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RAPID APPRAISAL PROCESS (RAP) REPORT

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Subject: Report on Rapid Appraisal Process (RAP) Visit
James Irrigation District

Dr. Charles Burt and Marcus Cardenas of ITRC conducted site visits to James Irrigation District in September and October of 2006 to perform a Rapid Appraisal Process (RAP) evaluation on behalf of the California Department of Water Resources (DWR). We were accompanied by Ken Mancini of James ID.

This project was supported by a CALFED Water Use Efficiency Grant. ITRC was asked to identify potential modernization opportunities for water conservation and improved water management. This report provides ideas for efficient and reliable water use with conceptual engineering recommendations.

Background

James Irrigation District (JID) services about 23,000 acres located around the community of San Joaquin in Fresno County, California. It delivers a water supply that varies by year, but which is approximately 80,000 AF/yr – about 33% of which comes from deep wells. **Figure 1** shows the layout of James ID.

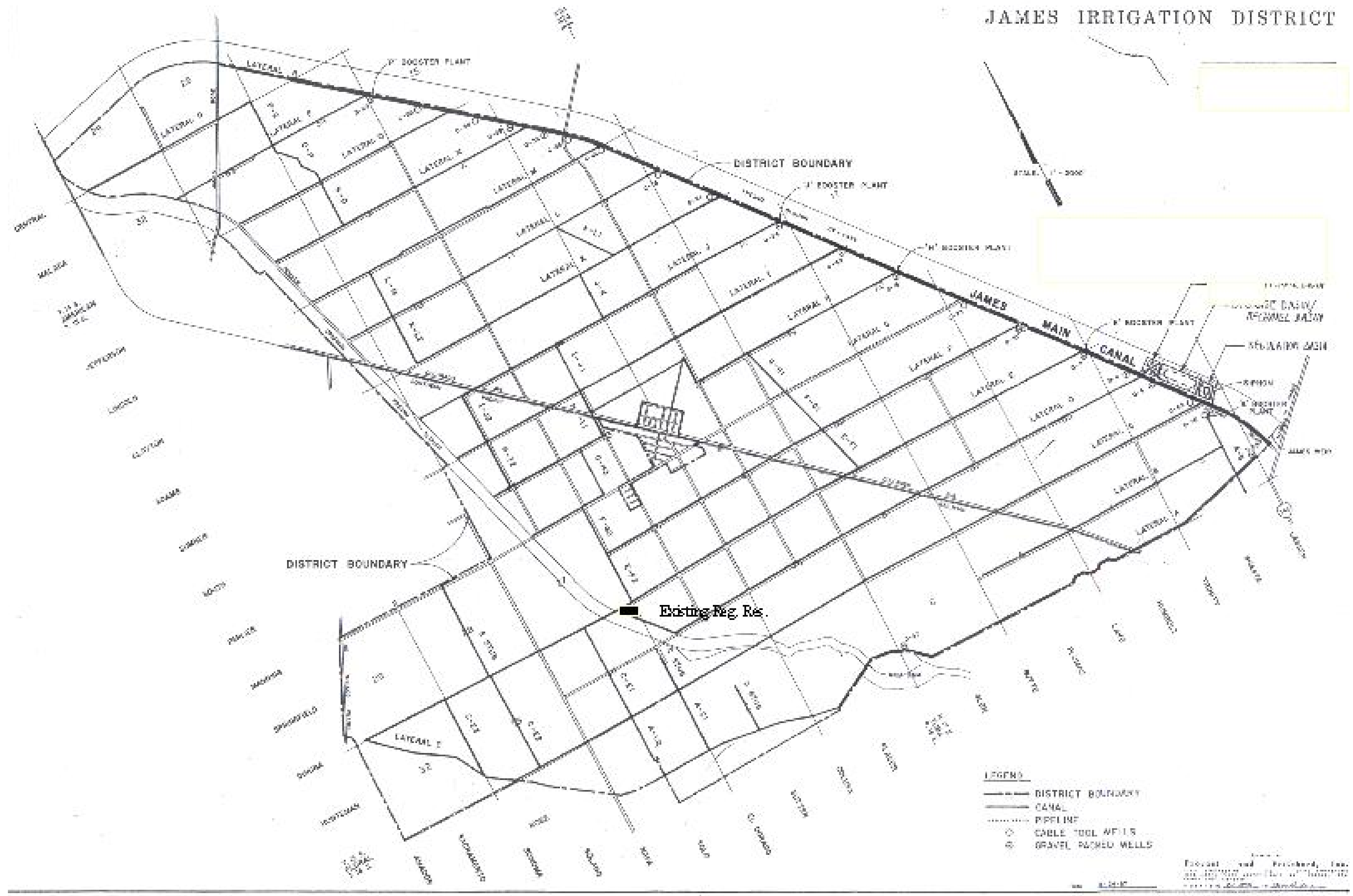

Figure 1. Layout of James Irrigation District

The district has the following characteristics:

1. Most of the canals are unlined, with the exception of the main canal and a few miles of laterals in very sandy sections in the northeastern part of the district.
2. In 1995, there were about 230 acres of drip/microspray in the district. In 2006, there are several thousand acres of drip/microspray and the district anticipates a future shift to more drip/micro irrigation.
3. The district is quite modern in many ways, including:
    a. Use of Water Pro for hand-held data recorders
    b. GPS locators placed on all ditchrider vehicles, so the office knows where they are at all times
4. It is estimated that about 4000 AF/yr of seepage occurs in the main canal.
5. There is no SCADA system, at present.
6. Deliveries are measured with propeller meters that are moved from turnout to turnout.
7. As are many irrigation districts, James ID is noticing difficulties controlling aquatic weeds. Magnicide has traditionally been the preferred alternative chemical treatment, but the district has recently had good results with Sonar, which is sprayed on the water surface (cost = $1600/gallon, with 2 quarts/surface acre). ITRC anticipates that as more farmers shift to drip and sprinkler irrigation, the district will come under even more pressure to keep the water clean.

In 2000, ITRC visited James ID on behalf of the Mid-Pacific Region of USBR for an initial Rapid Appraisal. Three key recommendations were made in that report:

1. *Improve water delivery flexibility to farmers*. The concepts of long-crested weirs in canals, spill collection systems, and spill recirculation systems were introduced. As of 2000, JID had none of these facilities. Between 2000 and 2006, JID has done the following:
    - Installed two regulating reservoirs: one on lateral A, and another on lateral E.
    - Installed about 15 long-crested weirs for better water level control. The district has a program of installing several new structures each year.
    - Arranged for the installation of two ITRC flap gates in the main canal to help maintain more constant water levels, which will help to stabilize flow rates into laterals.
2. *Develop a new approach to managing the deep wells*. The district has not taken any major steps on this recommendation.
3. *Determine the seepage rate in the sandy canal pools, and attempt to minimize seepage with new techniques*. In 2006, JID has worked with ITRC, Panoche WD, and Chowchilla WD to secure CALFED funding to accomplish this. The funding has been approved, and seepage tests are scheduled for early November, followed by in-situ compaction of canal banks and subsequent seepage tests to verify the extent of seepage reduction.

Changes at James ID

Since 2000, there have been 3 major changes that have impacted JID staff and board thinking:

1. JID farmers and staff have seen the benefits of the long-crested weirs and regulating reservoirs. This has made them receptive to even more new ideas, and they have developed plans on their own.
2. The shift to drip/micro has probably just begun. This shift is usually accompanied by new crops such as almonds. Farmers will need constant smaller flow rates for long durations, rather than large occasional flows. In the past, the district didn't even need to spend time scheduling drip deliveries because they were a small percentage of the total deliveries. Evidently, the drip/micro fields have such relatively small flows that their schedules have not even been accounted for with some laterals. They are almost in the category of "background noise" compared to the regular surface irrigation deliveries. This will now change.
3. Electric power rates continue to climb.

Current Operations

Currently, the turnout deliveries are of very high flow rates/delivery and of "relatively" short duration. A relatively small number of turnouts receive deliveries at any one time, and there are large flow rate changes within the canal system as deliveries are started and stopped. Furthermore, capacity problems arise if several growers request deliveries at the same time in some areas of the district.

Therefore, the focus of district staff and farmers, to this point, has been on:

1. The need to increase flow capacities at some places.
2. The need to have regulating reservoirs that have a "ready supply" to meet large demands downstream, or to temporarily receive rejected (shutoff water) from upstream.

Future Operations

Future operations will look quite different, and the board and staff should consider the trends when investigating investment options.

The key difference will be the method of field irrigation. James ID will see the same trend that has been seen in Westlands WD, Panoche WD, San Luis WD, Fresno ID, etc. That is, there will be a gradual, if not sudden, shift to drip and sprinkler irrigation methods. The impact on district operations will be significant.

First, the nature of "problems" will change. There will no longer be capacity problems to deal with, because flow rates per turnout will be less, and the flow rates will be delivered much longer.

At first glance, this appears to be a positive change, which will make many of the operation problems that dominate today's deliveries disappear. <u>However</u>, there will be subtle shift that is rarely anticipated but which requires some forethought in order for to the district to accommodate the farmers' needs.

There will be continual, small changes in flow rate throughout the district that are unpredictable and unintentional in nature.

These flow rate changes can be caused by several factors:

- The flow rate into a sprinkler or drip pump does not stay constant.
- The number of sprinklers irrigation per set is rarely the same as the irrigation moves across a field.
- Block sizes of drip or microspray are rarely all the same size within a field.
- Filters need extra flow when they flush.
- If farmers use electric pumps, they may opt for time-of-use rates with PG&E. There can also be power outages, which can cause all of the pumps to turn off simultaneously. Either situation can cause large flows to suddenly "appear" in the downstream sections of laterals.

With surface irrigation, if 10.2 CFS reaches the last open turnout instead of 10 CFS, the extra flow just passes through the turnout. The discrepancy isn't really noticed, from an operations point of view. With pumped systems, the flow rate must exactly match the pump need – which changes with time (as noted above). This assumes, of course, that the pump is directly connected to a sump that "floats" with the canal level – which is the recommended configuration.

Therefore, the conversion to drip/micro and sprinkler irrigation brings to the forefront an old discussion, but for different reasons than before. The district must once again ask itself: How can the spills be captured and reused? Should they be self-contained on each lateral? Or should there be an inter-connection system in the district that allows unexpected variations to be moved between laterals? This is discussed in more detail at the end of the report.

The RAP Focus

During the RAP visits, it was obvious that JID staff and the board have been creatively thinking about new solutions. Therefore, the focus during the visits was on the following:

1. Discussing options for the west end of Lateral E that have recently been considered by JID.
2. Clarifying some design points about long-crested weirs.
3. Exploring new ideas for removing flow bottlenecks that put a serious restriction on the flexibility that JID can offer at some times of the year.
4. Exploring design options for installing interceptor laterals and buffer reservoirs toward the northern areas of the district.

Each of these focus items are described in more detail below.

Bi-Directional Flow on the west end of Lateral E

A particularly challenging management area is on the far southwest side of the district, at the end of Lateral C and Lateral E. Several times a year, there are shortages of 20-30 CFS in that area. Therefore, JID staff and Provost and Pritchard Engr. have looked at converting the western-most 3 miles of Lateral E (west of the regulating reservoir) into a level pool so that water could be supplied to that area from either end of that 3-mile section. The idea is that this would also provide more flexibility in spills from Laterals A and C because any terminal spills would work their way back eastward in the flat stretch of Lateral E, to the regulating reservoir.

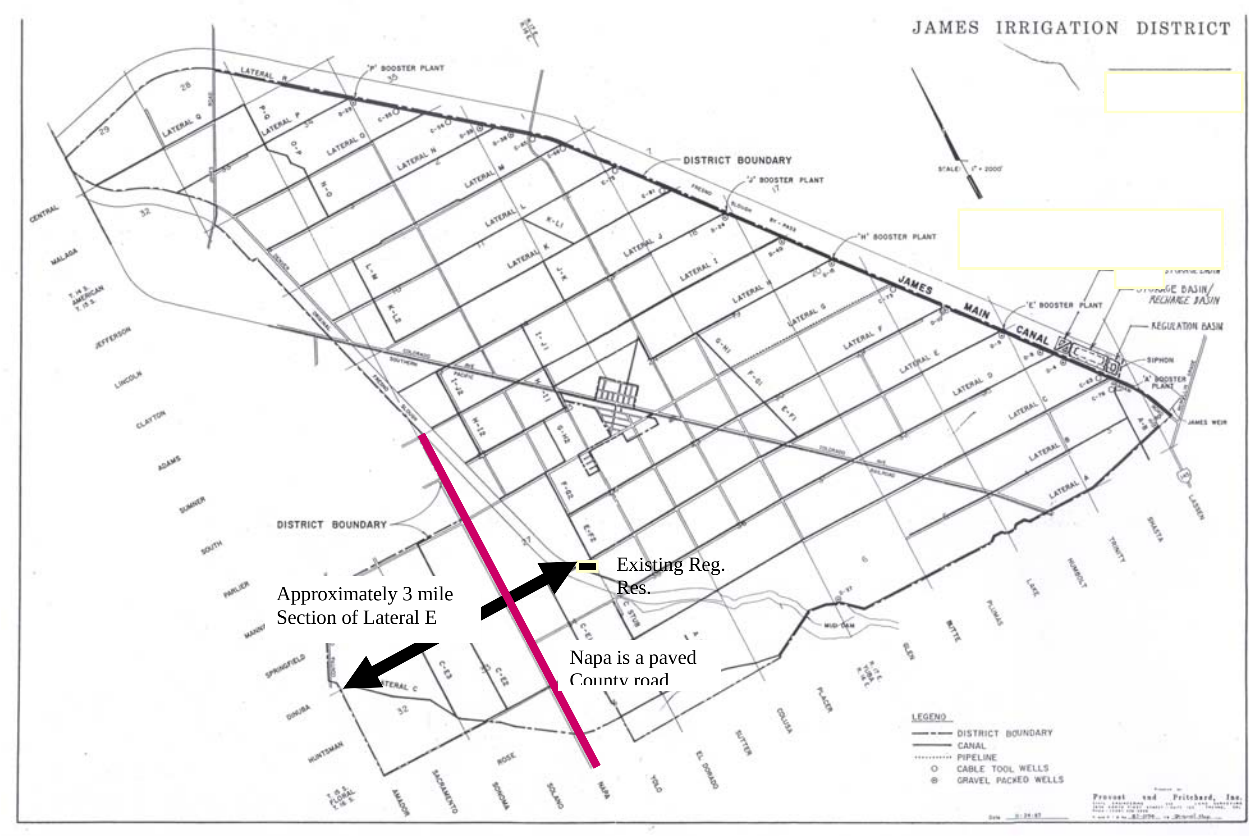

Figure 2. Bi-directional flow on the west end of Lateral E

JID has considered adding soil to the embankments of Lateral E, especially near Napa Road. This would enable JID to raise the water level, creating a level pool between the existing regulating reservoir and the far western end of Lateral E. Some field surveying has been done, and estimates of total yardage have been made. One plan is to expand the size of the regulating reservoir, and use the excavated soil to build up the Lateral E canal banks.

As part of the RAP, ITRC looked at the practicality of using Lateral E to run water in both directions. The assumptions and result of a quick analysis are provided below. The actual inside diameters of all the culverts should be checked.

Table 1 shows that if the Manning's "n" is 0.03, the majority (about 2/3) of the losses occur in and through the culverts.

Table 1. Effect of Manning's "n" on losses in and through the culverts

Assumed geometry of Lateral E, west of E basin

Length, ft =	15,840
Water depth, ft =	4.75
Bottom width, ft =	9.0
side slope	1.5
Manning's "n"	0.03

There are 3-48" culverts

Location	Dia, inches	L, ft
Napa Rd	48	70
E-Stub and CE-2	48	66
CE-3	48	30

Flow rate, CFS	Culvert entrances	Canal channel friction, feet	Culvert losses, feet	Total losses in one direction, feet
20	**Protruding (existing)**	**0.11**	**0.24**	**0.34**
20	Well rounded	0.11	0.17	0.27
20	Well rounded plus gradual exit	0.11	0.08	0.19
15	Well rounded	0.06	0.09	0.15
10	Well rounded	0.03	0.04	0.07

*All values are rounded.

From Table 1, we see that if the banks are raised so that there is a level pool, the water will need to be raised by about 0.34 feet on one end to make 20 CFS flow to the other end. Additionally, if 20 CFS flows in one direction one time, and in the other direction another time, the water level change at the far west end of Lateral E will total about:

Total change = 2 ×0.34' = about 0.7 feet.

This assumes that the water level next to the regulating reservoir remains constant. Very simplified water surface profiles for water moving in two directions are shown in **Figure 3**.

Therefore, just making the pool level is not sufficient to accomplish the objective of being able to effectively move water in both directions. If the water surface is flat, there will be no flow in either direction.

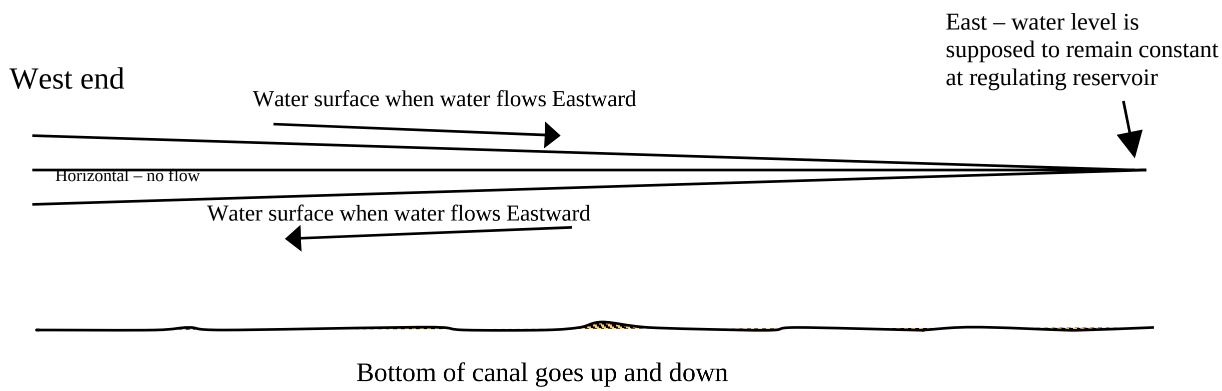

Figure 3. Water surface profiles corresponding to various flow rate directions

Table 1 also indicates that the major losses occur through the culverts. Culvert losses can be reduced in several ways:

1. Create well rounded entrances. This is inexpensive, but drops the total loss from about 0.34’ to 0.27’.

2. Create gradual expansions at the downstream end. This is more expensive, but it may be feasible if a 48” pipe is cut in half, and then welded or mortared to the discharge of the 48” culvert. The gap between the two halves can be filled on the top and on the bottom to create a gradual expansion of the sides only. If the expansion ends with a distance of about 3.2’ between the pipe halves, this will create the “well rounded plus gradual exit” condition described above. The total loss with a gradual exit and rounded entrance is about 0.19’ instead of the original 0.34’.

   Recommendation for gradual expansion:
   - Cut a 4’ diameter x 16’ pipe in half.
   - Put each half onto the end of the culvert; one on each side. The curvatures will point out to the sides.
   - Fill the floor in between the 2 pipes. This “fill” will be in the shape of a triangle, with a 3.2’ base on the downstream end.
   - Put some type of flat plate on the top.

3. Install a larger pipe. This can be very expensive when road crossings are involved, but would be relatively simple on two of the culverts. Furthermore, a larger pipe diameter may just stick above the water surface. JID would probably need to purchase oval-shaped culvert pipes that are wider than they are tall. On the two “simple” culverts, an additional 48” parallel pipe could be installed, which would reduce the culvert losses to 25% of what they currently are.

Bottom line: Modify the culverts if water is to flow in both directions. Exactly what combination of the techniques listed above is appropriate will depend upon the cost estimate by the district.

<u>Reservoir control for the western end of Lateral E</u>

Figure 3 indicated how the water surface of Lateral E will vary as the flow rate changes. However, things are actually worse than shown in Figure 3. To understand this, one must focus on the far right-hand side of Figure 3, which depicts the water level in Lateral E next to the reservoir.

In reality, that water level does not stay constant, as it appears in Figure 3. Instead, it changes for two reasons:

1. When there is excess water, the canal level must rise to pass water over the weir at the entrance to the pool. The length of the weir determines the rise in water level above the weir wall.
2. When there is insufficient water, the canal level drops before the pump is turned on.

These ideas are shown, conceptually, in **Figure 4**.

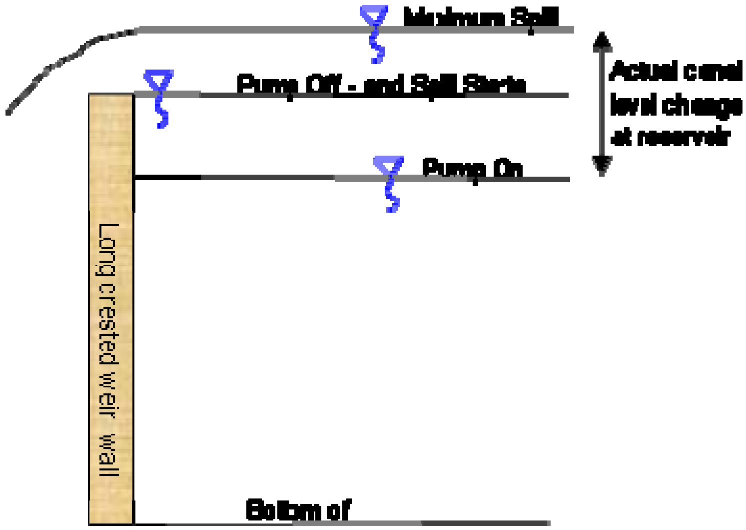

Figure 4. Side view of current canal water levels next to Lateral E reservoir

The wider this gap in water level, the more dirt will be needed for fill on the western Lateral E canal banks. There are two solutions to minimize the gap (illustrated in **Figure 5**):

1. Make the weir longer.
2. Set the "Pump on" switch higher. This will risk causing the pump to cycle on/off too much. However, the "pump off" can be higher than the top of the weir wall – but lower than the spill level needed to pass the full flow of the pump. This means that some of the pumped water will recycle into the reservoir some of the time, which may sound inefficient. However, this is cheap insurance against excessive pump cycling, and will significantly help minimize the canal water level fluctuation.

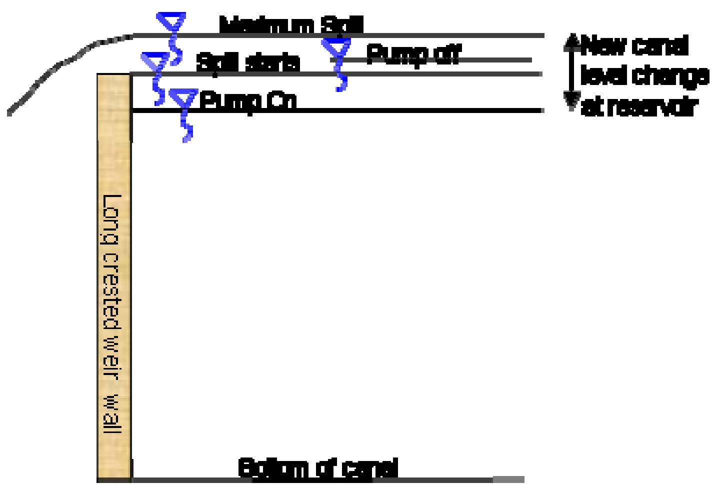

Figure 5. Side view of recommended situation for Lateral E reservoir. Effect of different on/off pump setpoints and a longer weir.

Of course, there are much more complicated computerized controls that ITRC has helped implement in other districts to maintain a tight water level. For this particular case, those are not recommended.

Long-Crested Weir Design Clarification – Within the Canals

A long-crested weir has a very long spill crest that allows large changes of flow rate to pass over the structure with minimal changes in water level. There are several reasons that some irrigation districts always operate the long-crested weirs "full" – with most or all of the water passing over the crest. These reasons include:

1. Labor is minimized – there is nothing to change if the crest is long enough.
2. A constant water level in the canal can reduce rodent damage to the canal banks that can occur if water levels are raised and lowered frequently.

Most irrigation districts have gates in the long-crested weir structures. In general, this is recommended so that:

1. Silt can be flushed out continuously or occasionally.
2. If the majority of the canal flow rate is passed through these gates, the weirs do not need to be extremely long. This is because they can be designed to always pass a certain flow over the weir, which will give both a "plus" and "minus" buffer in flow rate.

Other irrigation districts use the gates in the structures for entirely different reasons. Basically, they do not use the water level control capability of the long-crested weir unless a turnout upstream of the weir is operating. At all other times, all of the flow passes through the open gates. The reasons for this include:

1. The higher velocities reduce silt in the canal.
2. The lower water levels and higher velocities reduce aquatic growth.
3. If only one turnout is open at the far downstream end of the lateral, the whole canal does not need to be filled up in order to deliver water to that one user. Passing water through the gates without "building up" the water level at each structure saves considerable time.

If there is a regulating reservoir downstream, then the temporary discrepancies in flow rate that occur when the operators fill and empty pools won't cause the operators grief at the end of the laterals.

Removal of Flow Rate Bottlenecks

It appears that there are several bottlenecks at culverts that cross roads – such as the Colorado crossing of Lateral E. Please refer to the earlier discussion of culvert modifications.

To determine whether these culverts truly cause restrictions, it would be good to survey the change in water level across the culvert. The water levels should be measured within a few feet of the culvert, but in still water. At the time of the surveying, the flow rate through the culvert should be measured.

For example:

Flow rate = 20 CFS
Elevation of upstream water level = 10.2'
Elevation of downstream water level = 9.6'

Change in water level = Elevation of inlet water level - Elevation of outlet water level

Computed difference in water level = 10.2' – 9.6' = 0.6'

How much will the upstream water level rise if the flow increases to 25 CFS?

To predict the RISE in water level on the upstream side at a different flow rate, the following equation gives the approximate answer:

$$\text{RISE} = = \left[\left(\frac{\text{New flow rate}}{\text{Old flow rate}}\right)^{2.5} - 1\right] \times \text{ Original difference in level}$$

For example, the estimated additional RISE in water level with a flow rate of 25 CFS can be predicted to be:

$$\mathbf{RISE =} \quad = \left[\left(\frac{25\text{ CFS}}{20\text{ CFS}}\right)^{2.5} - 1\right] \times 0.6' \quad \mathbf{= 0.45'}$$

If there is a substantial difference in water level across a culvert at high flows, it is worth investigating a change in pipe diameter, adding an additional pipe, or changing the inlet/outlet conditions of the culvert. If there is not a substantial difference, the bottleneck is due to something other than the culvert.

Buffer Reservoirs and Interceptors

Some time was spent examining existing inter-ties in the district. **Figure 6** shows the locations visited. The arrows indicate sections that appeared to have water flowing in only one direction (singe big arrow), or through which water could flow in either direction (narrow lines with arrows on each end).

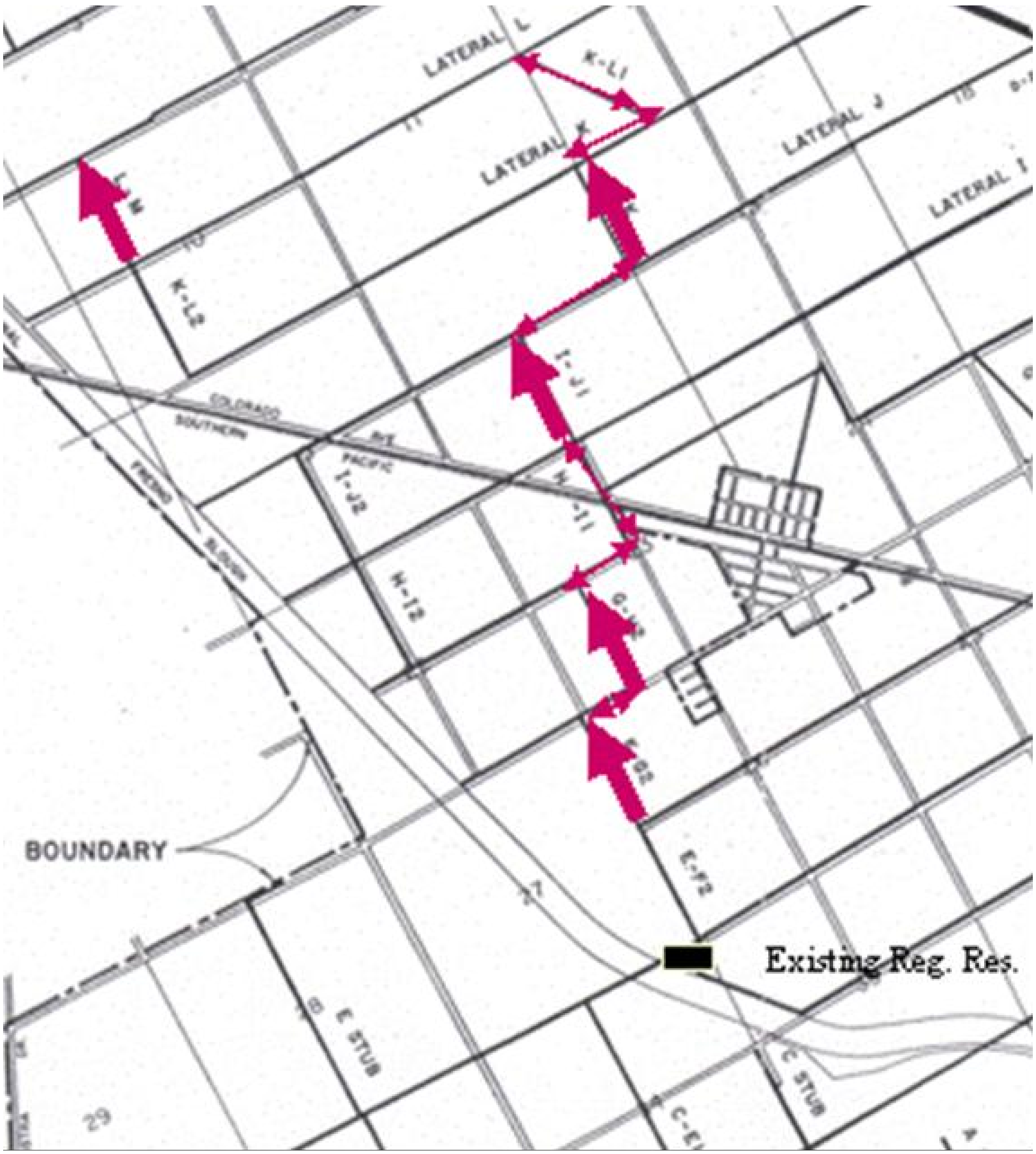

Figure 6. Segments of existing cross-ties

Obviously, the short visit did not include elevation surveys, examination of capacities, details of control structures, etc. However, it did lead to some thoughts that might stimulate further brainstorming by district staff and board members. Those are indicated in **Figure 7** and described in detail below.

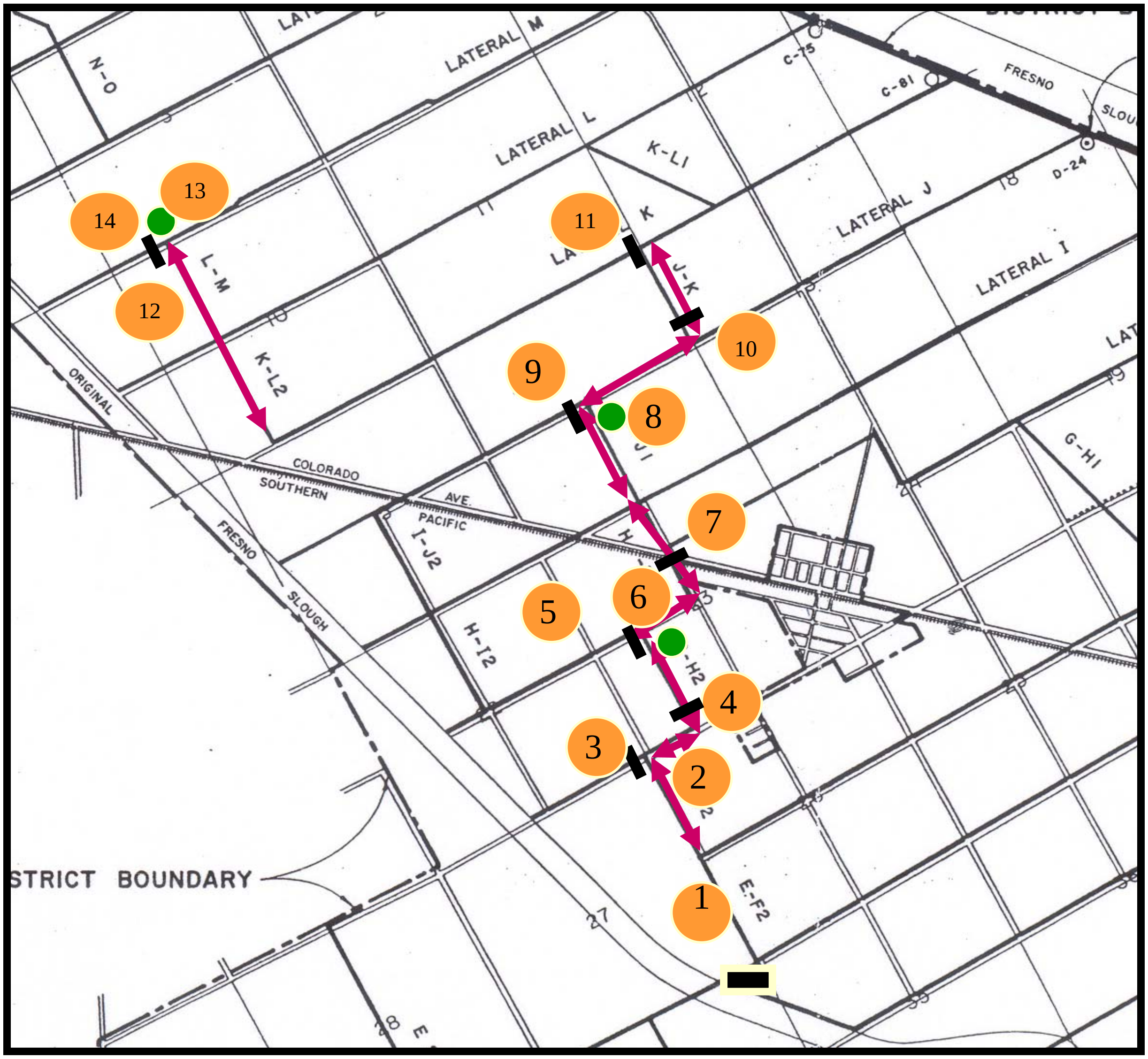

Figure 7. Possible structural/operational changes to move water around while obtaining more flexibility and minimizing spills

1. E-F2 segment – should be abandoned.
2. Pump located in the F-G2 segment – pumps into the flat canal segment between F-G2 and G-H2, based on water level in the F-G2 segment.
3. New flow control gate to the west of F-G2, on Lateral G.
4. Long-crested weir at the entrance to G-H2 – allows excess flows from Lateral G to go north.
5. New flow control gate to the west of G-H2, on Lateral H.
6. Regulating reservoir that is designed to maintain a constant water level in a level pool that consists of G-H2, and the short piece of H to the east of G-H2.

7. Flow control gate where Lateral H turns to the south – controls flow into remainder of Lateral H.
8. Small regulating reservoir – maintains a constant water level in the short section of Lateral J, between I-J1 and J-K.
9. Check structure – flow control gate on Lateral J.
10. Entrance to section J-K – flow control.
11. First canal structure downstream of the J-K segment – a long crested weir.
12. Complete segment consisting of K-L2 and L-M – will be level, and capable of moving water between K, L, and M.
13. Small regulating reservoir – will maintain a constant water level in the level L-M, K-L2 segments.
14. New flow control gate to the west of L-M.

The structural changes that are noted here are relatively simple in construction. James ID already knows how to construct long-crested weirs, standard check structures that can be used for flow control, and pumps/reservoir inlets.

Remote monitoring. Remote monitoring of water levels on all of the regulating reservoirs would be very helpful, so that operators know if they are filling up or emptying out. A history (graph) of the regulating reservoir water levels can tell operators a tremendous amount about the status of all the canal segments upstream.

Small tail-end reservoirs. Figure 7 indicates possible inter-ties and small regulating reservoirs that will enable operators to provide more flexible deliveries fairly easily. However, with flexibility some spills will always occur at the tail ends of the laterals once drip/micro and sprinkler systems become common. The first consideration is that these will not be large flows – ignoring the possibility of a large electrical power outage. Therefore, it is not unrealistic to construct small tail-end reservoirs and install a small pumpback system in each. A typical pumpback system may have an 8” pipe, and be capable of pumping 500-600 GPM uphill to a larger re-regulation point.

Another option is to work with the most downstream growers to construct a large pond which will collect the spills for those growers’ usage at a reduced or at no charge.

Quantifiable Objectives

James ID is within Quantifiable Objective Region 15. The following are listed by CALFED as the pertinent quantifiable objectives:

167. Core: Reduce existing flows to salt sinks by _____ acre-feet per year.
    QO: <1 TAF per year
    – Improve farm irrigation management (such as irrigation scheduling) and more uniform irrigation methods (such as shorter furrows, sprinkler, or drip).

168. Core: Reduce unwanted ET by _____ acre-feet per year.
    QO: 6.1 TAF/Yr plus additional water generated through reduction in application through improved irrigation systems
    - Reduce ET flows using improved irrigation methods, such as drip irrigation, and planting densities.

169. Enhance the effectiveness of potential conjunctive use programs by reducing flows to groundwater to _____ acre feet per year during periods of shortage; and increasing flows to groundwater to _____ acre-feet per year during periods of excess.
    QO: TBD

170. Salt affected soils: While remaining within the salinity threshold for a given crop, take advantage of periodic opportunities to reduce salinity impacts by increasing leaching by _____ during periods of excess supply and by reducing by ____ leaching during water short periods.
    QO: TBD

This RAP was not intended to quantify the values in the various quantifiable objectives. However, QO's 167 and 169 are pertinent.

QO 167. The district-level improvements that are recommended in this RAP are targeted toward providing improved service to farmers, with a special emphasis on the changes that will be needed to service drip/micro irrigation.

QO 169. The RAP did not need to make additional recommendations for this objective. However, it should be noted that James ID is presently engaged in a major seepage reduction study along with ITRC (as noted in the report), and has recently constructed a large, additional recharge basin. Both of these efforts match QO 169, but did not result from this particular RAP.