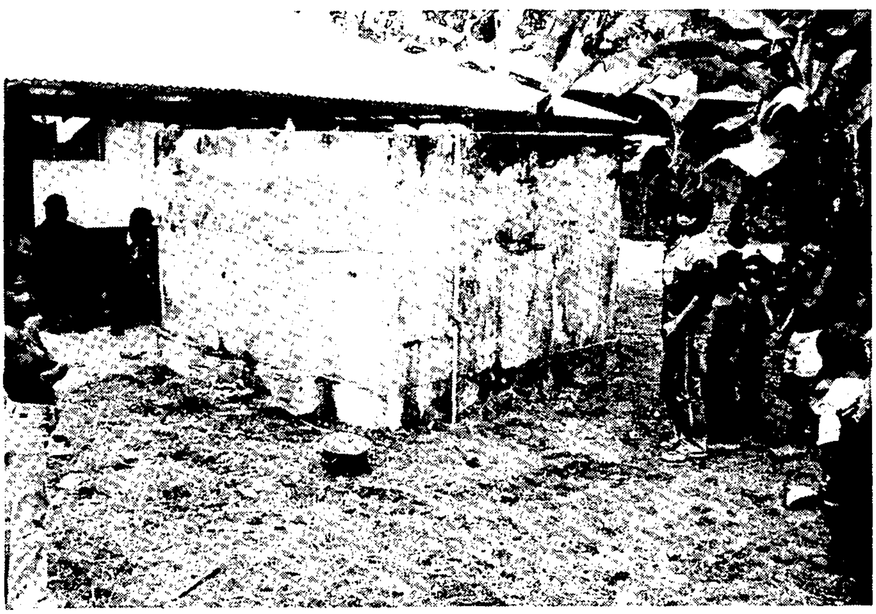

Figure 10. Typical piping arrangement and faucet location at storage tank.

Figure 11. Typical site for "WERI WELL" installation.

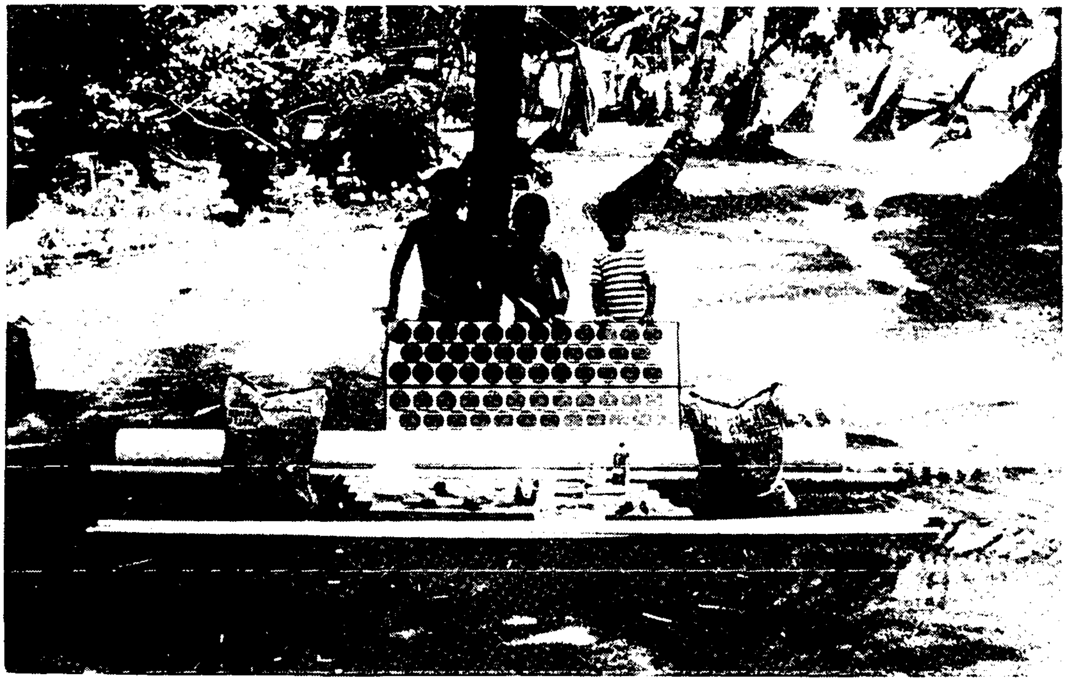

Figure 12. The "WERI WELL" kit.

The following sequence of figures illustrates the procedure for installing the "WERI WELL":

Figure 13. Digging the hole. The hole should be 3 feet by 3 feet and at least 3 feet below the low tide water level.

Figure 14. Disinfecting the well. Add chlorox, calcium hypochlorite, or other disinfectant to the well through the well casing. This will disinfect both the well and piping system. The taste of chlorine will disappear in a few days.

Figure 15. Backfilling with aggregate, step 1. Place about 6 inches of aggregate in the bottom of the well.

Figure 16. Placing the well casing. Place the 6-inch PVC pipe in the center of the well. This pipe will serve as the well casing.

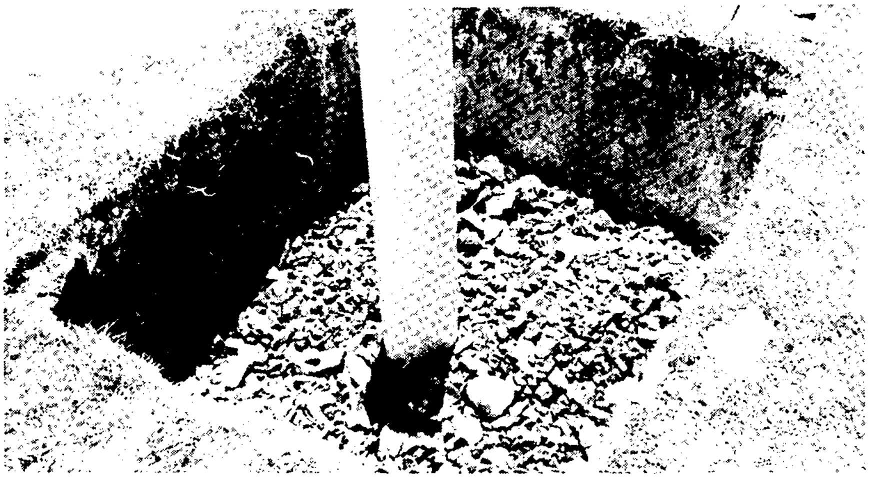

Figure 17. Backfilling with aggregrate, step 2. Carefully place aggregate in the well around the 6-inch pipe until it reaches the water level.

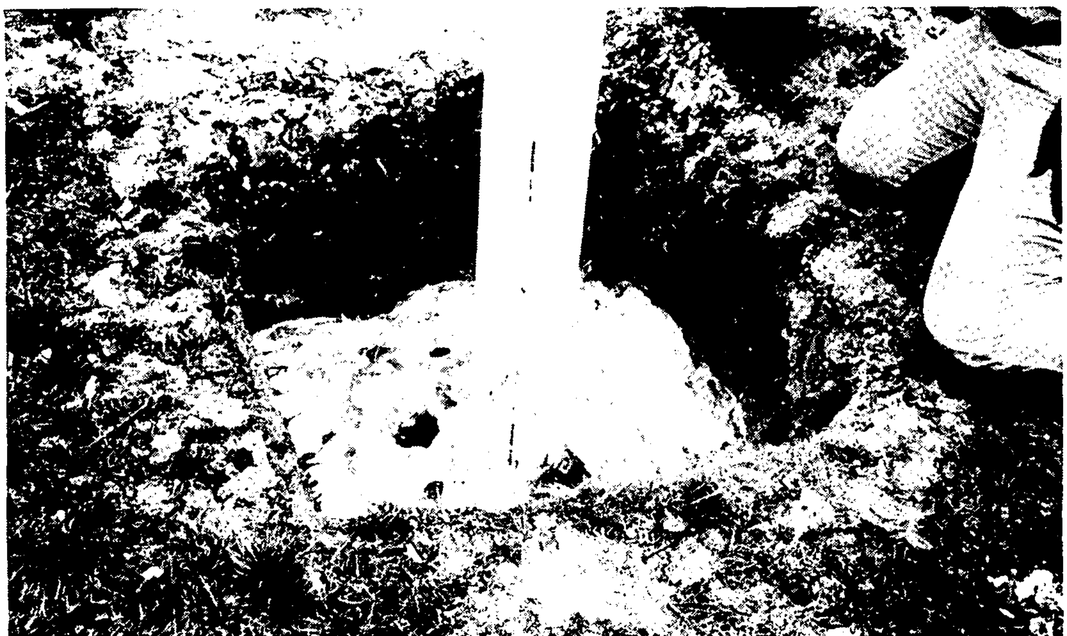

Figure 18. Placing the plastic liner. Make a small hole in the center of the plastic sheet and slide it down the 6-inch pipe and over the surface of the aggregate.

Figure 19. Backfilling with sand. Backfill the remaining portion of the well with sand originally dug from the well. Tamp it thoroughly every 6 inches.

Figure 20. Cutting the well casing. Saw off the well casing approximately 1 foot above the ground.

Figure 21. Connecting the pump and hose. Using a hose clamp, connect the 3-inch long piece of rubber hose to the pump.

Figure 22. Connecting the well pipe and hose. Use another hose clamp to connect the other end of the rubber hose to a 10-foot length of ½-inch PVC pipe (the well pipe).

Figure 23. Installing the pump. Place the well pipe/pump assembly in the well casing, allowing the pump to rest on the aggregate at the bottom of the well (photo on the left).

Figure 24. Installing the well cap. Place the 6-inch PVC pipe cap (the well cap) over the end of the well and fit the cap snugly on the well casing (photo on the right).

Figure 25. Measuring the well pipe. Lift the well pipe/pump assembly 6 inches off the bottom of the well and mark the pipe where it comes out of the well cap (photo on the left).

Figure 26. Cutting the well pipe. Cut the well pipe off at the mark (photo on the right).

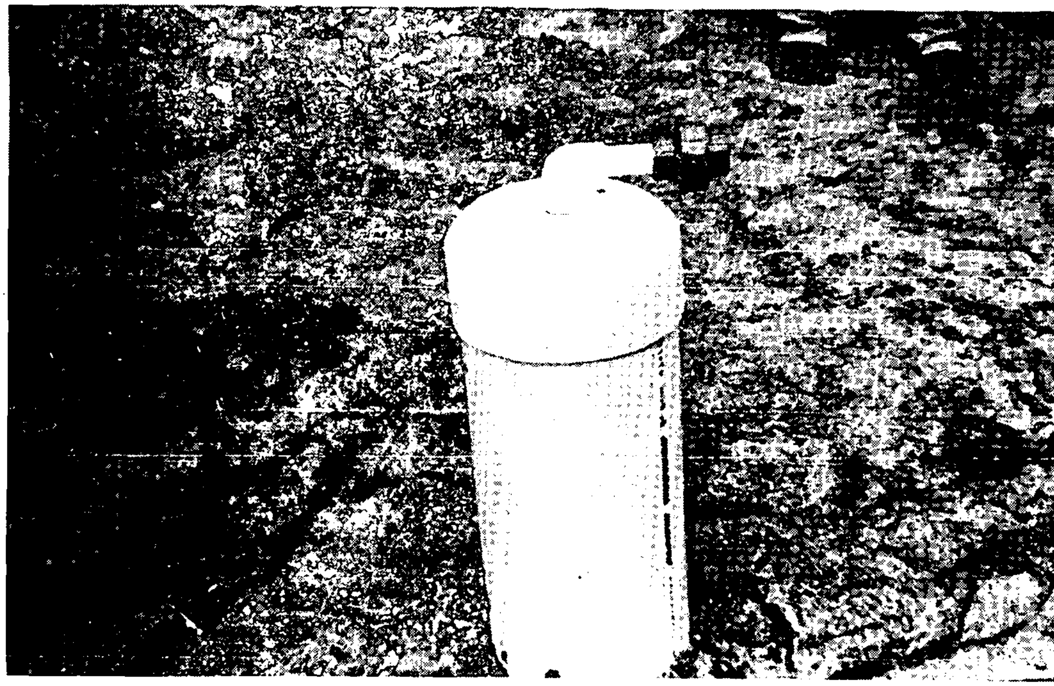

Figure 27. Installing the union/elbow assembly. Use PVC glue to attach the elbow end of the assembly to the well pipe. (Note: before gluing, rough edges of the pipe end should be removed with a knife and the end of the pipe should be sanded lightly). After gluing, the elbow will rest on the well cap keeping the pump 6 inches from the aggregate at the bottom of the well.

Figure 28. Removing the well pipe/pump assembly. Lift up the well cap and remove the well pipe/pump assembly from the well casing.

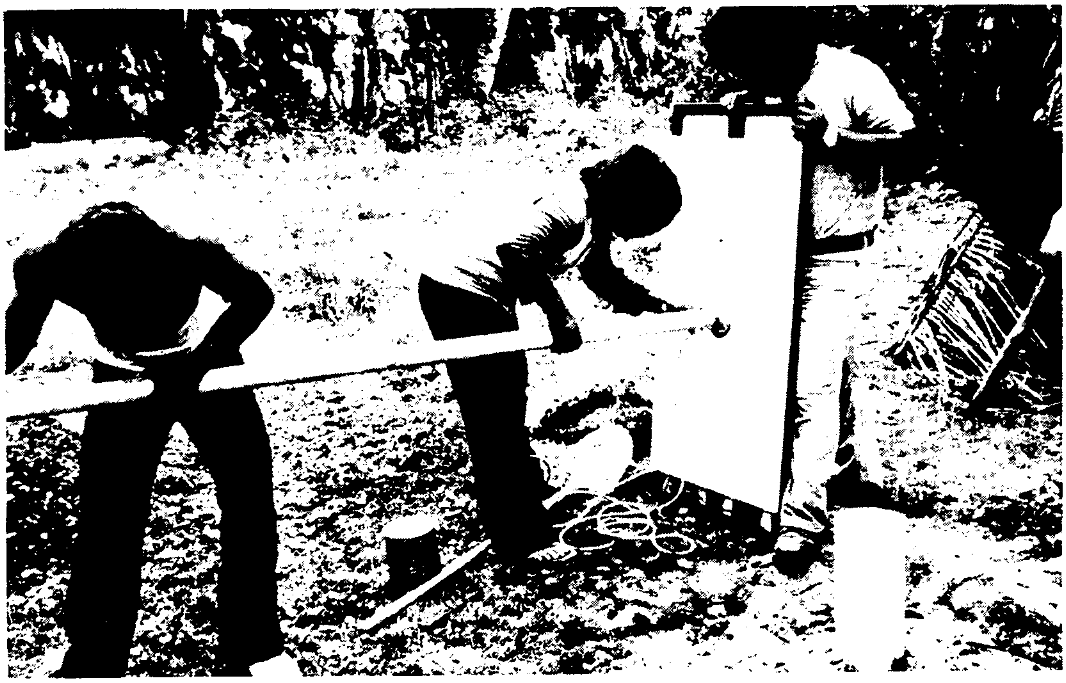

Figure 29. Attaching the galvanized pipe. Screw the 10 foot long piece of 2-inch galvanized pipe into the flange (located on the back of the solar panel assembly) until it is snug.

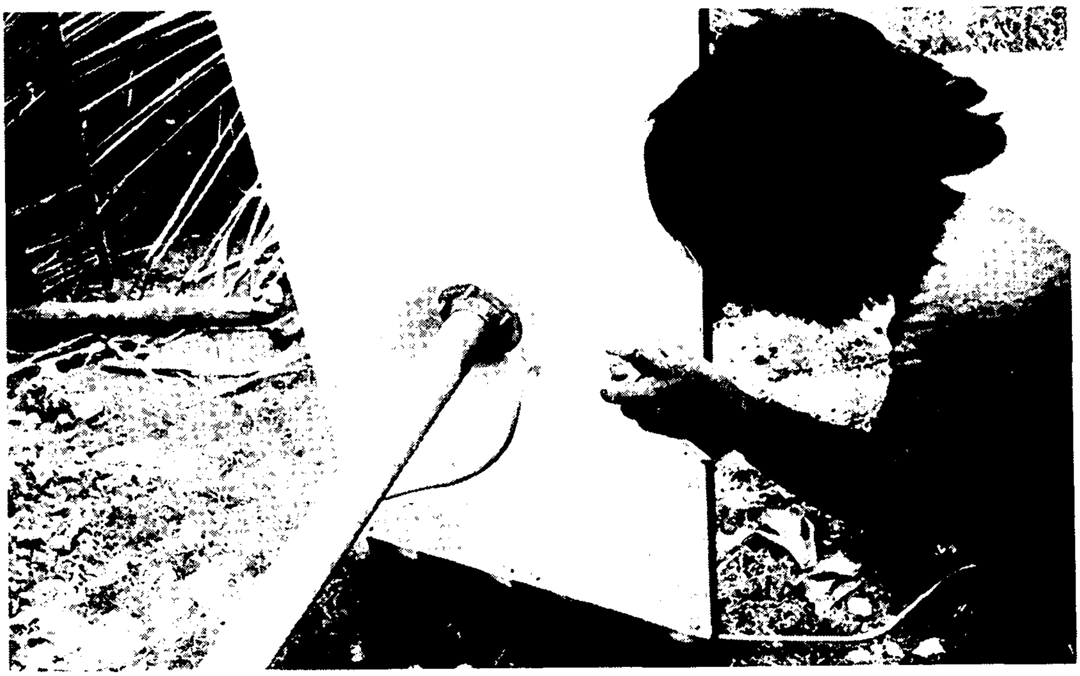

Figure 30. Spraying the pipe. Apply the cold galvanizing spray to the threaded end of the galvanized pipe to prevent rust. (Note: The face of the solar panels should remain covered with cardboard or cloth until the well installation is complete).

Figure 31. Installing the solar panels Raise the solar panel/pipe assembly and place the pipe end at least 1 foot in the backfilled sand near the well casing (A concrete slab will later be poured around the galvanized pipe and well casing) (photo on the left).

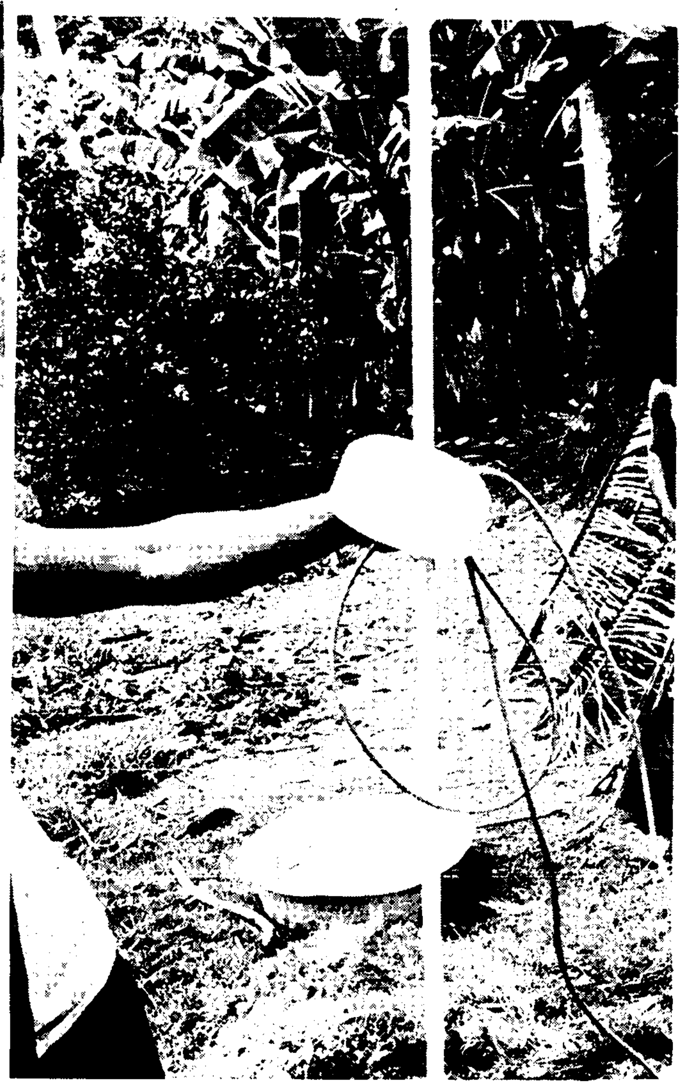

Figure 32. Connecting the wiring, step 1. Insert the electrical cord from the solar panels through the pre-drilled hole in the well cap (photo on the right).

Figure 33. Connecting the wiring, step 2. Connect the white wire from the solar panel cord to the white wire from the pump cord by twisting them together. Do the same for the dark wires.

Figure 34. Insulating the connection. Apply silicone sealant to the connecting wires.

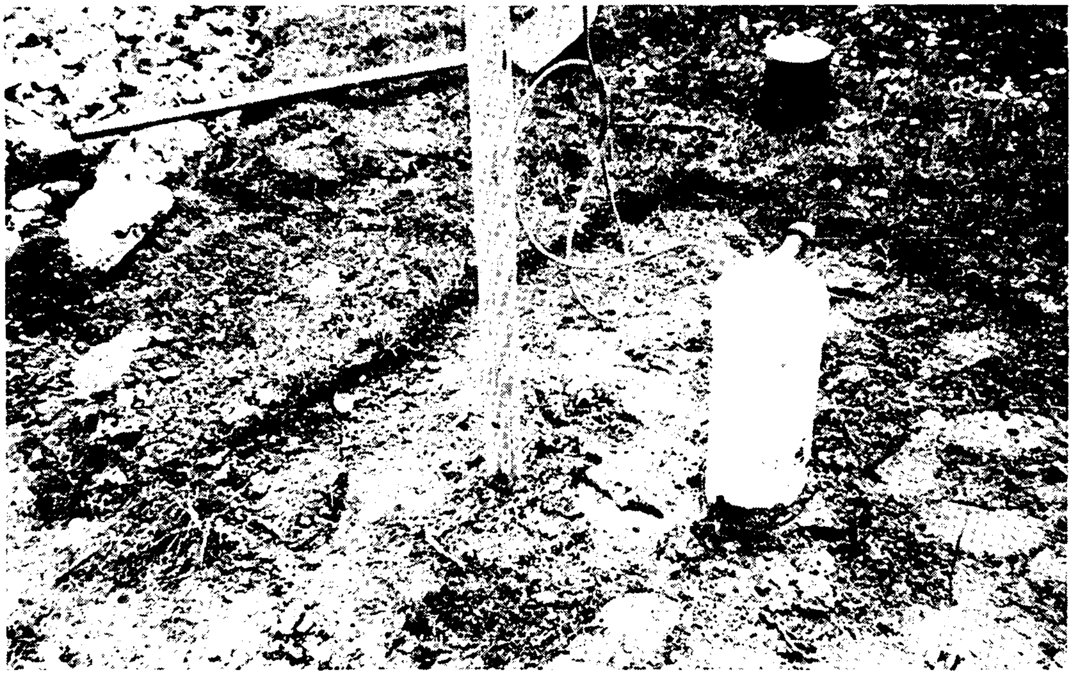

Figure 35. Reinstalling the pump. After the silicone sealant has "skinned over", place the well pipe/pump assembly back in the well casing and reinstall the well cap.

Figure 36. Running the ½-inch PVC pipe. Run pipe from the well to the tank location. The pipe should be buried slightly below the ground to help protect it from damage.

Figure 37. Pouring the slab. Use the 2-inch by 4-inch lumber to make a 4 feet by 4 feet form around the well, mix concrete, and pour into the form.

Figure 38. Energizing the pump. Remove the cardboard or cloth from the face of the panels. If there is sunlight, the pump will begin the run.

OPERATION

"The "WERI Well" is designed to operate only during the hours when the sun is fairly high in the sky (roughly from 9 a.m. to 3 p.m.). Should it be necessary to stop pumping water during the day, a piece of cardboard or other lightweight material should be carefully placed over the panels to block the sunlight.

MAINTENANCE

The only maintenance that the "WERI Well" requires is the occasional rinsing of the surface of the solar panels. If the well fails to deliver water on a sunny day, the following steps should be taken:

1. Check the panels for damage. If a panel is damaged, it must be replaced.

2. Check for and remove any debris that may be on the surface of the panels.

3. Check the electrical cord and repair any damaged portions.

   To open the well or gain access to the pump, the two halves of the union should be disconnected (be careful not to lose the rubber o-ring). The well cap can then be removed from the casing along with the well pipe/pump assembly (Figure 28).

4. Check that the water in the well is deep enough to cover the pump. If it is not, the well may have to be abandoned or dug deeper and reconstructed (this should not occur if the well was installed correctly).

5. Check for and remove any debris from the pump filter.

6. If all of the above items check out satisfactorily, the pump has probably failed. Remove the pump and replace it with a new one (see INSTALLATION section of this report for information on pump installation).

7 If the well still does not function, one or both of the solar panels have become defective (this is very unlikely). The agency who installed the well should be contacted to check the panels.

CONCLUSIONS

This report is based on the installation of over 20 "WERI Wells" in Truk State. It is believed that all are functioning according to design specifications. Over 100 additional wells will be installed in Truk State in the near future by local personnel. Owing to the comparative success of this project (compared to many others in Micronesia), serious consideration should be given elsewhere to the use of the "WERI Well" to address water supply problems. It is cautioned, however, that the installation of a great number of the wells in a small area or of a larger capacity well should be preceded by a groundwater assessment.

ACKNOWLEDGEMENTS

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