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THE CALIFORNIA STANDARD COMPANY
7TH AVENUE & RAGLAN STREET • VIRDEN, MANITOBA
MAILING ADDRESS: P.O. BOX 100

December 21, 1964.

The Oil and Natural Gas Conservation Board,
Department of Mines and Natural Resources,
Province of Manitoba.
WINNIPEG 1, Manitoba.

Attention: Mr. J. G. Cowan,
Chairman

Dear Sir:

The California Standard Company, under and pursuant to The Mines Act, Revised Statutes of Manitoba 1954, and amendments thereto, hereby, on behalf of itself and other Working Interest Owners in the Virden Roselea Field, requests the Board to hold a hearing to consider and approve the following:

(1) "PLAN FOR UNIT OPERATION GOVERNING THE UNITIZED MANAGEMENT OPERATION AND FURTHER DEVELOPMENT OF VIRDEN ROSELEA UNIT NO. 1" pursuant to Section 73 of The Mines Act.

(2) "PROPOSAL FOR PRESSURE MAINTENANCE BY WATER FLOODING" pursuant to Section 59 of The Mines Act.

(3) "APPLICATION FOR A UNIT MAXIMUM PERMISSIBLE RATE OF PRODUCTION" pursuant to Section 59 of The Mines Act.

Enclosed please find the following:

10 copies - "PLAN FOR UNIT OPERATION GOVERNING THE UNITIZED MANAGEMENT OPERATION AND DEVELOPMENT OF VIRDEN ROSELEA UNIT NO. 1".

10 copies - "PROPOSAL FOR PRESSURE MAINTENANCE BY WATER FLOODING".

The "PROPOSAL" for water flooding a portion of the pool includes an APPENDIX I relating to the investigation of the feasibility of water

flooding the Virden Roselea Field and APPENDIX II covering the physical details of the proposed water flood program.

10 copies - "APPLICATION FOR A UNIT MAXIMUM PERMISSIBLE RATE OF PRODUCTION".

At the hearing we would also like to refer the Board to the following references:

(1) Engineering Report entitled: "Waterflood Evaluation - Virden Roselea Field, Manitoba - September 1963".

(2) Rate Cumulative Decline Curves - Virden Roselea Field.

(3) Primary History and Prediction Curves for all wells and leases in proposed Unit area.

In addition we are also enclosing the following information which has been requested by the Board:

(1) A list of Royalty Owners in the proposed Unit Area which may assist the Board in sending out notices of the hearing.

(2) Discussion of Virden Roselea Unitization and Participation Formula.

An early consideration of our request would be greatly appreciated.

C. F. KIRKVOLD, Chairman,
VIRDEN ROSELEA OPERATORS COMMITTEE.

CFK/as

Encl.

# PROPOSAL FOR PRESSURE MAINTENANCE BY WATER FLOODING

The applicants propose to unitize a portion of the Virden Roselea Field. The proposed Unit Area is outlined in Figure 1 and consists of 76 wells, two of which are currently used for salt water disposal. The purpose in unitizing this portion of the Virden Roselea Field is to facilitate the operation of a water flood in the subject area. An engineering report entitled "Waterflood Evaluation - Virden Roselea Field - Manitoba" and dated September, 1963, has been included in support of this submission.

The indicated ultimate primary recovery from the proposed Unit Area is 5,700,000 barrels. By comparison, water flood calculations indicate an estimated total ultimate primary plus secondary recovery of 15,000,000 barrels from the same area. A water flood project is planned for the subject area in order to recover the estimated 9,300,000 barrels of additional oil. The details regarding these estimates are provided in the report. Appendix I contains a summary of the investigation of the feasibility of waterflooding. An inverted 160 acre 9 spot pattern is planned for the Virden Roselea Waterflood. A detailed outline of the proposed waterflood program is presented in Appendix II.

Unitization of the area under application would enable all interest in the area to be merged so that this portion of the reservoir may be operated as a single property. Under unit operation a maximum recovery efficiency and reduced production costs may be attained when waterflooding is systematically applied to a large tract. This will be achieved by selecting injection wells without regard to property lines and by controlling injection and production rates to obtain a high degree of recovery efficiency.

Certain wells in the proposed Virden Roselea Waterflood are required for conversion to water injection. The owners must be ensured of a continued income from present wells including those converted to water injection. Additional production will be obtained from the water flood and the Unit must also provide a fair and equitable basis for sharing this benefit. The applicants submit that the participation formula provides a fair and equitable basis for sharing the unitized production.

It is noted in Figure I that the western edge of the proposed Virden Roselea Unit is bounded by producing wells which have been excluded from the unit and waterflood area. It is apparent from the high water production that the excluded area is operating under a strong natural water drive; therefore, inclusion of this portion of the field in the proposed Unit Area is considered unnecessary. It is anticipated that the wells offsetting the proposed Unit Area to the north will be included in a future unitized water flood. Steps have been taken to avoid any water flooding of lands excluded from the subject area. Notwithstanding the present exclusion of lands from the proposed Unit Area, if future development indicates they should be included, the Board may, at any time,

under Section 76 of The Mines Act, hold a further hearing to consider the admission of these or any other lands to the Unit Area. Therefore, should any outside acreage be subsequently developed and proven productive, it could enter and participate in the Unit by order of the Board. Similarly, should it be deemed necessary or advantageous to water flood any of the currently proven and developed acreage which is presently excluded, it could also enter and participate in the Unit.

# APPENDIX I

## INVESTIGATION OF THE FEASIBILITY OF WATER FLOODING

The majority of the wells in the proposed Virden Roselea Unit area were drilled during the period 1954 to 1957 with the final completion being in 1962. The rapid production decline of individual wells indicated that some form of secondary recovery was necessary to increase the ultimate oil recovery from the field. Both geological and reservoir studies were therefore initiated to properly evaluate methods of secondary recovery.

Although flood tests have not been conducted on cores from the Virden Roselea Field, it is felt that the results of the laboratory tests on North Virden Scallion cores would be reasonably representative. The laboratory tests indicated that substantial additional oil could be recovered by water flooding. The "Water Flood Evaluation - Virden Rosela Field, Manitoba" dated September, 1963 may be briefly summarized as follows:

1. The size and structure of the reservoir was studied to obtain an estimate of oil in place.

2. An estimate of the ultimate primary oil reserves as a percentage of the estimated original oil in place was determined from decline curves.

3. The approximate amount of oil that could be obtained by water flooding the field was calculated using the laboratory water flood test data with consideration given to displacement efficiency and vertical and areal sweep efficiencies.

4. An estimate of the possible gain which may result from water flooding was obtained by comparing the ultimate primary with the ultimate water flood reserves estimate.

## SUMMARY OF PRIMARY RESERVES ESTIMATE

| | Cherty Zone | Oolitic Zone | Sandhill Zone | Crinoidal Zone | Total |
|---|---|---|---|---|---|
| Est.Surface Area - Acres | 3,040 | 3,040 | 1,980 | 1,560 | |
| Est.Average Pay Thickness - feet | 17.5 | 8.0 | 4.0 | 8.5 | |
| Est.Average Porosity - Percent | 13.3 | 11.1 | 12.2 | 9.8 | |
| Est.Average Water Saturation - % | 52 | 52 | 48 | 52 | |
| Est.Average Initial Oil Saturation - % | 48 | 48 | 52 | 48 | |
| Formation Volume Factor - Res.Bbls/ S.T. Bbl. | 1.05 | 1.05 | 1.05 | 1.05 | |
| Est.Oil-in-place -Bbls/Acre-ft. | 470 | 393 | 468 | 347 | |
| Total Est.Oil-in-place-Barrels | 25,000,000 | 9,600,000 | 3,700,000 | 4,600,000 | 42,900,000 |
| Total Est.Primary Rec.Oil-Bbls. | | | | | 5,700,000 |
| Est.Primary Rec.- % of Oil-in-Place | | | | | 13.3%* |

* Higher than in reservoir study because of higher recovery at five out of the additional six wells (Approx. 18.5%)

## SUMMARY OF ESTIMATE OF WATER FLOOD RESERVES

A summary of the water flood tests conducted on North Virden Scallion cores is presented since it is on the basis of these tests that the proposed Virden Roselea Water Flood is considered feasible.

Twenty-five core plugs were selected on the basis of permeability distribution plots. The distribution of plugs by zones is as follows:

| Zone | Number of Samples Selected | Number of Samples Water Flooded by CRC |
|---|---|---|
| Cherty | 17 | 7 |
| Oolitic | 5 | 3 |
| Crinoidal | 3 | 2 |
| Total | 25 | 12 |

In the laboratory, one inch diameter plugs were cut and resaturated to simulate reservoir oil and water saturations and viscosities. The plugs were then flooded with brine solution until production of oil had practically ceased. The results are tabulated below:

| | Cherty Zone | Oolitic Zone | Sandhill Zone | Crinoidal Zone |
|---|---|---|---|---|
| Initial oil saturation Fraction of pore volume | 0.76 | 0.79 | | 0.67 |
| Average oil saturation at breakthrough - Fraction of pore volume | 0.48 | 0.62 | | 0.42 |
| Average oil saturation at infinite WOR-Fraction of pore volume | 0.34 | 0.40 | | 0.25 |
| Average oil recoveries at breakthrough as % of original oil-in-place | 36% | 20% | | 38% |

Using the above mentioned laboratory data and calculation procedures, which take into account such factors as areal and vertical sweep efficiencies and are described more fully in the Reservoir Study, it has been estimated that a properly engineered water flood might increase the ultimate recovery for the proposed Unit Area to 35% of the original oil-in-place or 15,000,000 barrels. This is more than double the presently estimated 5,700,000 barrels expected under natural depletion.

APPENDIX II

## DETAILS OF OPERATION TO BE CONDUCTED IN UNIT AREA

### INTRODUCTION

The basic objective of the Virden Roselea Water Flood proposal is to recover the greatest amount of oil economically. Injectivity to a large degree controls the choice of flood pattern which is desirable in initiating a water flood. Injectivity calculations have been made which indicate an average zone capacity of 1.84 BWPD/md. ft. This suggests injection rates ranging up to 610 barrels per day with an average of about 255 barrels per day. These rates should be considered as illustrating the anticipated order of magnitude rather than the absolute values. The injectivity calculations indicate that the proposed Unit Area can be flooded using an inverted 9 spot pattern. The applicants propose to water flood each of the Crinoidal, Sandhill, Oolitic and Cherty Zones simultaneously. Completions are to be conducted in both injectors and producers with this in mind.

It is estimated that 3800 barrels of Devonian water per day will be injected into the reservoir through sixteen injection wells. Figure I shows the proposed Unit outline and the proposed injection wells. It may be noted that all injection wells are located on odd numbered legal subdivisions. An advantage of the inverted 160 acre 9 spot pattern is that the pattern can be converted to a complete 80 acre 5 spot pattern if injectivity should prove to be much lower than anticipated.

Producing wells have been excluded on the west flank of the proposed Unit Area. These wells are influenced by a strong natural water drive and reservoir pressure is being maintained. Water oil ratios have increased pronouncedly due to water encroachment, consequently, it is not considered desirable or necessary to include these wells in the water-flood project. A separate unit and water flood project, to include the producing wells along the north boundary of the subject area, is currently under study.

### A. Source of Water for Injection

The water source for the injection system will be Devonian water from the water supply well at 10-25-10-26. It is felt that this source is capable of supplying in excess of 5000 BWPD which should be sufficient for the calculated stabilized injectivity for the injection system.

### B. Injection Plant

The water injection plant will be located at Lsd. 10-25-10-26and will consist of two Johnston vertical turbine pumps which will take the water directly from the Reda submersible pump at the Devonian water supply and transfer it down the injection system.

C. High Pressure Injection System

It is proposed that all injection lines shall be cement lined nominal sized grade A line pipe, coated and wrapped and tested to a pressure greater than the anticipated injection pressure. Line losses were obtained from a set of flow curves for water based on the Hazen and Williams formula. A coefficient of friction of 100 was used for all cement lined steel pipe. The interior diameter of all steel pipe was reduced by 0.4 inches to allow for cement lining. In general, pipe sizes were selected to maintain line losses below 2 psi/1000 feet. Line sizes and calculated injection rates are shown in Figure 2. Line sizing has been selected to provide for increased capacity should it be required.

D. Salt Water Gathering System

Produced Mississippian water will be gathered at the Injection Plant and transferred by Calstan's existing gathering system to Lsd. 2-26-10-26 where it will be disposed into the Devonian formation. It is proposed that all required gathering lines, not currently in existence in the area will be cement lined steel. Figure 3 indicates the proposed salt water gathering system.

E. Conversion of Wells to Water Injection

It is the applicants' intention to flood the four oil bearing horizons (Crinoidal, Sandhill, Oolitic and Cherty) simultaneously. A schematic diagram of a typical injection well is shown in Figure 4. The following procedure outlines the program to be carried out in converting the wells to water injection. Additional remedial work such as restimulation, addition of plugging material, etc., may be required at a later date to rectify difficulties which cannot presently be anticipated.

1. Pull rods, pump and tubing.
2. Run casing scraper.
3. Re-run open-end tubing.
4. Reverse circulate hole to T.D.
5. Perform salt water injection test at maximum surface pressure of 1000 psi.
6. Acidize well-bore if indicated necessary in (5).
7. Pull tubing.
8. Place well on injection down the casing until such time as well is "pressured up".
9. Run plastic-lined tubing for injection string.
10. Fill casing annulus with oil.
11. Place well back on injection.

F. Capital Cost Estimates

The following is an estimate of the capital expenditures for the water flood project;

| | |
|---|---|
| Plant Costs | $ 33,000 |
| Injection System | 105,000 |
| Salt Water Gathering System | 28,000 |
| Water Supply | 68,000 |
| Injection Well Conversion | 75,000 |
| Battery Consolidation | 26,000 |
| Total | 335,000 |

## APPLICATION FOR A UNIT MAXIMUM PERMISSIBLE RATE OF PRODUCTION

The applicants propose that a degree of production flexibility which is consistent with good engineering practice, be provided for the Unit.

At the present time production may be considered to be unrestricted since the majority of the Virden Roselea wells are being produced at capacity. It is the applicants contention that no reservoir damage has resulted from producing these wells at capacity.

During the proposed water flood program, it is anticipated that water injection rates will be such that reservoir fluid withdrawals will be completely replaced. It is anticipated that the productive capacity of certain wells will be significantly increased. There is no reason to believe that reservoir damage would result from producing these increased capacity wells at unrestricted rates.

It is the applicants contention that Unit producing wells, where offset by non-unit producing wells should also be allowed to produce at unrestricted rates in order to fulfill the basic objective of the water flood, i.e., to recover the greatest amount of oil economically. There is no reason to believe that reservoir damage within the Unit Area would result by producing these wells at capacity, nor is there any reason to believe that non-unit oil would be produced within the Unit since the Unit well capacities would increase only as a direct result of the unitized water flood and therefore the increased production would be made up of oil from the Unit Area only. There is also no reason to believe that reservoir damage outside the Unit Area would result or that the production at offsetting non-unit wells would be in any way affected by the production of Unit boundary wells at unrestricted rates.

The applicants respectfully request that, on and after the first day the Virden Roselea Unit becomes effective, the Unit be excluded from any provisions governing the limitations and allocation of production of oil.

# DISCUSSION OF THE VIRDEN ROSELEA UNITIZATION AND PARTICIPATION FORMULA

Previous reports have demonstrated the increase in oil production rate and ultimate recovery which is to be achieved under water flooding. An efficient water flood program requires the selection of injection wells without regard to property lines and with a control of injection and production rates to obtain maximum recovery from the reservoir. In order to institute the most efficient water flood, it is therefore necessary that the field be unitized.

Unitization of any field or portion of a field requires incentive. We believe there is a great deal of incentive for the owners to unitize their producing properties in the proposed Virden Roselea Unit area. The incentive is provided in the form of increased producing rates, additional oil recovery, lower capital costs, lower producing costs and as a result, a substantial increase in income.

A major problem in accomplishing the unitization of a producing area is to determine the most suitable basis for participation. Every possible attempt should be made to insure a minimum dislocation of current income for all owners. The present producing wells in the proposed unit area cover a wide range of productivities. There is a certain amount of month to month variation in the production from specific wells due to several contingencies. A stipulated six month test period has therefore been selected by the operators in arriving at a respresentative current producing rate for each well. This has been expressed as a current production factor and is the percentage calculated by dividing the oil production for each tract during the test interval by the total oil production of all tracts during the test interval and multiplied by one hundred.

A further consideration in determining participation is to provide a fair basis for sharing the additional oil which will be recovered by the water flood. One of the conventional procedures for estimating oil reserves, which may be attributable to water flooding, is to prepare a volumetric estimate of the oil saturated reservoir which may be effectively flushed and apply an appropriate flushing efficiency. Certain conditions exist in this area which render it difficult to calculate, with any degree of accuracy, the water flood reserves that can be attributed to individual leases or tracts of land. The drilling and completion procedures were such that most of the wells did not penetrate the entire Cherty Zone which is the deepest and the main producing horizon. Wells that were drilled through the entire producing interval show that there is no uniformity to the base of effective oil saturation. In addition, the logs and core analyses available indicate considerable lateral variation in the hydrocarbon pore volume of the many producing zones throughout the field. A program of deepening these wells including extensive coring, logging and testing procedures would provide a great deal of engineering data to enable making more reliable estimates of the water flood reserves attributable to individual leases or tracts of land. The cost of such a program

would however be prohibitive and the expenditure cannot be justified. In consideration of these circumstances, the Operators' Committee proposed that alternative procedures for estimating water flood reserves attributable to individual leases should be pursued.

Where wells were produced at capacity, production history is, for the most part, a measure of the effective reserves and may be used as a general guide in estimating water flood potential. Porosity, permeability and effective oil saturation are all factors which contribute to well performance. Where porosity, permeability and oil saturation are high, they should generally be reflected by a good producing rate and low water cut. These same conditions will generally afford a high potential for water flood recovery. Conversely, low producing rate and high water cut would be indicative of a lower water flood potential. For two wells having the same initial producing characteristics, the one which has produced for the longer time will have reached the more advanced stage of primary depletion and will have exhibited the greater production decline. Consequently, this well could not be expected to have as much oil left to produce under water flood. It is therefore recognized that the length of time during which a well has been on production and the decline rate it has established are also factors in such an analysis. A parameter which is readily calculable and generally recognizes all of these considerations is a cumulative average producing rate which includes a water production penalty. This factor is referred to as the average monthly oil production factor penalized for water production. A detailed description of the method followed in arriving at this factor is outlined in the "Plan for Unit Operation".

The majority of members of the Virden Roselea Operators' Committee have agreed that the two factors, namely current production factor and average monthly oil production factor penalized for water production, provide a satisfactory basis for unitization and sharing of remaining primary and water flood reserves. These two factors have the advantage of being readily and precisely determinable. A further consideration then becomes the relative weighting to give to each factor in providing a participation formula. The report entitled "Waterflood Evaluation - Virden Roselea Field, Manitoba" and dated September, 1963 indicates a primary reserve of 5,300,000* barrels in the proposed unit area of which there will be approximately 2,100,000* barrels remaining as of January 1, 1965. The report further estimates an additional 9,100,000* barrels will be recovered by water flooding. The Operators' Committee, however, believe that greater emphasis must be placed on the production which is immediately recoverable than the production which will be obtained towards the termination of the water flood project life. This is considered necessary to prevent any abrupt and significant changes in production and income allocated to individual tracts as a result of unitization. The Operators' Committee has therefore recommended that each of the two factors previously discussed be given equal weighting of 50 percent in arriving at the participation formula. This in summary, outlines the development of the participation formula which is being presented and the reasoning behind the recommendation that it is an equitable basis for unitization.

* Six additional wells are being included in the proposed Unit Area that were not included in the reservoir report, therefore the following revisions are necessary:

Ultimate Primary Reserves- 5,700,000 Bbls. instead of 5,300,000 Bbls.
Remaining Primary Reserves 12/31/64- 2,400,000 Bbls. instead of 2,100,000 Bbls.
Additional Oil Due to Waterflooding- 9,300,000 Bbls. instead of 9,100,000 Bbls.

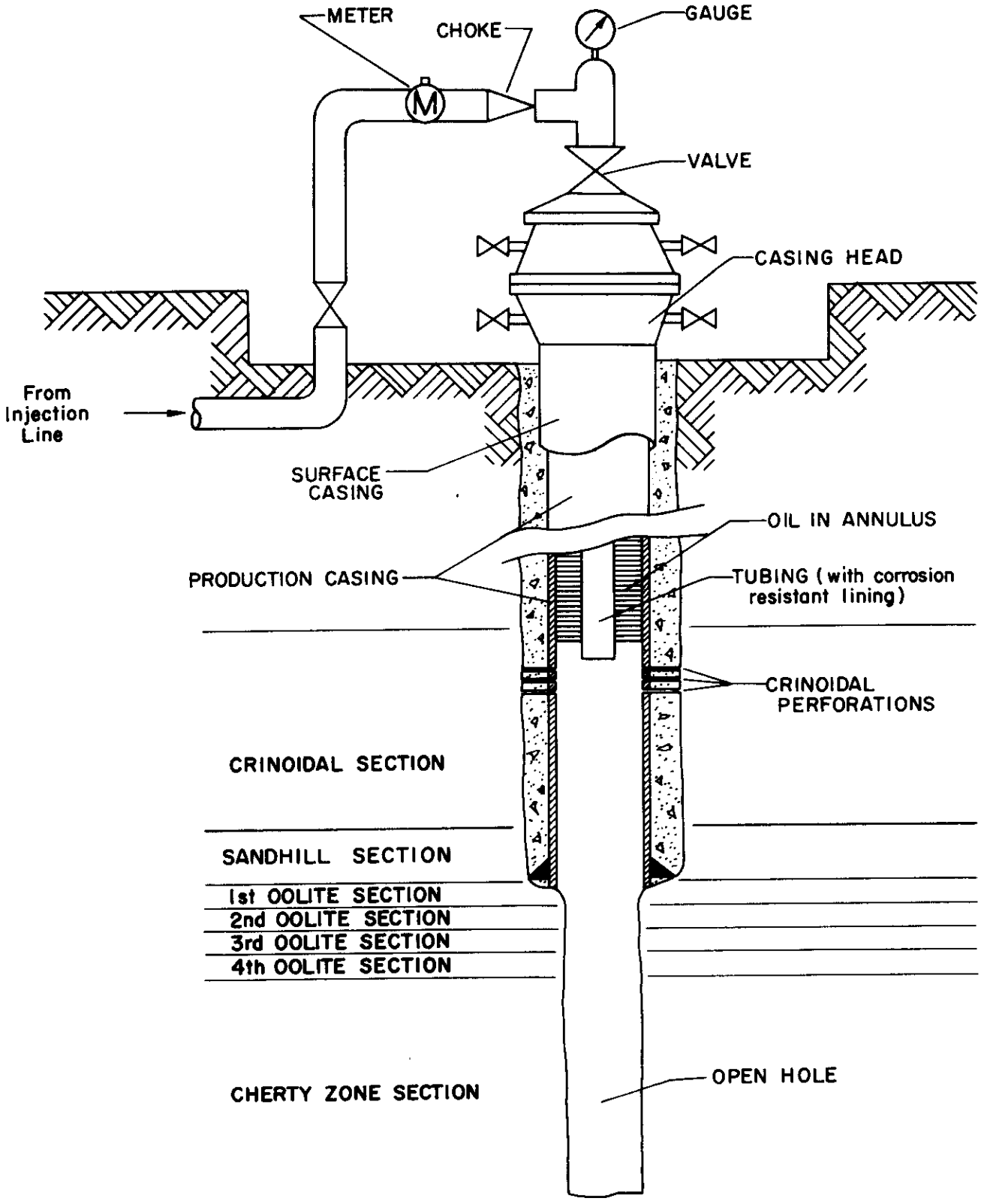


FIGURE 4

PROPOSED VIRDEN ROSELEA UNIT
TYPICAL INJECTION WELL

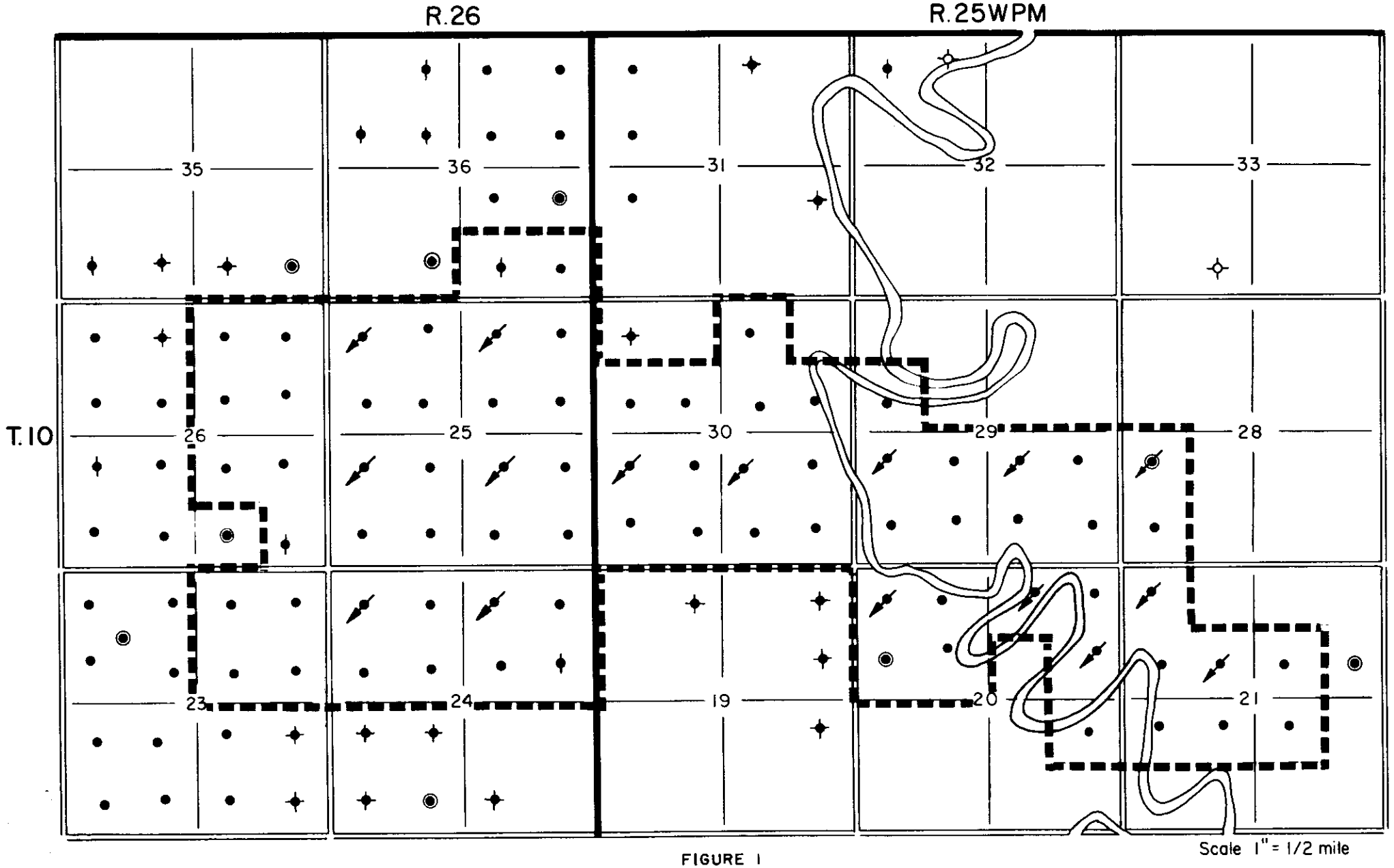


FIGURE 1

# PROPOSED VIRDEN ROSELEA UNIT
# WATER FLOOD PATTERN

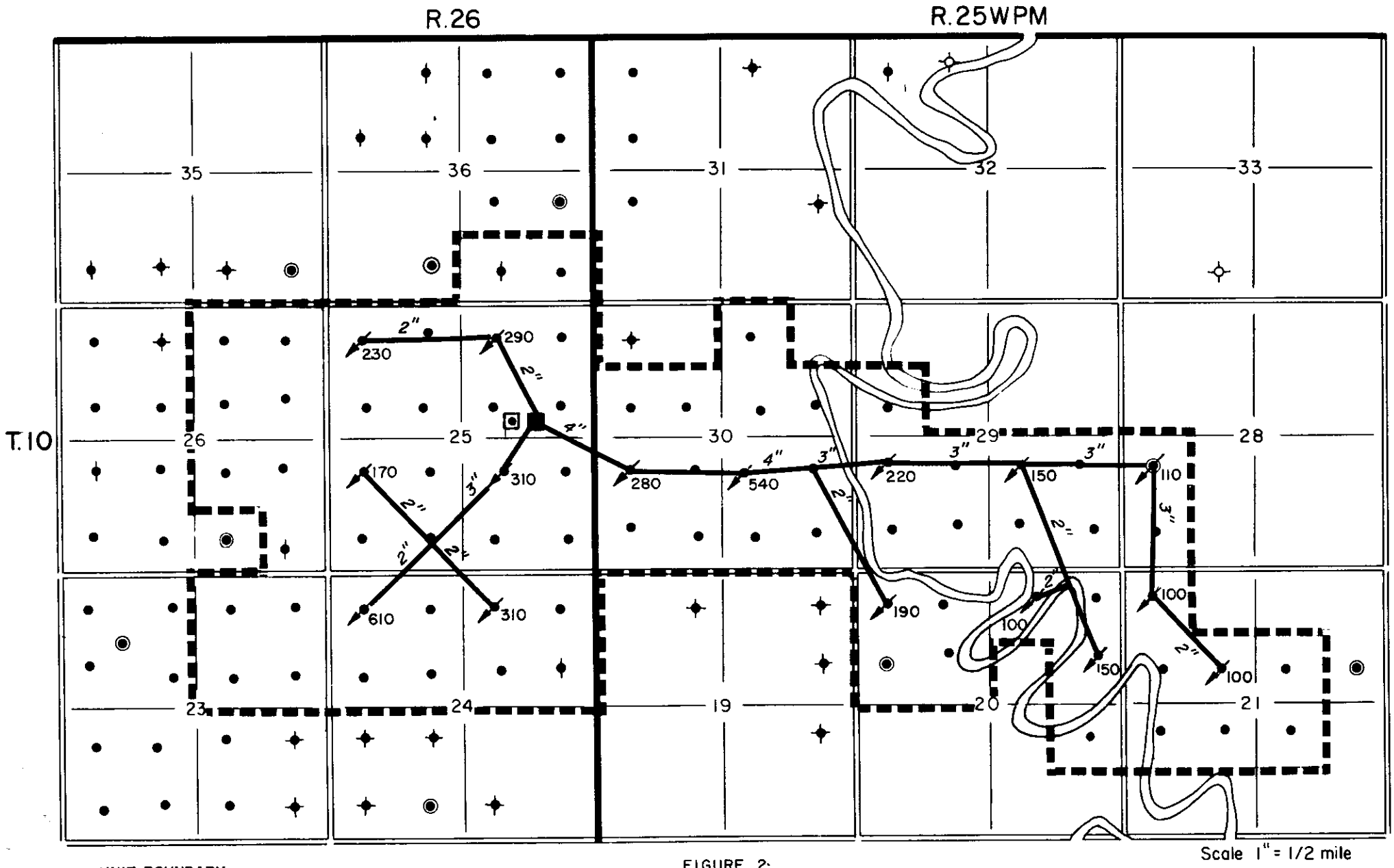


FIGURE 2.

# PROPOSED VIRDEN ROSELEA UNIT
# WATER INJECTION SYSTEM

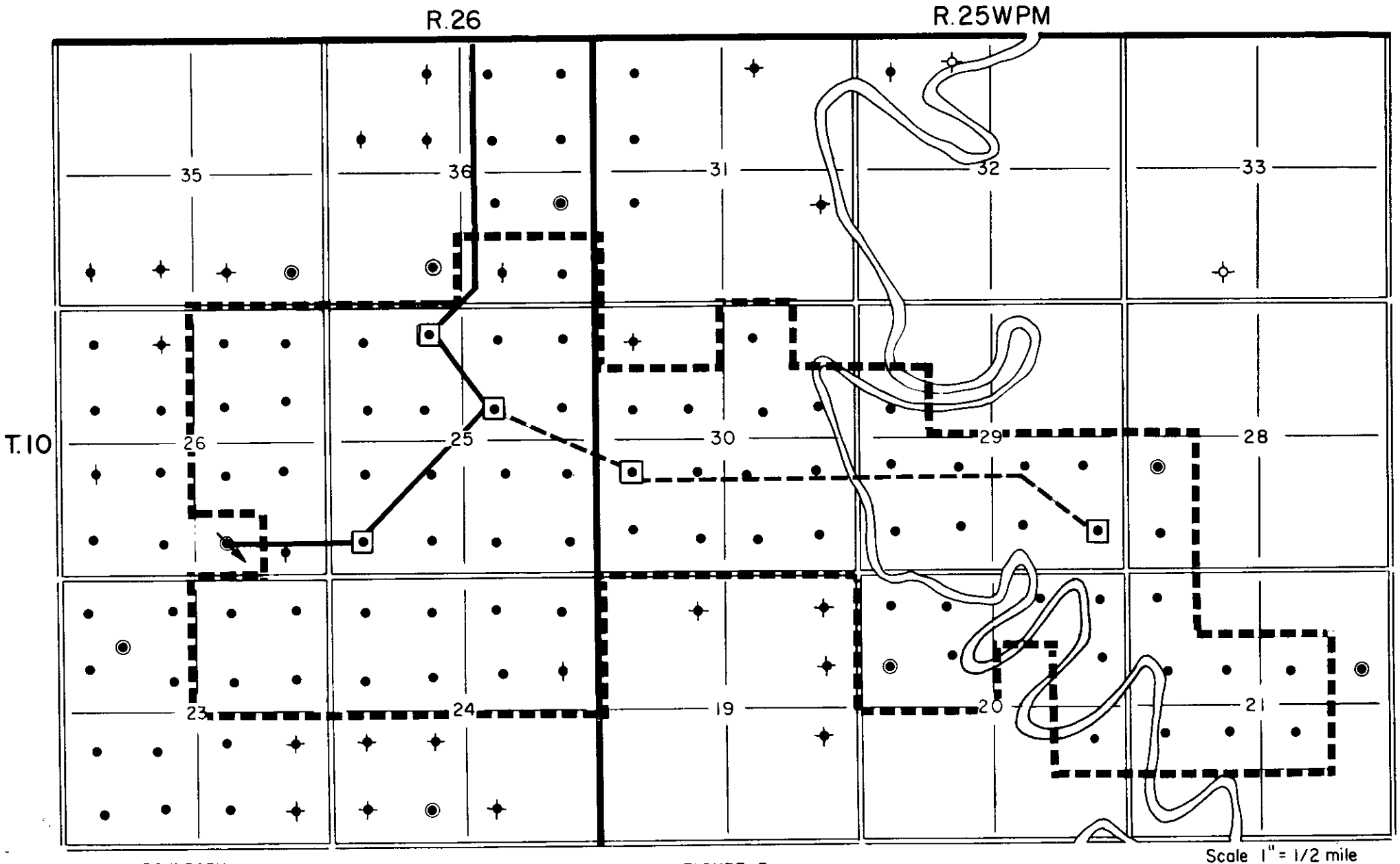


FIGURE 3

# PROPOSED VIRDEN ROSELEA UNIT
# SALT WATER GATHERING SYSTEM