IRRIGATION TRAINING & RESEARCH CENTER

Flathead Indian Irrigation Project

Moiese Canal System Modernization

U.S. Bureau of Indian Affairs
Branch of Irrigation & Power

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MOIESE CANAL SYSTEM MODERNIZATION

Modernization Plan

The Moiese Canal System services approximately 7,000 irrigated acres and has some of the best crop production in all of FIIP. The overall goals for the modernization changes to the Moiese Canal System are:

- Utilize the storage level in Hillside Reservoir by increasing the capacity to supplement the MA Canal and Lateral 30MA.
- Provide excellent delivery service to farmers by piping nearly all laterals in the area. This will eliminate large portions of laterals that have high seepage losses and are only used for conveyance.
- Ease management for operators.

Figure 1 on the next page shows the overall modernization changes in the Moiese Canal System. The modernization changes include:

1. The MA Canal headgates on Crow Creek will be automated and remotely controlled via SCADA in order to make frequent flow rate changes based on the storage level in Hillside Reservoir.
2. Approximately 10 miles of the existing MA Canal will be cleaned, expanded, and vibratory compacted to reduce seepage losses and increase the flow rate capacity.
3. Multiple limited-demand pipelines will be constructed to service water users throughout the Moiese Canal System that are not already supplied directly from the MA Canal via a pipeline.
4. A new 48" pipeline will provide supplemental water on demand to the MA Canal from the Hillside Reservoir. The new Hillside Pipeline will also service a few individual fields along its new alignment.
5. A new level pool will be integrated with the discharge from the new Hillside Pipeline to automatically supplement variable canal flows in the southern portion of the Moiese Canal System.
6. The existing laterals that meander through the valley and produce large amounts of seepage will be abandoned.
7. SCADA will be incorporated to remotely monitor flow rates and water levels at key points in the canal unit.

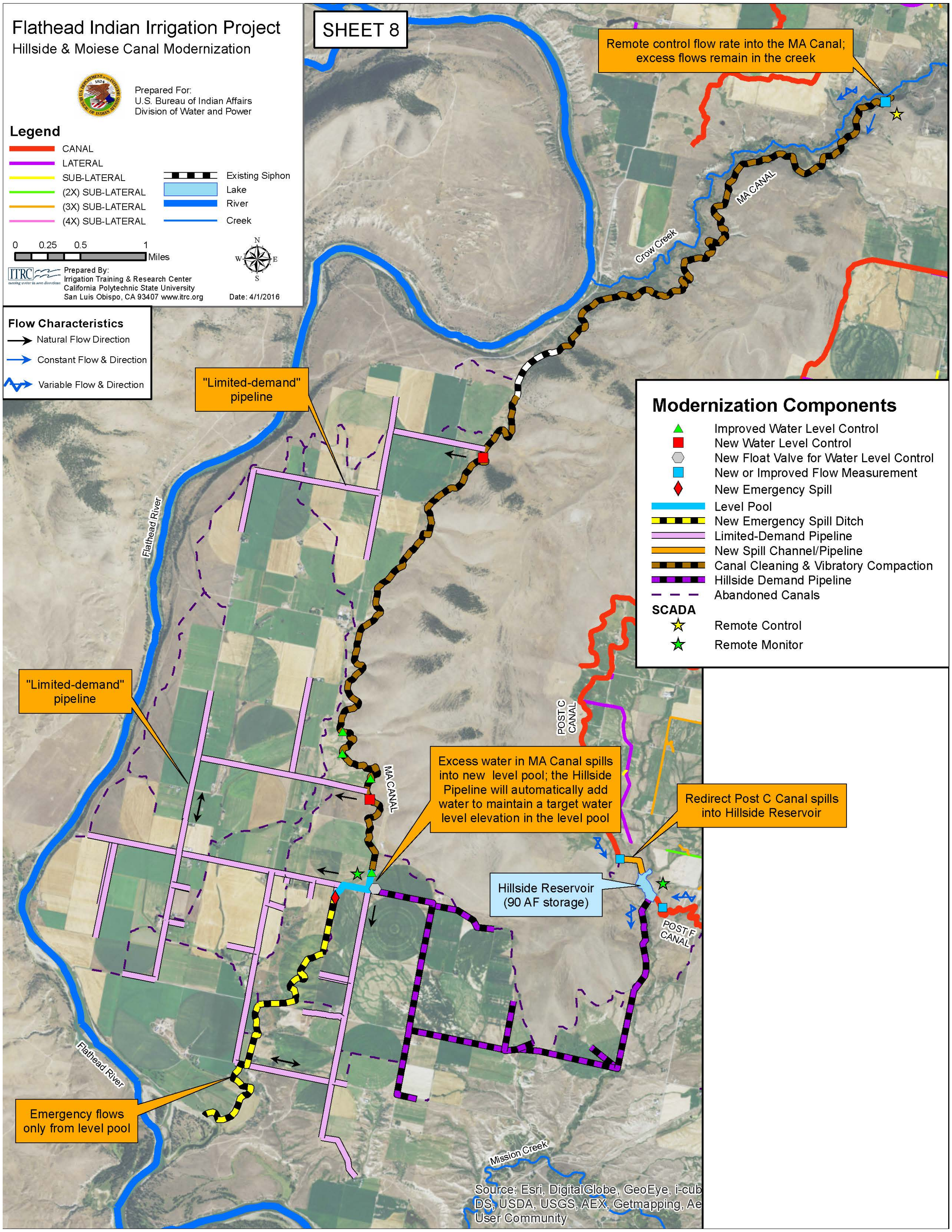


Figure 1. Overview of modernization changes to Hillside Reservoir and the Moiese Canal Unit

New Operational Management Scheme

The following describes the new operational management scheme of the Moiese Canal System:

1. Using SCADA, operators will be able to remotely monitor the storage level in the Hillside Reservoir.
2. The MA Canal headgates will be automated and have the ability to be controlled remotely via SCADA or on-site.
3. The new Hillside Pipeline will:
   a. Increase the discharge flow rate capacity from Hillside Reservoir.
   b. Automatically provide supplemental water to the MA Canal and Lateral 30MA (with the new level pool system) to meet irrigation demands in the southern portion of the Moiese Canal System.
4. A new level pool that is hydraulically connected to the Hillside Reservoir will service new limited-demand pipelines for turnouts in the southern portion of the valley and "buffer" the flows in the MA Canal. The Hillside Reservoir essentially becomes a regulating reservoir for the entire Moiese Canal System.
5. Frequent flow rate changes will be made to the MA Canal headgates based on the storage level in Hillside Reservoir. The general operation will be as follows:
   a. Flow will be diverted into the MA Canal to service the entire upper canal portion and approximately half of the area in the south (fields south of the inflow from Hillside Reservoir).
   b. When Hillside Reservoir starts to approach full storage capacity, the diverted flow rate into the MA Canal will be reduced. Simultaneously, a flow cut can be made at the Lower Crow Reservoir that supplies Crow Creek.
   c. By reducing the flow rate at the head of the MA Canal, Hillside Reservoir will automatically supplement more flow to the new level pool to meet the irrigation demand in the south.
   d. Hillside Reservoir will be allowed to be drawn down to a low storage capacity.
   e. Once Hillside Reservoir is near low storage capacity, the flow rate diverted into the MA Canal from Crow Creek will be increased.
   f. Once the increased flow rate from the MA Canal arrives at the new level pool, the flow rate from Hillside Reservoir will be automatically reduced and the reservoir will begin to re-fill.
6. The water level in the main canals will be maintained fairly constant with the construction of long-crested weirs (LCWs). The new water level control structures will:
   a. Provide a fairly constant pressure on lateral and turnout headgates
   b. Automatically pass all flow variations downstream without the manipulation of check structures by operators
   c. Protect the canal from overflowing
   d. Allow flow rate changes to quickly move down the canal
7. Emergency canal structures will be incorporated into the level pool system to automatically handle any emergency flows that may be due to:
   a. Unexpected large flow rate variations in the MA Canal
   b. Power outages causing turnout deliveries on the limited-demand pipelines that are tied directly into sprinkler irrigation systems to stop operating

Hillside Pipeline

Existing Conditions

Figure 2 shows the existing alignment of the Hillside Ditch from Hillside Reservoir to the confluence with the MA Canal (approximately 4.25 miles).

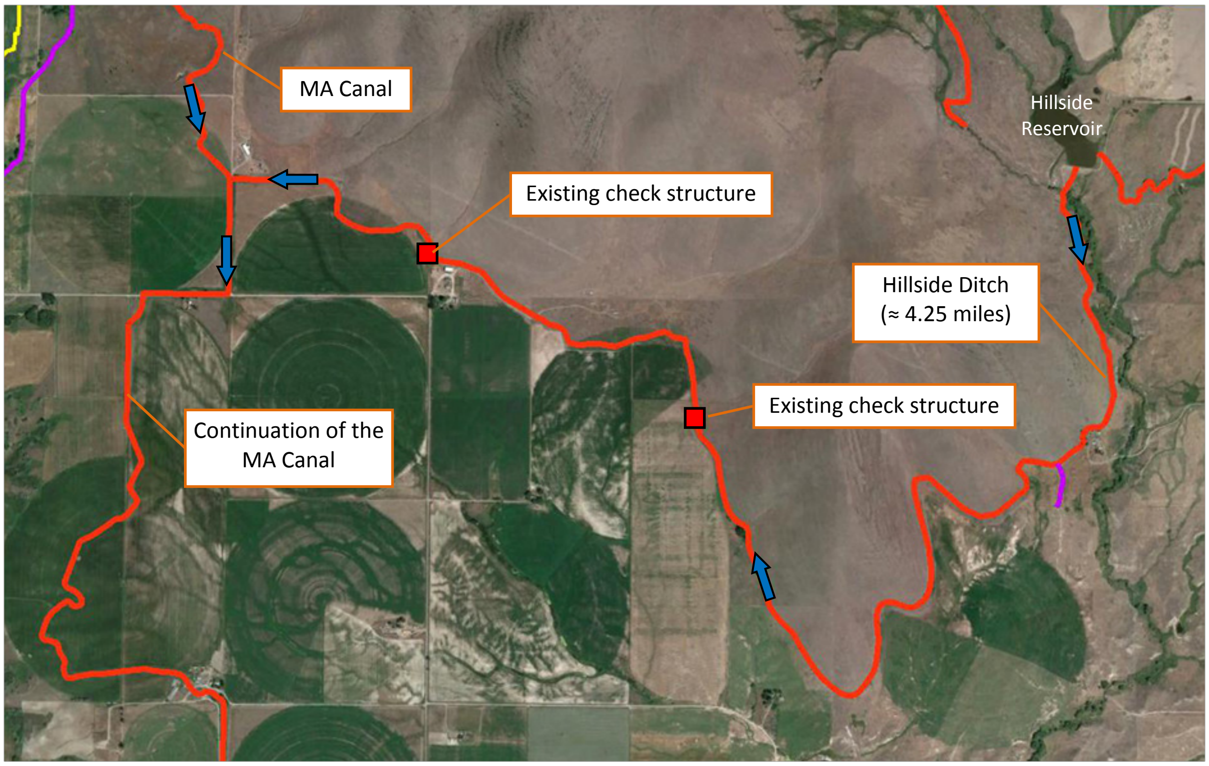


Figure 2. Existing alignment of the Hillside Ditch

Figure 3 and Figure 4 show the existing control downstream of the Hillside Reservoir discharge at the Hillside Ditch headgate.

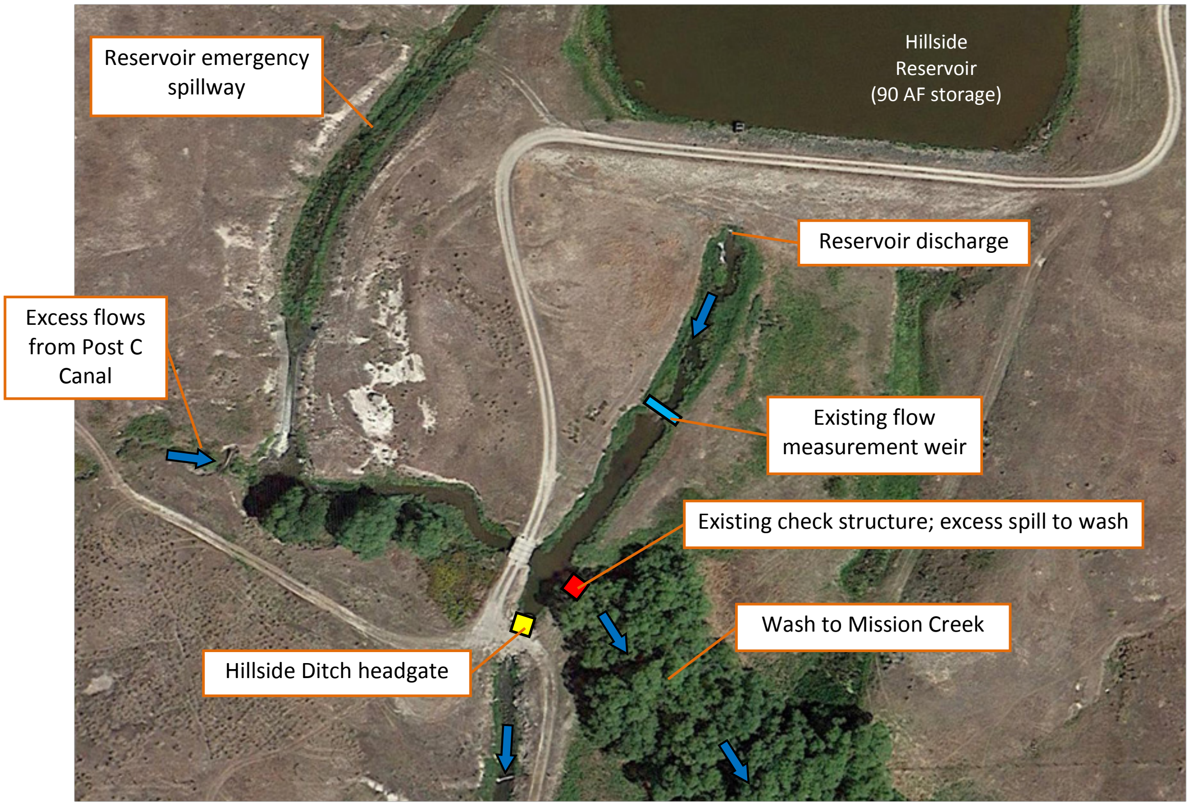


Figure 3. Existing control downstream of the Hillside Reservoir discharge at the start of the Hillside Ditch

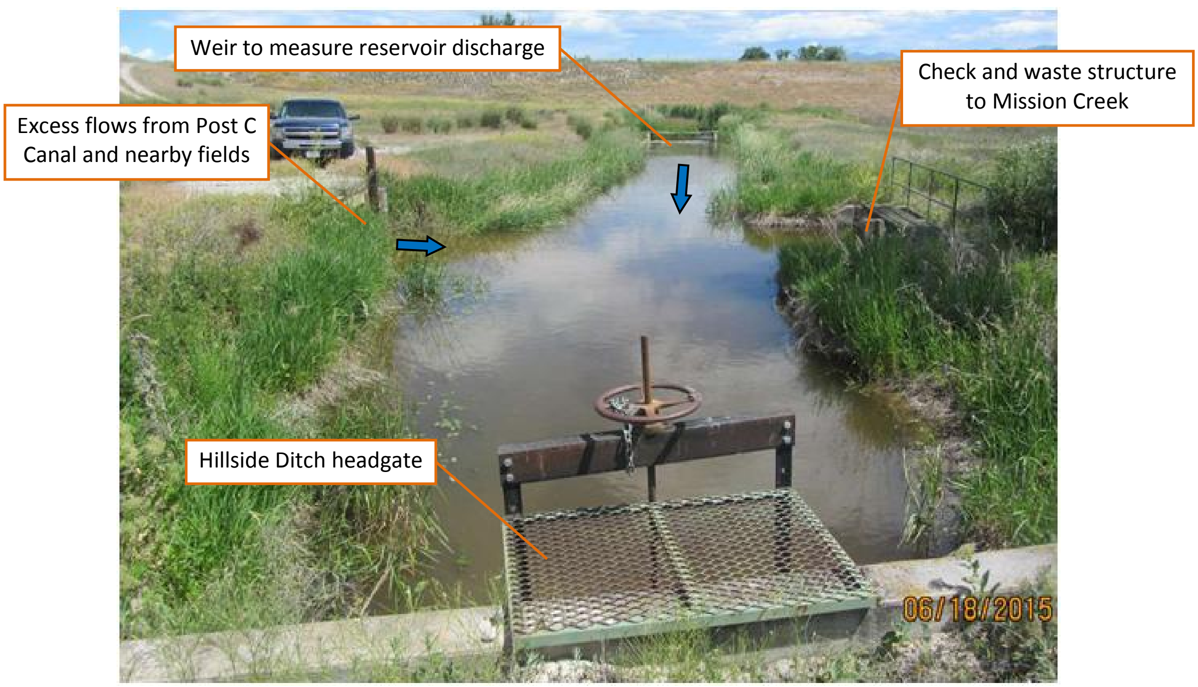


Figure 4. Existing control downstream of Hillside Reservoir

The existing control is as follows:

- An existing flow measurement weir is used to measure the releases from Hillside Reservoir.
- A single canal pool located downstream of the reservoir consists of:
    - Releases from Hillside Reservoir
    - Emergency spill from Hillside Reservoir
    - Excess flows from the Post C Canal and nearby fields
- An existing check structure in the canal pool performs the following functions:
    - Manages the water level in the canal pool so that a delivery can be made to the Hillside Ditch
    - Passes excess flows to a nearby wash that eventually discharges to Mission Creek. Water that enters the wash becomes unusable by FIIP.
- Approximately 15-20 CFS max is diverted into the Hillside Ditch from the canal pool.
- The Hillside Ditch services several turnouts prior to spilling into the MA Canal.

Problems Associated with Hillside Reservoir and Ditch

There are several current operational problems associated with the Hillside Reservoir and Ditch:

- The Hillside Reservoir is under-utilized from an operational and management standpoint. The reservoir always remains full for the following reasons:
    - The Hillside Reservoir collects uncontrolled and variable drainage flows/spills from the following:
        - Post A Canal
        - Post C Canal
        - Post F Canal
        - Irrigation runoff from fields in the northeast
        - Storm runoff
    - Numerous bottlenecks and lack of freeboard (see Figure 5) limit the flow rate capacity of the Hillside Ditch to supply irrigated fields in the southern portion of the Moiese service area.
    - Other reasons include lack of maintenance, no easy access, no flow measurement, etc.

Figure 5. Example of the Hillside Ditch with little freeboard

- At the confluence of the Hillside Ditch and the MA Canal, often there is a shortage of water during peak times for irrigators in the southern portion of the Moiese service area. During these times, the farmers in the area do not have enough water to operate their center pivots or wheel lines.

Hillside Pipeline Design

In order to increase the effectiveness of Hillside Reservoir by providing more flow to the southern portion of the Moiese Canal System, a new pipeline will be constructed from the reservoir to a new level pool in the MA Canal. Figure 6 shows the proposed alignment of the new Hillside Pipeline.

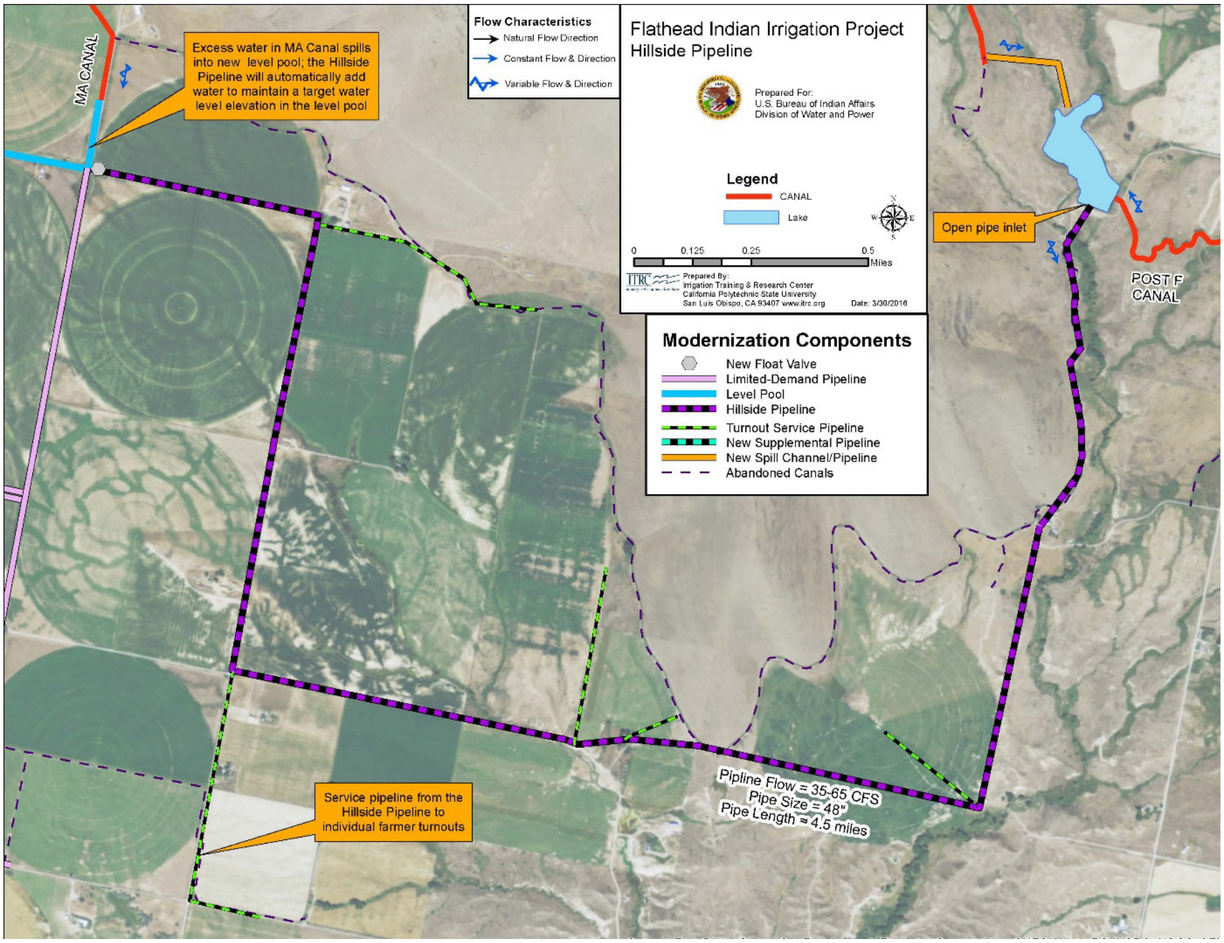


Figure 6. Alignment of the new Hillside Pipeline

The new Hillside Pipeline will consist of a 48" PVC (C905, 100 psi pressure rating) pipeline with a total length of approximately 4.5 miles. Components of the pipeline will include:

1. An open inlet in Hillside Reservoir to allow water to freely flow into the pipeline. A manual on/off control gate will also be installed at the pipeline inlet to stop water from entering the pipeline if maintenance needs to be performed.
2. Direct turnout valves to individual farmer fields for easy access for operators.
3. A float valve installed at the discharge end of the Hillside Pipeline will automatically control the discharge to the new level pool in the MA Canal. The float valve will maintain a target water level elevation in the new level pool.

The Hillside Pipeline will have the ability to supply up to a maximum of 65 CFS, but the flow rate will vary depending on the water elevation in the Hillside Reservoir. Table 1 contains the basic hydraulic summary of the Hillside Pipeline based on the low and high water level elevations in the Hillside Reservoir.

Table 1. Hydraulic summary of new Hillside Pipeline based on water elevations in the Hillside Reservoir

Hydraulic Summary for 48" Hillside Pipeline Based On Hillside Reservoir Water Levels					
Reservoir Water Level	Reservoir Sill Elevation[1] (ft.)	Reservoir Water Elevation[1] (ft.)	Change in Elevation from Reservoir Water Level to MA Canal[2] (ft.)	Approximate Pipe Flow Rate (CFS)	Approximate Pipe Friction (ft.)
Low	2,175	2,718	10	35	10
High		2,738	30	65	30

[1] Table 2-1 from Flathead Indian Irrigation Project Flathead Agency Operation & Maintenance Guidelines
[2] Assumed elevation at MA Canal = 2,708 ft.

Improvements along the MA Canal

Figure 7 on the next page shows the existing conditions for the MA Canal. Based on flow data provided from the tribal water engineers, the MA Canal diverts a maximum flow rate of approximately 70-80 CFS from Crow Creek. The first 5-mile stretch of the MA Canal has no turnout deliveries and is only used for conveyance. The Hillside Ditch merges with the MA Canal approximately 10 miles downstream from the diversion point on Crow Creek.

The following report sections describe the modernization changes at various points along the MA Canal that will focus on:

- Remote control of the flow rate diverted into MA Canal
- Improving the physical capacity of the MA Canal
- Improving water level control along the MA Canal

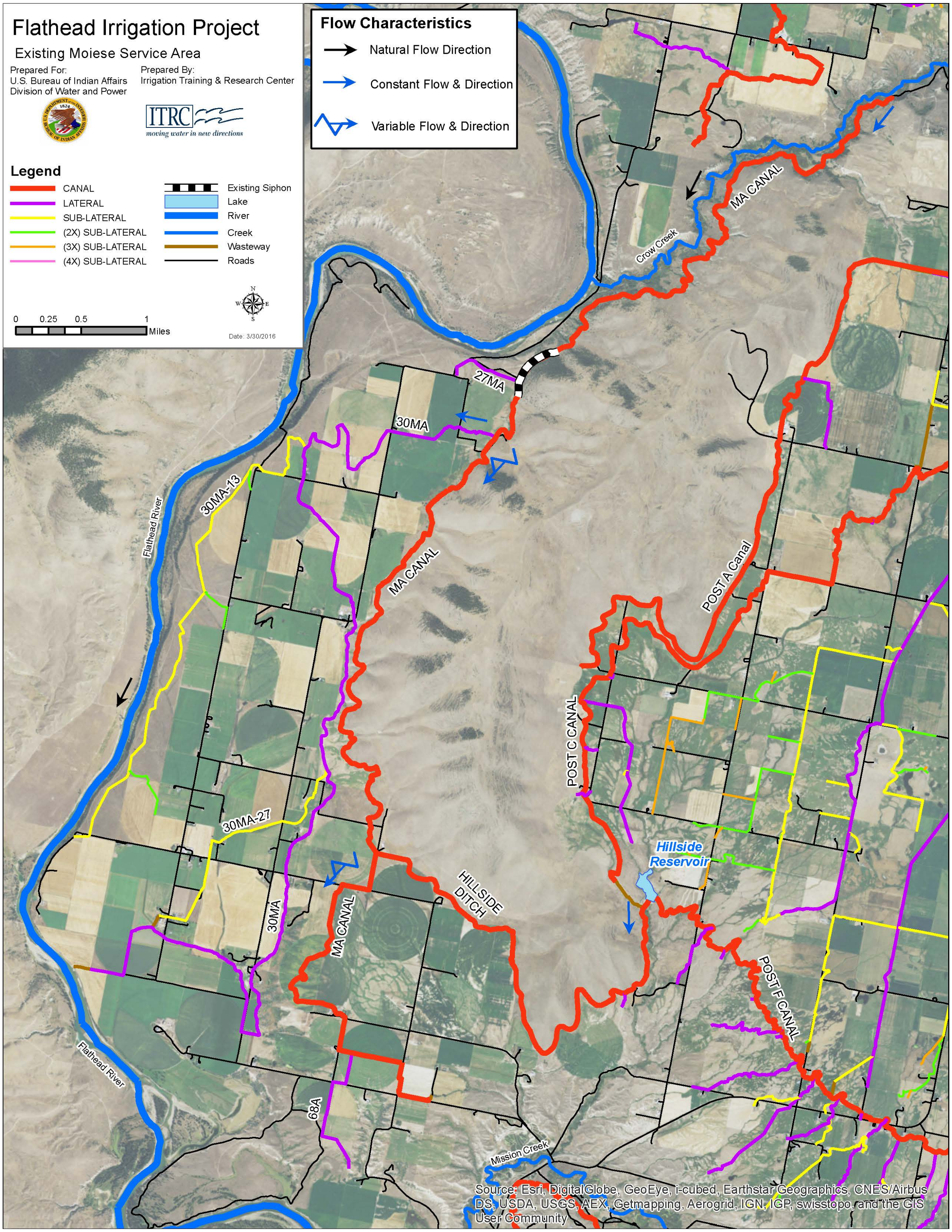


Figure 7. Existing layout of MA Canal

Head of MA Canal

Figure 8 shows the existing diversion dam in Crow Creek at the head of the MA Canal.

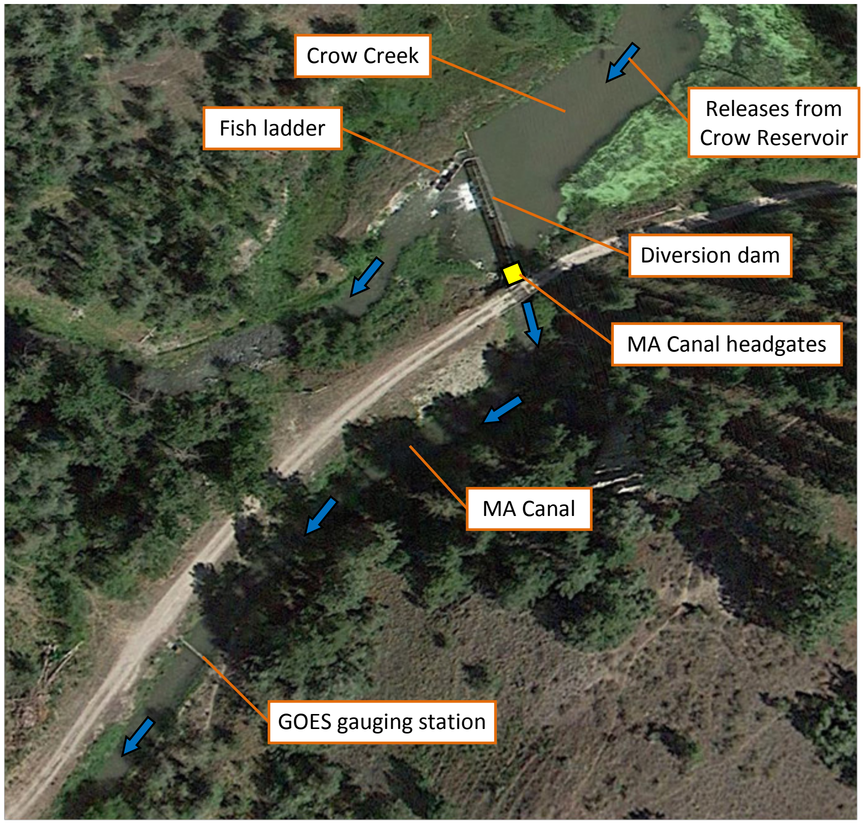


Figure 8. Existing MA Canal diversion on Crow Creek

As mentioned before, approximately 70-80 CFS is diverted into the MA Canal from Crow Creek. Figure 10 through Figure 12 show pictures of the existing diversion dam and MA Canal headworks in Crow Creek. The MA headworks consist of the following:

- A diversion dam with built-in fish and trash screening
- A fish ladder
- Two manual sluice gates to control the flow rate into the MA Canal

Figure 9. Downstream side of diversion dam in Crow Creek. Photo from HKM 2008 report (DD-12).

Figure 10. Upstream of diversion dam in Crow Creek for the MA Canal. Photo from HKM 2008 report (DD-12).

Figure 11. MA Canal headgates. Photo from HKM 2008 report (DD-12).

Figure 12. Fish ladder on the side of the diversion dam in Crow Creek. Photo from HKM 2008 report (DD-12).

New Control at Head of MA Canal

The modernization changes made at the head of the MA Canal are shown in Figure 13. With the new operation scheme of Hillside Reservoir, frequent flow rate changes will be needed at the head of the MA Canal. Automation will be implemented with the support of SCADA to allow operators to make the flow rate changes remotely instead of only on-site.

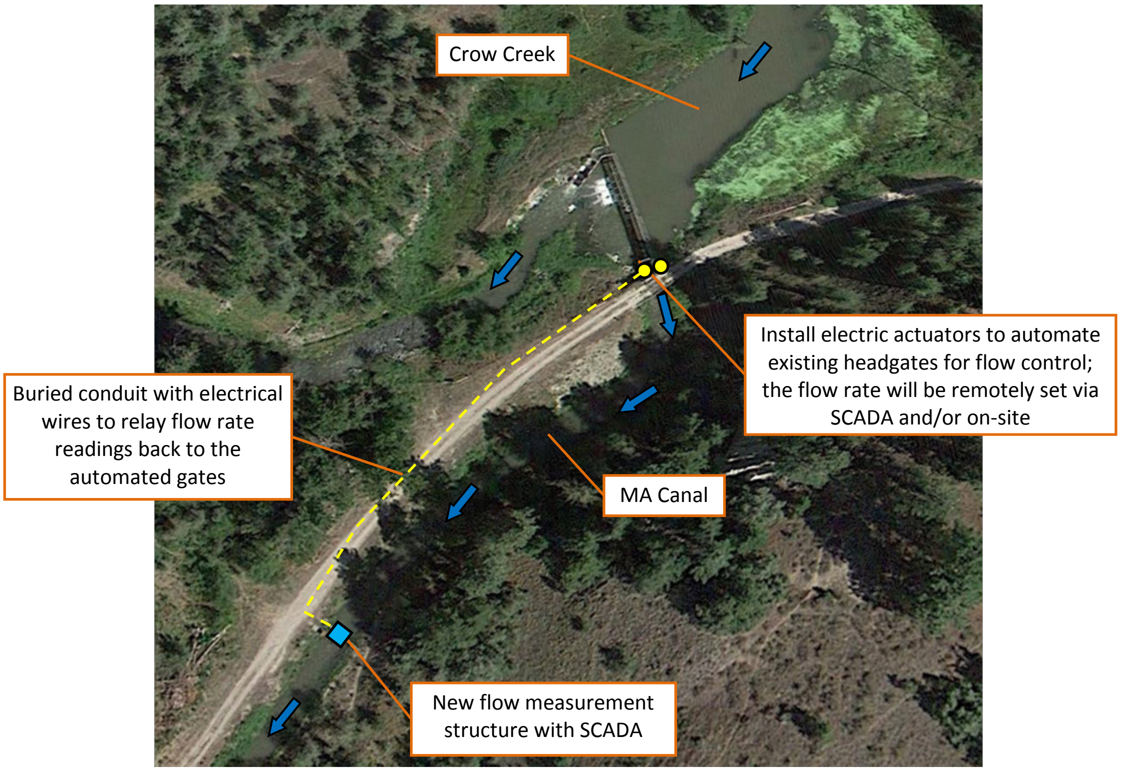


Figure 13. Modernization changes at the head of the MA Canal

The modernization changes will include:

1. A SCADA site will be established to relay information every few minutes using either satellite or radio communications. Other standard information such as battery voltage and gate setting (manual/auto) would also be obtained. The SCADA information would include data from redundant sensors of the following:
    a. The water elevation directly upstream and downstream of the MA Canal headgates
    b. The positions of the shafts for the headgates
2. The MA Canal headgates will be equipped with electric actuators. The positions of those gates will be remotely set via SCADA and/or on-site. An electric power supply must be provided, with battery backup.
3. The existing gauging station will be replaced with a new flow measurement structure. The type of structure will depend on the available headloss. Ideally, a flow measurement flume would be the best option. If there is limited headloss, a subcritical contraction with an acoustic Doppler velocity meter (ADVM) will be used for flow measurement.
4. Buried conduit housing electrical wires will be run from the new flow measurement structure to the newly automated headgates. The headgates will automatically adjust based on the instantaneous flow reading.

Physical Improvements to the MA Canal

The existing MA Canal can be characterized as the following:

- Long, winding, and runs along the hillside above the valley (refer back to Figure 7 for the existing alignment of the MA Canal).
- The first 5 miles of the canal is for conveyance only to supply the Moiese Valley.
- Assumed to be a large contributor of seepage.
- Aquatic growth could possibly be limiting the flow capacity of the canal.

Figure 14 shows an example of the physical condition of the MA Canal.

Figure 14. Example of existing condition of the MA Canal. Picture shows a large amount of aquatic growth in the canal.

Under the new operational management scheme of the Moiese Canal System, frequent flow rate changes will be made at the head of the MA Canal. In addition, large flow rate variations will occur in the canal with the construction of multiple limited-demand pipelines. Therefore, the MA Canal will need to be able to handle large and frequent flow rate changes.

Physical improvements will be made to the first 10 miles of the MA Canal in order to:

1. Improve the physical flow rate capacity of the canal by:
    a. Cleaning the canal of excess aquatic growth
    b. Possibly excavating portions of the canal to increase the cross-sectional area
2. Reduce seepage losses by performing vibratory compaction.
    a. Vibratory compaction costs approximately $2 per lineal foot to perform.
    b. The process is so inexpensive that the vibratory compaction should just be performed rather than investing money in a study to estimate how much the existing seepage may be reduced.

Improved Water Level Control along the MA Canal

Figure 15 shows two examples of existing check structures used to provide upstream water level control along the MA Canal.

Figure 15. Examples of existing check structures along the MA Canal. Photos from HKM 2008 report (top photo CH-243, bottom photo CH-245)

The water level control along the MA Canal will need to be improved for the following reasons:

- Under the new operation management scheme of the Moiese Canal System, frequent flow rate changes will be made at the head of the MA Canal.
- Flow rate variations will increase for two reasons:
    - Improved flexibility will be provided to the turnouts along the MA Canal.
    - With the construction of the new limited-demand pipelines, flow rate changes will immediately show up in the MA Canal with the starting/stopping of turnout deliveries on the pipelines.
- Have the ability to move flow rate changes down the MA Canal quickly and without the manipulation of operators.
- The existing check structures are not capable of handling large and frequent flow rate variations while simultaneously maintaining a constant upstream water level.
- New check structures will be needed at the headings for the new limited-demand pipelines.

Table 2 contains a summary of the improved water level control structures. Figure 16 shows the approximate locations for completely new and improved existing check structures along the MA Canal.

Table 2. List of new or improved water level control structures along the MA Canal

No.	Longitude	Latitude	Status	Structure Type	Design Length (ft.)	Priority
1	-114.2940	47.4500	New Structure	LCW	40	High
2	-114.3079	47.4162	Improved Structure	LCW	30	Low
3	-114.3073	47.4138	Improved Structure	LCW	30	Low
4	-114.3020	47.4117	Improved Structure	LCW	30	Low
5	-114.3022	47.4101	New Structure	LCW	30	High
6	-114.1351	47.3919	Improved Structure	LCW	30	Low

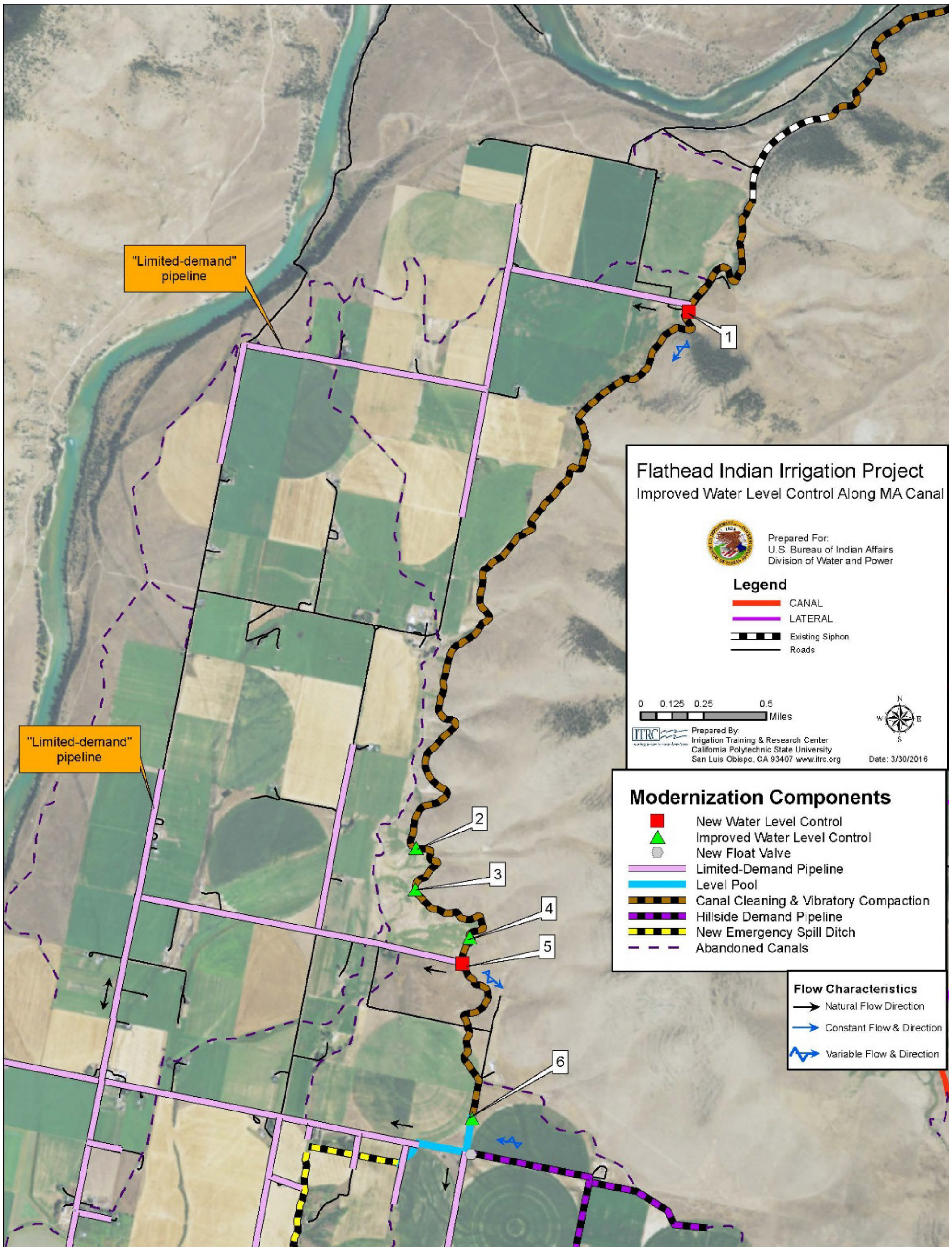


Figure 16. Approximate locations for new and improved water level control structures along the MA Canal

Figure 17 shows a conceptual example of the new LCW structures to be utilized along the MA Canal. The advantages to the presented LCW design are:

- The construction is relatively simple, so the cost of the entire structure is relatively low.
- The structure does not need to be designed by a civil engineer.
- The crest height can easily be adjusted by adding or removing flashboards.

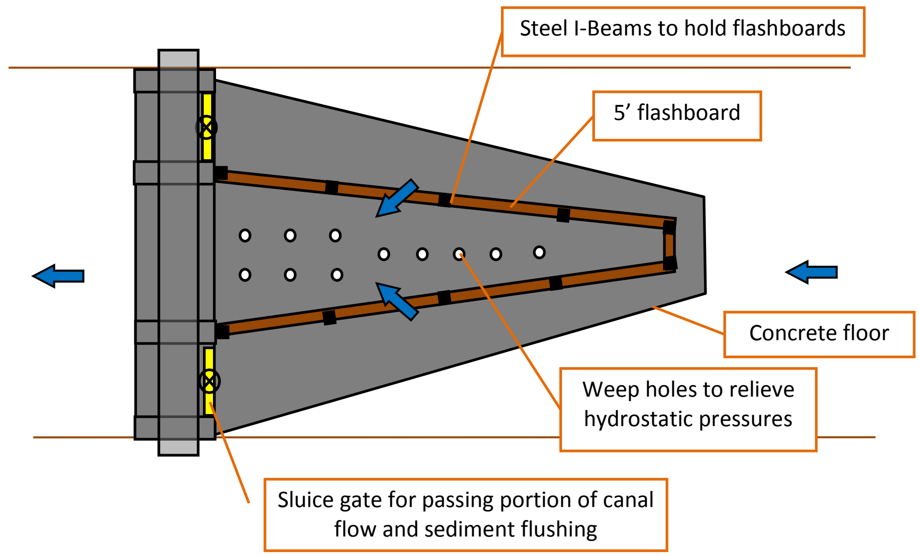


Figure 17. Example of a new LCW structure to be constructed along the MA Canal (not to scale)

Figure 18 and Figure 19 show similar examples of existing LCW structures installed in two irrigation districts in California.

Figure 18. Somewhat similar LCW installed at Turlock ID

Figure 19. Somewhat similar LCW in Fresno ID, but lacking the side sluice gates and the tapered configuration of the LCW itself (although the banks are tapered). This illustrates a construction technique for tying the walls together for strength, and providing access for operators to clean off the weir crest.

Level Pool System

Figure 20 shows the existing canal system near the Hillside Ditch spill into the MA Canal.

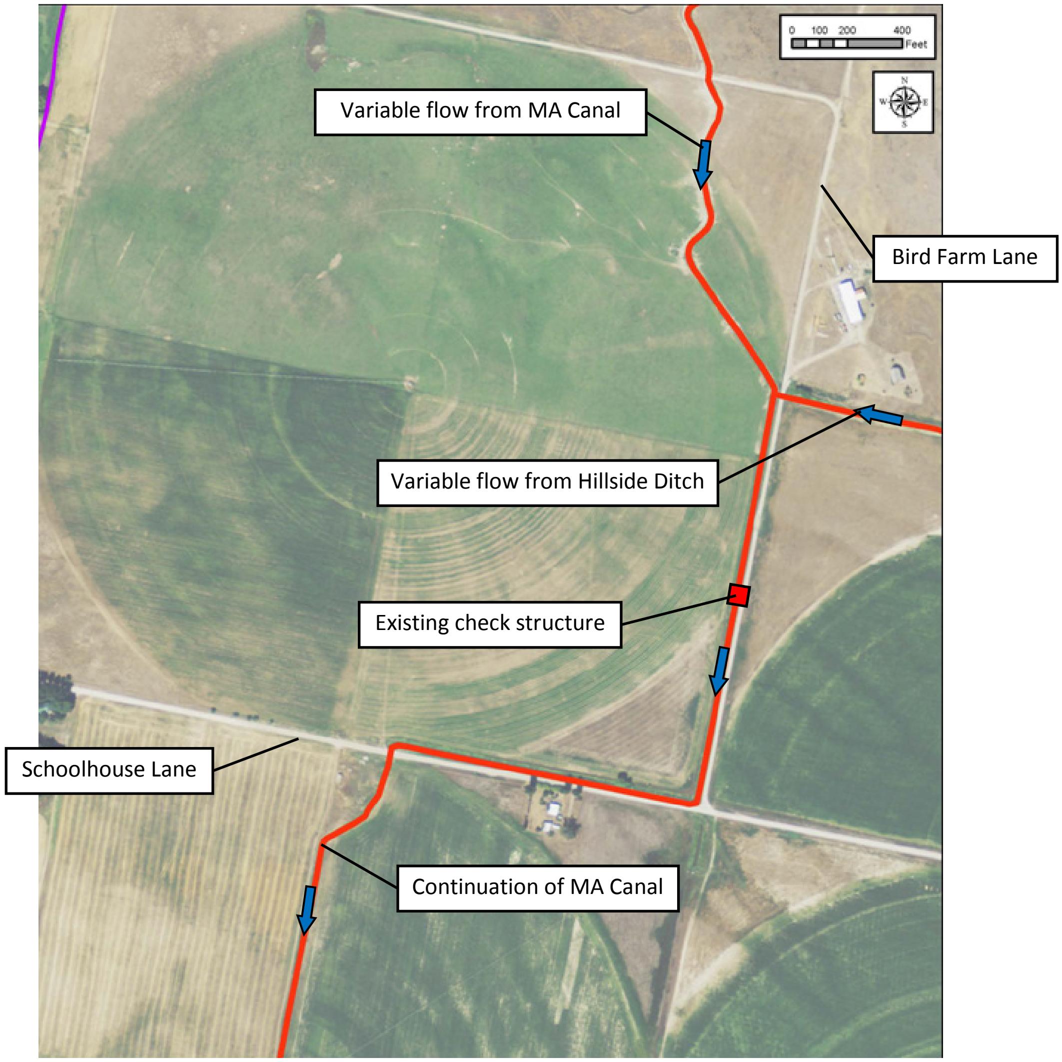


Figure 20. Existing conditions of MA Canal near the inflow from Hillside Ditch

Problems associated with operation of the southern portion of the Moiese Canal System are:

- Large flow rate variations tend to occur at the merge point of the two canals.
- Often there is a shortage of water so farmers have a difficult time operating their pivots.
- The existing infrastructure is not designed to easily handle constantly changing flow variations.
- Limited access, a large number of turnouts, and winding canals makes it difficult for operators to manage the water.

Modernization Components

A new level pool in the MA Canal will simplify the operation of the southern portion of the Moiese Canal System. The following benefits will be provided:

- Variable flows in the MA Canal will be automatically supplemented with flow from Hillside Reservoir to meet the irrigation demand in the southern portion of the Moiese Canal System.
- Hillside Reservoir provides the necessary "buffer" for the MA Canal.
- Operational spill at the end of the canal will be significantly reduced.
- The management issues for operators will be reduced.
- Excellent service and flexibility will be provided to water users.

Figure 21 and Figure 22 show the modernization components of the new level pool in the MA Canal.

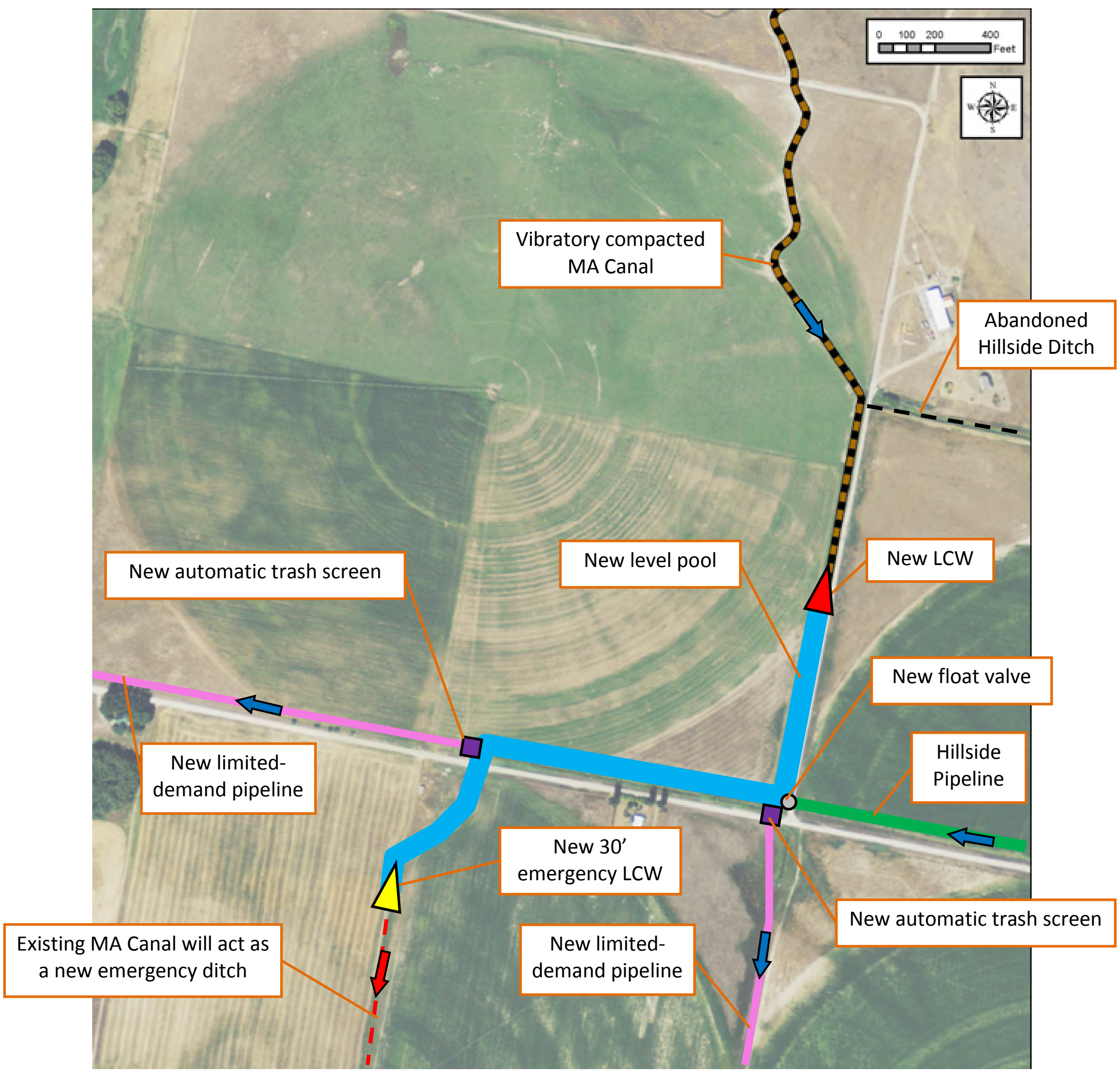


Figure 21. Modernization components of the new level pool in the MA Canal

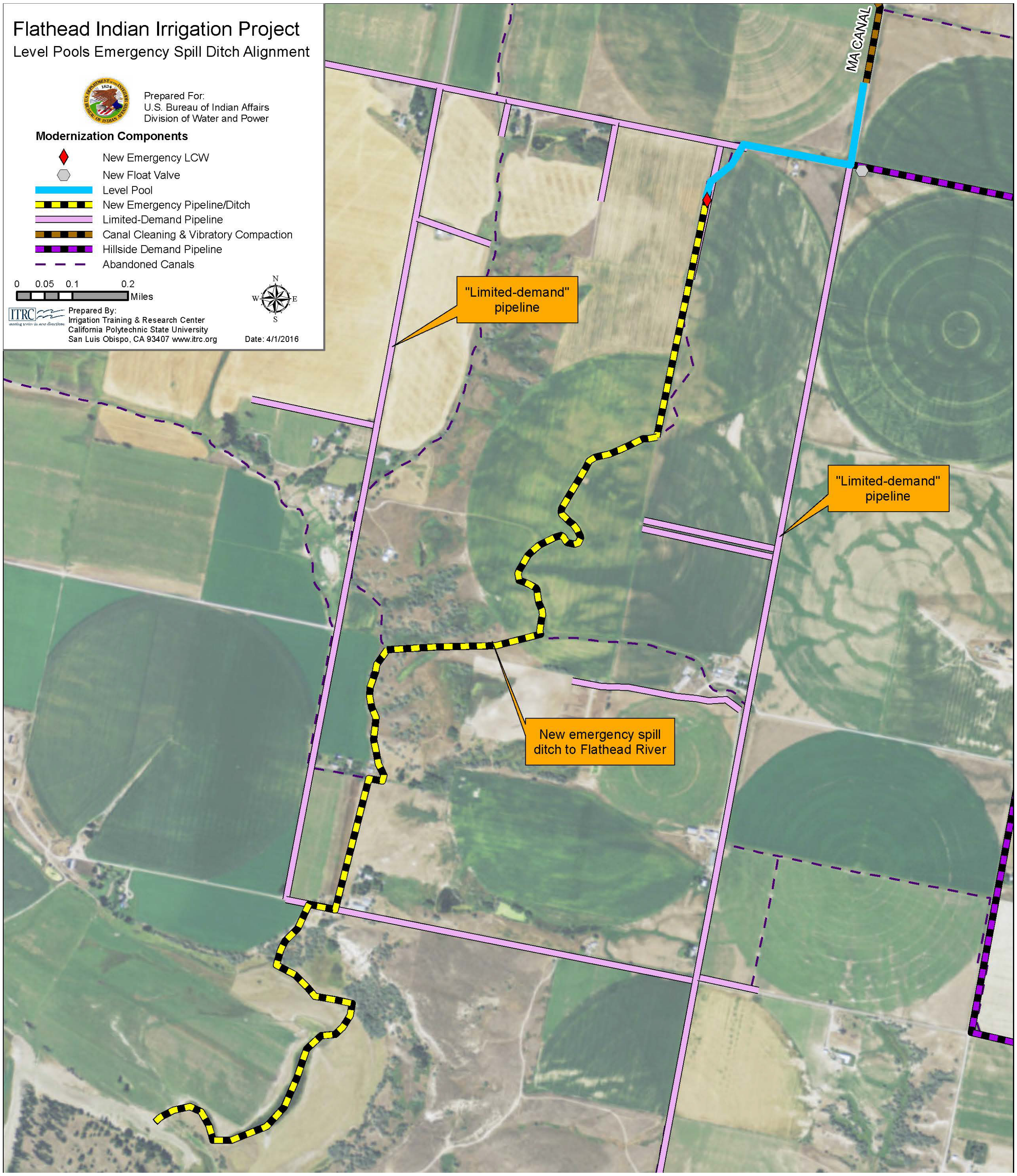


Figure 22. Approximate alignment of new emergency spill ditch from the Lower Level Pool to the Flathead River

The control components of the new level pool include the following:

1. Variable flow will enter the new level pool (near the corner of Schoolhouse and Bird Farm Lanes) from the MA Canal. The MA Canal will need to be excavated and widened to form the new level pool.
2. The new Hillside Pipeline will discharge directly into the level pool. A float valve installed at the end of the Hillside Pipeline will automatically regulate the discharge from the pipeline in order to maintain a constant target water level in the level pool.
3. Two new limited-demand pipelines will divert water directly from the level pool to supply turnouts in the southern portion of the Moiese Canal System.
4. Automated trash screens will be installed directly upstream of the entrance to each limited-demand pipeline.
5. A 30 ft. emergency-only LCW will automatically spill emergency flows into an emergency spill ditch mostly composed of existing canal and lateral alignments before eventually discharging into the Flathead River.

<u>Operation Control Scheme of the Level Pool</u>

The new operation control scheme of the level pool systems will be as follows:

- Variable flow from the MA Canal will automatically flow into the level pool.
- The target water level elevation in the level pool will be maintained by a float valve installed at the end of the Hillside Pipeline. The control scheme of the float valve will be as follows:
    - When the water level in the level pool drops below the target water level elevation, water will automatically discharge into the level pool from the Hillside Pipeline.
    - Water will continue to discharge into the level pool from the Hillside Pipeline until the target water level elevation is achieved.
    - When the target water level is obtained, the float valve will close down, preventing any discharge into the Upper Level Pool from the Hillside Pipeline.
- If the water level in the level pool continues to rise above the target water level elevation, the excess/emergency flow will automatically spill over the new emergency-only LCW. The crest of the emergency LCW will be set approximately 0.2 ft. above the target water level elevation.
- The emergency flow will pass down an emergency spill ditch until it eventually discharges into the Flathead River.

Limited-Demand Pipelines

Currently, the MA Canal unit services approximately 5,900 acres. Approximately 1,900 acres have direct turnouts originating from the main MA Canal. The Hillside Canal unit services approximately 660 acres. Limited-demand pipelines were designed to improve delivery flexibility to the remaining 4,000 acres in the Moiese Unit and the 660 acres in the Hillside Canal unit.

Assumptions and Pipeline Design

The pipeline design considered a variety of factors:

1. The flow rate requirement is very different from the volumetric allocation. For efficient irrigation with most irrigation systems, the flow rate that is needed is dependent upon the irrigation system design. For example, a wheel line (side roll) sprinkler design will have a design flow rate requirement. The turnout must meet that flow rate requirement.
2. The volumetric limitation can be enforced if USBIA operators have easy access to accurate flow meters with totalizers. In other words, a high flow rate can be allowed, but not 24/7.
3. The design flow rate for each parcel was 8 GPM/acre. A check of various sprinkler designs in the area indicated that this was adequate.
4. Major pipelines are located adjacent to roads where possible for ease of access for flow and volume measurement by FIIP staff.
5. All turnout flow meters and emergency on/off valves are located adjacent to roads. The normal operating valves and final discharge flanges are located at the high point of each parcel.

Other considerations for the conceptual design include:

1. The maximum velocity in the large pipelines is limited to 5 feet/second. There should be no water hammer damage at these velocities, because the total flow rate cannot be stopped simultaneously.
2. Maximum pipeline pressures (which occur under static conditions in this case) must be less than 75% of the pressure rating of the pipes.
3. A minimum pressure rating of 80 psi is allowed for all pipes 12” and above. Smaller pipes (6” – 10”) are rated at a minimum of 100 psi. These minimum pressures are selected based on the properties needed for external soil loading and installation requirements.

Field Turnout Design

In the *Modernization Plan* for the Moiese area, the high point of every parcel would be supplied by an individual meter and shutoff valve that is located along a road. The key ingredients of the turnout at each parcel are:

1. The materials and design must be robust so parts do not easily break.
2. The flow meter must provide readings of both instantaneous flow rate, plus totalized volume.
3. The flow meter must be positioned so that there is a good straight section of pipe upstream of it (for good accuracy), and the pipe must always flow full.
4. A buried emergency on/off valve is included.
5. A typical on/off/regulation valve (manual) is needed for normal operation.
6. Air vents will provide air release for the supply pipelines.
7. The unit should be of fairly low profile, and easy to monitor and service.
8. The responsibility of the USBIA will end just downstream of the operating valve. A flange will be provided for the farmer to make any connection desired.

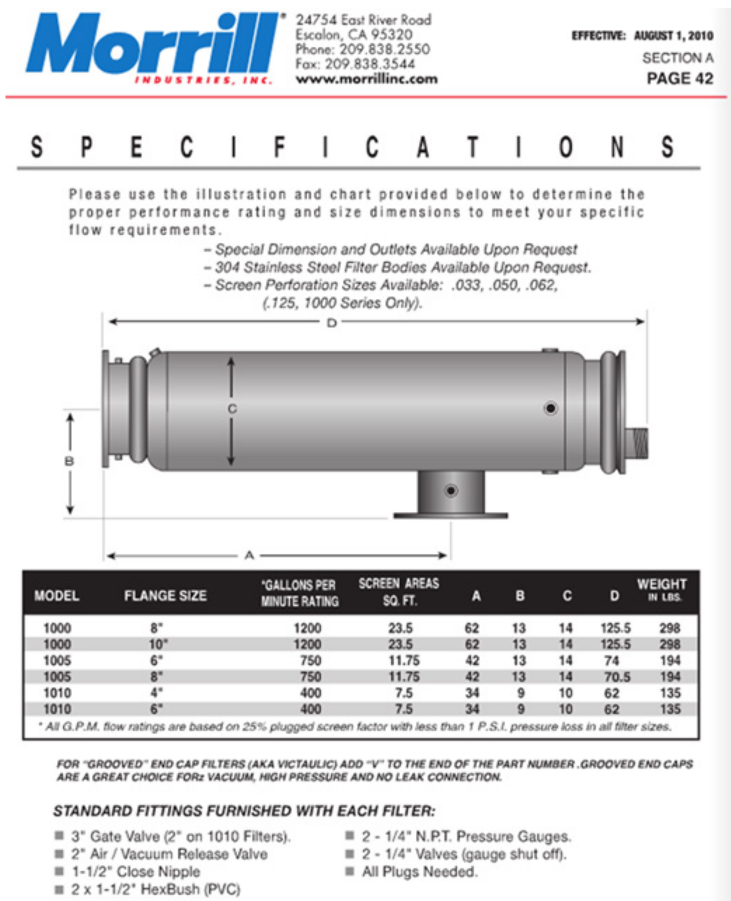
9. Each turnout is sized for a flow rate of 8 GPM/acre and therefore will vary in size for each parcel.
10. If the parcel is not adjacent to a road, the operating on/off valve and discharge flange will be located at the high point of the serviced field.

Details of turnout design are found in Appendix A.

Filtration at the Canal

Relatively clean water is important for pipeline applications such as this. For the irrigation water supplier, clean water translates into less need to flush pipes, and no blockage of valves and flow meters. For the farmer with sprinklers, pre-filtration means that only simple screen filters are needed on-farm, and those screen filters will likely need minimal attention. For details on a recommended trash screen model called the AquaSystems 2000, refer to Appendix B.

Filtration from the Hillside Reservoir into the Hillside Pipeline will have a different configuration than the filtration required on the MA Canal. For ease of access for cleaning and maintenance, a filter station with 20 horizontal stainless steel irrigation filters will be located on the pipeline downstream of the Hillside Reservoir. Figure 23 is an example of the horizontal irrigation filter designed by Morrill Industries.


Morrill INDUSTRIES, INC.
24754 East River Road
Escalon, CA 95320
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Fax: 209.838.3544
www.morrillinc.com

EFFECTIVE: AUGUST 1, 2010
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S P E C I F I C A T I O N S

Please use the illustration and chart provided below to determine the proper performance rating and size dimensions to meet your specific flow requirements.

– *Special Dimension and Outlets Available Upon Request*
– *304 Stainless Steel Filter Bodies Available Upon Request.*
– *Screen Perforation Sizes Available: .033, .050, .062, (.125, 1000 Series Only).*

MODEL	FLANGE SIZE	*GALLONS PER MINUTE RATING	SCREEN AREAS SQ. FT.	A	B	C	D	WEIGHT IN LBS.
1000	8"	1200	23.5	62	13	14	125.5	298
1000	10"	1200	23.5	62	13	14	125.5	298
1005	6"	750	11.75	42	13	14	74	194
1005	8"	750	11.75	42	13	14	70.5	194
1010	4"	400	7.5	34	9	10	62	135
1010	6"	400	7.5	34	9	10	62	135

** All G.P.M. flow ratings are based on 25% plugged screen factor with less than 1 P.S.I. pressure loss in all filter sizes.*

FOR "GROOVED" END CAP FILTERS (AKA VICTAULIC) ADD "V" TO THE END OF THE PART NUMBER .GROOVED END CAPS ARE A GREAT CHOICE FORz VACUUM, HIGH PRESSURE AND NO LEAK CONNECTION.

STANDARD FITTINGS FURNISHED WITH EACH FILTER:

- 3" Gate Valve (2" on 1010 Filters).
- 2" Air / Vacuum Release Valve
- 1-1/2" Close Nipple
- 2 x 1-1/2" HexBush (PVC)
- 2 - 1/4" N.P.T. Pressure Gauges.
- 2 - 1/4" Valves (gauge shut off).
- All Plugs Needed.

Figure 23. Example of horizontal filter for Hillside Reservoir outlet. Courtesy Morrill Industries.

Pipeline Layout

The pipeline design (Figure 24) includes three separate pipelines that have been identified as:

1. Northern Pipeline (Figure 25) – northernmost pipeline on the MA Canal serving approximately 880 acres. This pipeline is standalone.
2. Looped Pipeline (Figure 26) – essentially three separate pipelines originating on the MA Canal and connected at two locations to create a looped pipeline. This pipeline is also connected to the Hillside Pipeline through a level pool.
3. Hillside Pipeline (Figure 27) – a 48" pipeline originating at the Hillside Reservoir and terminating at the level pool located at the terminus of the MA Canal.

With this layout of the pipelines, there are technically five entry points where water can enter pipelines to meet water deliveries; however, with the use of the Looped Pipeline and the level pool, there are only three pipelines that require management.

The benefits of this pipeline layout are:

- Excess from the Hillside Reservoir can go through the Hillside Pipeline and enter the level pool to be distributed throughout the Looped Pipeline if the MA Canal cannot meet delivery requirements.
- The flow in the Looped Pipeline is bidirectional, meaning flow can go in both directions. This ensures that pressure and flow requirement will be met at turnouts served by the Looped Pipeline regardless of which canal the deliveries originated from.

The disadvantage of this pipeline layout is that utilizing the Looped Pipeline will require full understanding of the points of entry into the looped system and how to achieve the bidirectional flow into the system with minimal manipulation to the system by FIIP staff.

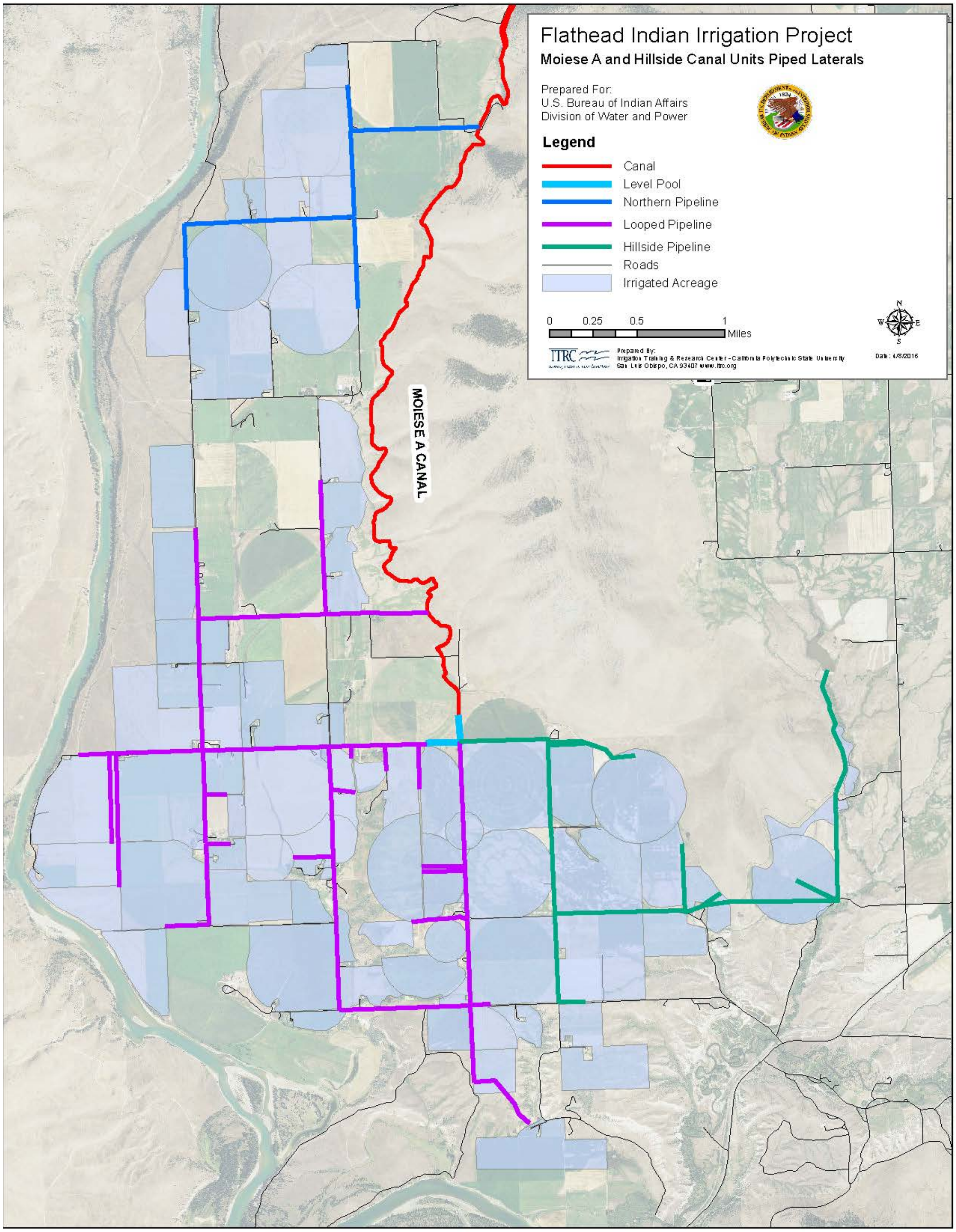

Figure 24. Layout of piped laterals in Moiese Unit

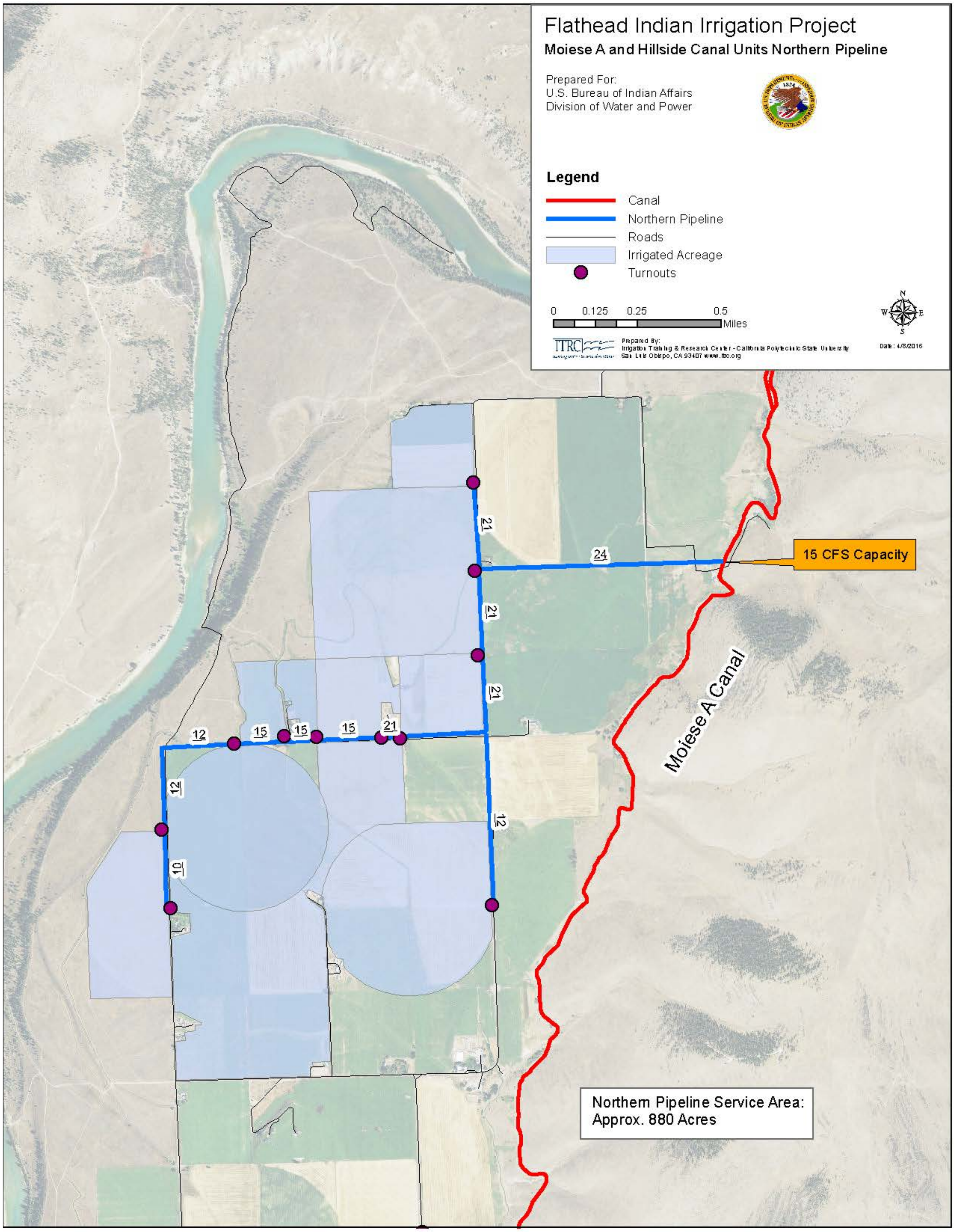

Figure 25. Pipe sizes on Northern Pipeline

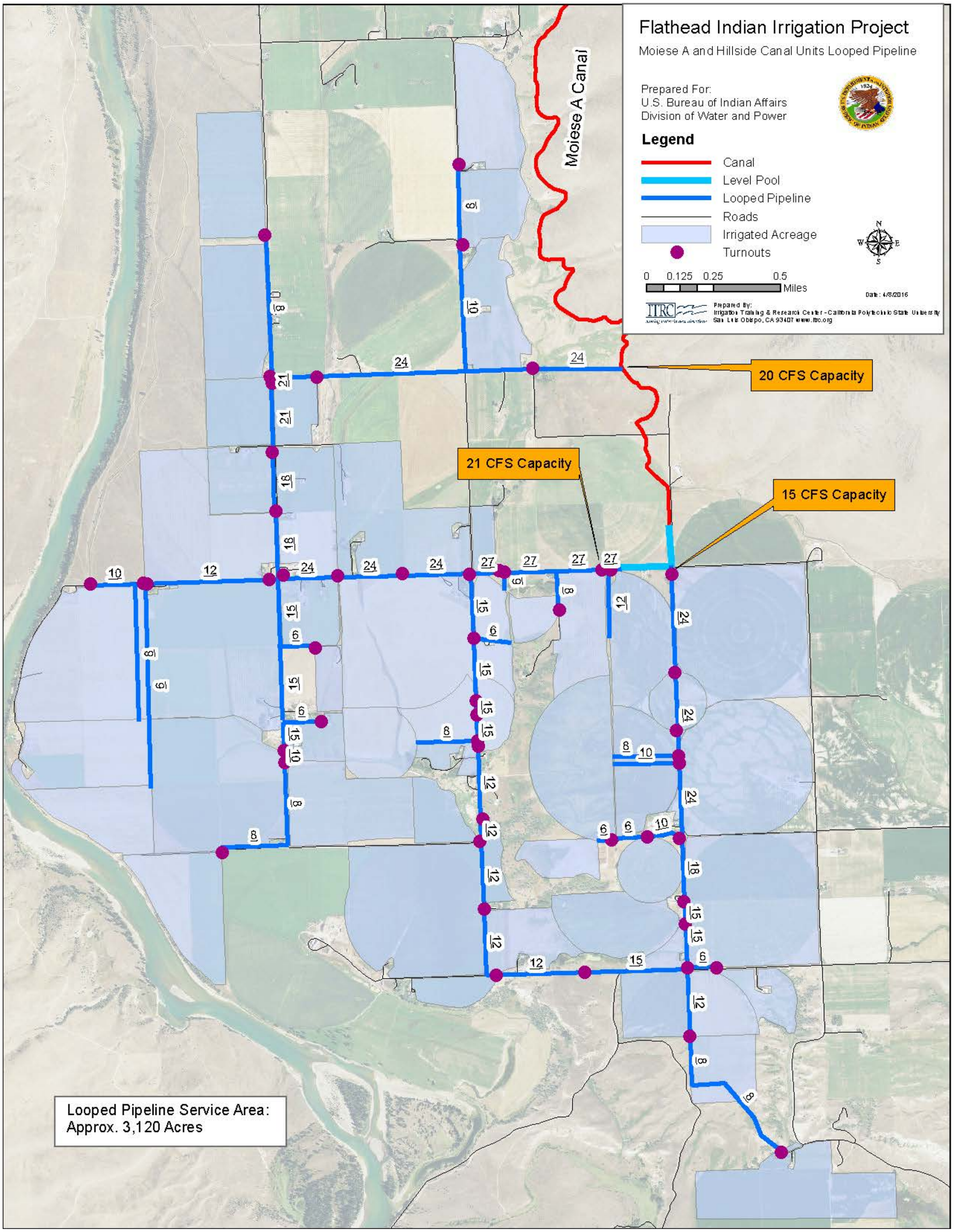

Figure 26. Pipe sizes on Looped Pipeline

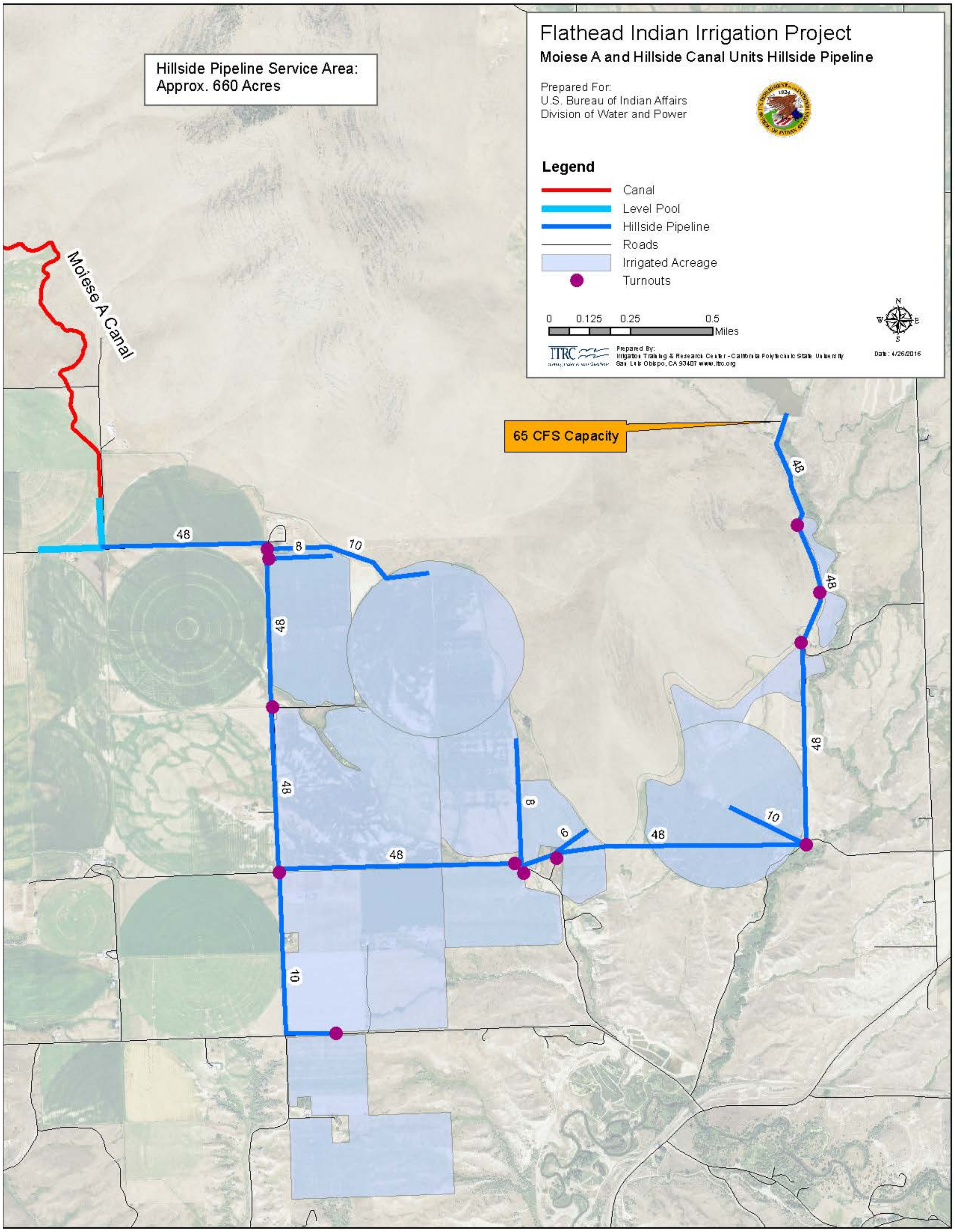

Figure 27. Pipe sizes on Hillside Pipeline

Pipeline Cost

The service area and cost for each of the three pipelines is summarized in Table 3. The cost of the Looped Pipeline is significantly greater than the cost of the other pipelines because it serves a significantly larger area. Although the Hillside Pipeline serves a smaller area than the Northern Pipeline, the Hillside Pipeline has a larger diameter pipeline.

Table 3. Irrigated acreage and construction cost for Moiese area pipelines

Pipeline	Service Area (Acres)	Construction Cost
Northern	880	$740,200
Looped	3,120	$5,900,300
Hillside	660	$1,147,300
Total	4,660	$7,768,700

The most significant cost for the limited demand pipeline is the pipeline materials, labor, and equipment for installation.