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# Flathead Indian Irrigation Project
## *SCADA*

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

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# SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA)

## *Existing SCADA*

The Tribes operate about 70 remote monitoring stations for the purposes of environmental flow measurement and archiving throughout the FIIP service area. Each remote monitoring station measures water depths at various river, creek and canal rated stations.

Periodically, water depth data are wirelessly transmitted via the Geostationary Operational Environmental Satellite (GOES) system to a third party webserver. Flow rates are computed by applying known stage-discharge equations to the data within the third-party webserver software.

From an internet connection, current and historical flow rates can be viewed and downloaded. Additional options such as automatic alarming are also available, which could automatically send notifications to interested parties if the measurements fall outside of preset alarm thresholds.

Table 1 on the next page summarizes the existing remote monitoring stations. The existing monitoring stations listed in the table are located in the maps provided in Figure 1 through Figure 5 on the following pages.

**Table 1. Existing monitoring stations installed by the Tribes**

| Station No | Location | Site Type |
|---|---|---|
| 12374250 | Mill Creek above Basso Creek | USGS |
| 352900 | South Crow Feeder Canal at headworks | Tribes |
| 311100 | Camas A Canal below Mill Creek | Tribes |
| 317610 | Camas B | Tribes |
| 317710 | Camas C | Tribes |
| 489700 | Coleman Coulee | Tribes |
| 354000 | Crow at Pump | Tribes |
| 359500 | Crow Creek below Moiese A Canal | Tribes |
| 164000 | Dayton | Tribes |
| 489200 | Dublin Gulch | Tribes |
| 517800 | Finley Creek Near Mouth | Tribes |
| 6000 | Hellroaring Creek above reservoir site | Tribes |
| 489000 | Hillside Ditch | Tribes |
| 514000 | Jocko K Canal below headworks | Tribes |
| 514090 | Jocko K at Lamoose | Tribes |
| 519400 | Jocko River below lower J Canal | Tribes |
| 514900 | Jocko River bl K Canal | Tribes |
| 486920 | KH Feeder | Tribes |
| 313100 | Little Bitterroot River below Camas A Canal | Tribes |
| 319800 | Little Bitterroot River near mouth | Tribes |
| 358590 | MA Wasteway | Tribes |
| 510000 | Middle Fork Jocko River below Tabor Feeder Canal | Tribes |
| 481410 | Mission A Canal below headworks | Tribes |
| 482910 | Mission C Canal below headworks | Tribes |
| 0 | Mission Creek at Bison Range | Tribes |
| 483100 | Mission Creek at St. Ignatius Mt | Tribes |
| 481500 | Mission Creek below Mission A Canal | Tribes |
| 358500 | Moiese A Canal near headworks | Tribes |
| 513000 | North Fork Jocko River below Tabor Feeder Canal | Tribes |
| 351500 | North Crow Creek below Pablo Feeder Canal | Tribes |
| 486880 | Pablo Feeder Canal above Pablo Drop | Tribes |
| 486830 | Pablo Feeder Canal below North Crow Creek | Tribes |
| 486800 | Pablo Feeder Canal below Post Creek | Tribes |
| 486891 | Pablo A Canal below Pablo Reservoir | Tribes |
| 510100 | Placid Canal | Tribes |
| 487890 | Post F Hillside | Tribes |
| 487510 | Post F at Headworks | Tribes |
| 487600 | Post Creek near Fort Connah | Tribes |
| 486897 | Pablo A Canal at Round Butte Weir | Tribes |
| 353000 | South Crow Creek below South Creek Feeder Canal | Tribes |
| 510570 | TFC Twin Lakes | Tribes |
| 510520 | Tabor Feeder Canal below North Fork Jocko River | Tribes |
| 513100 | Upper S at Headworks | Tribes |
| 519200 | Valley Creek near mouth | Tribes |

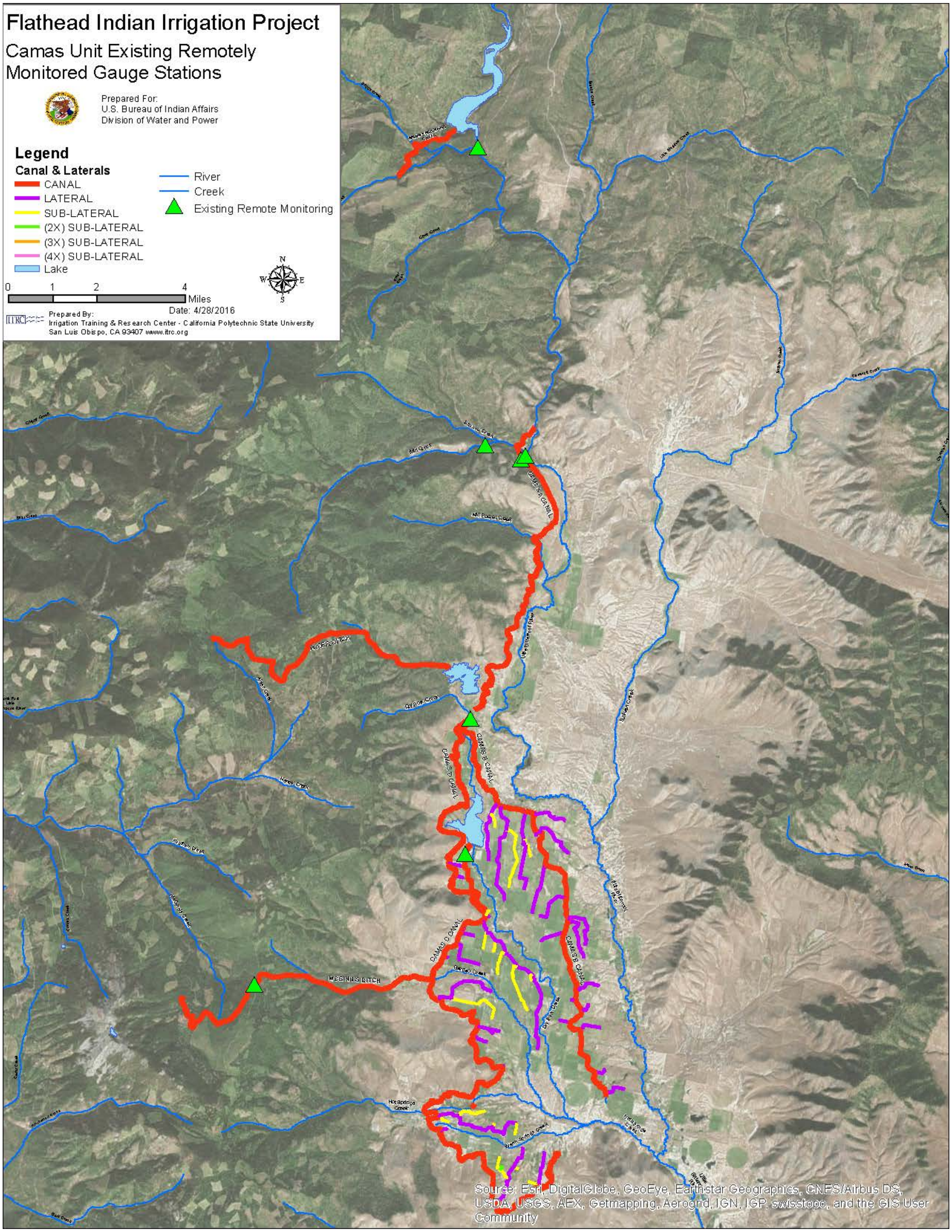


**Figure 1. Existing remote monitoring stations within the Camas Canal Unit**

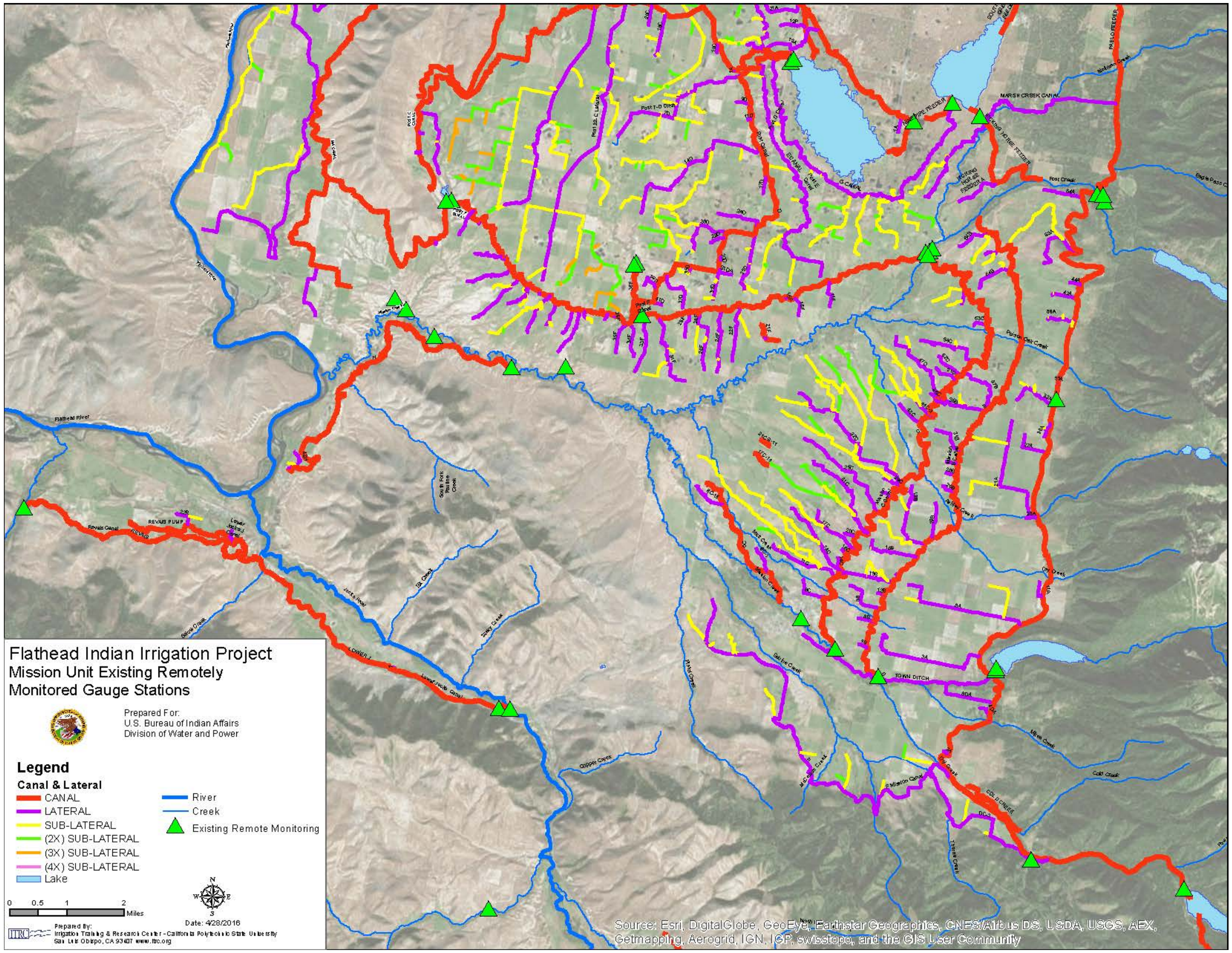


**Figure 2. Existing remote monitoring stations within the Mission area**

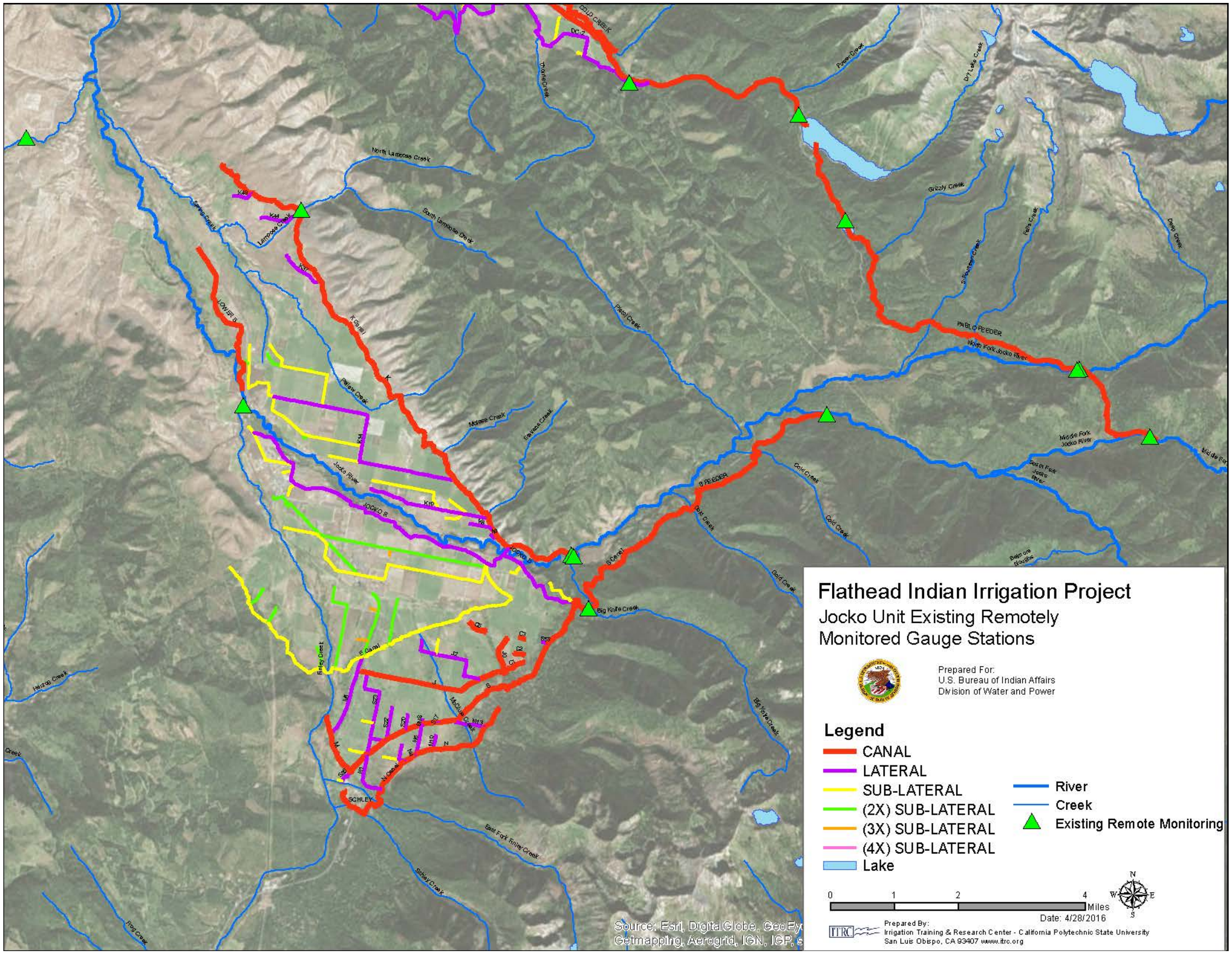


**Figure 3. Existing Jocko Canal Unit remote monitoring stations**

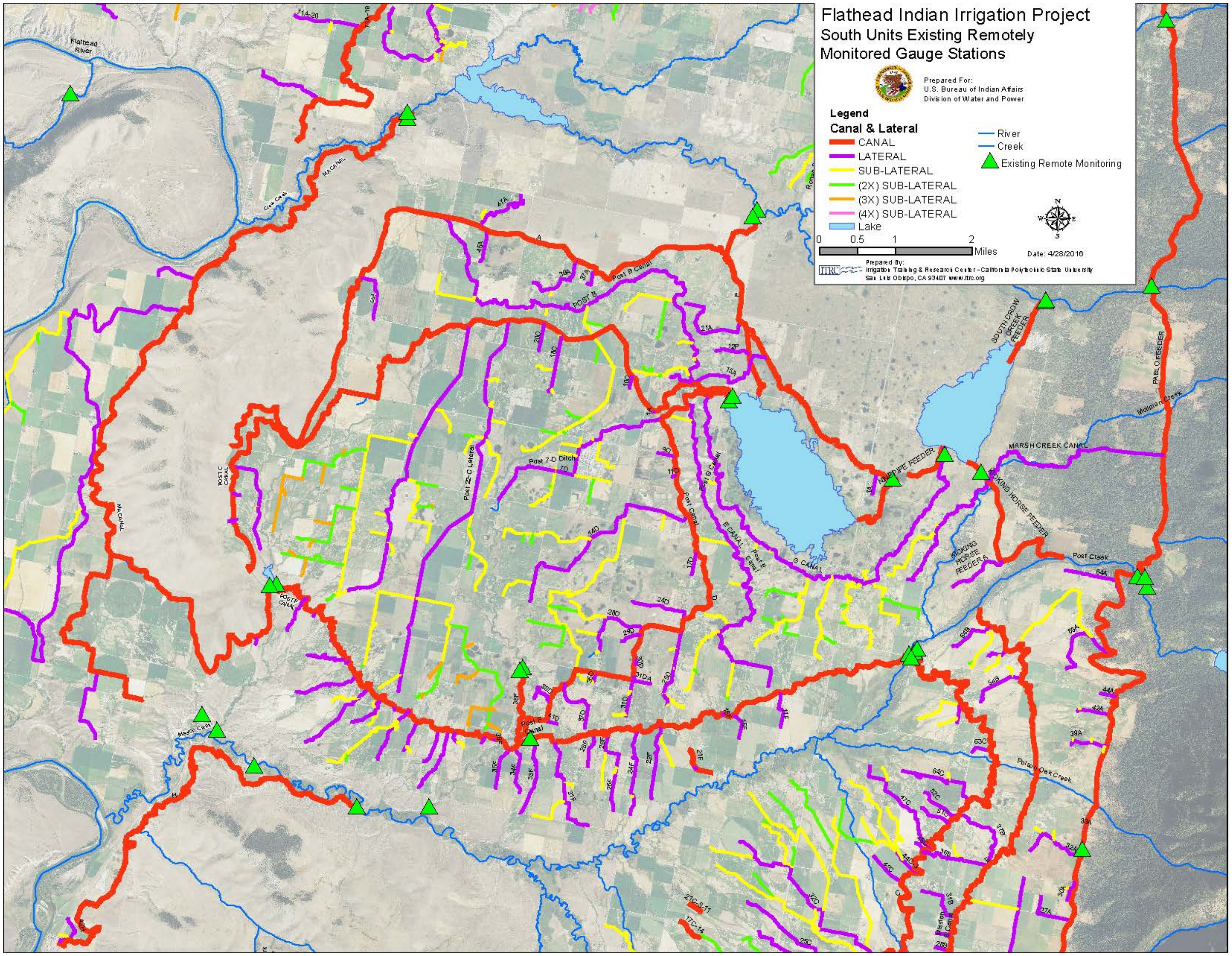


**Figure 4. Existing remote monitoring stations within the southern canal units**

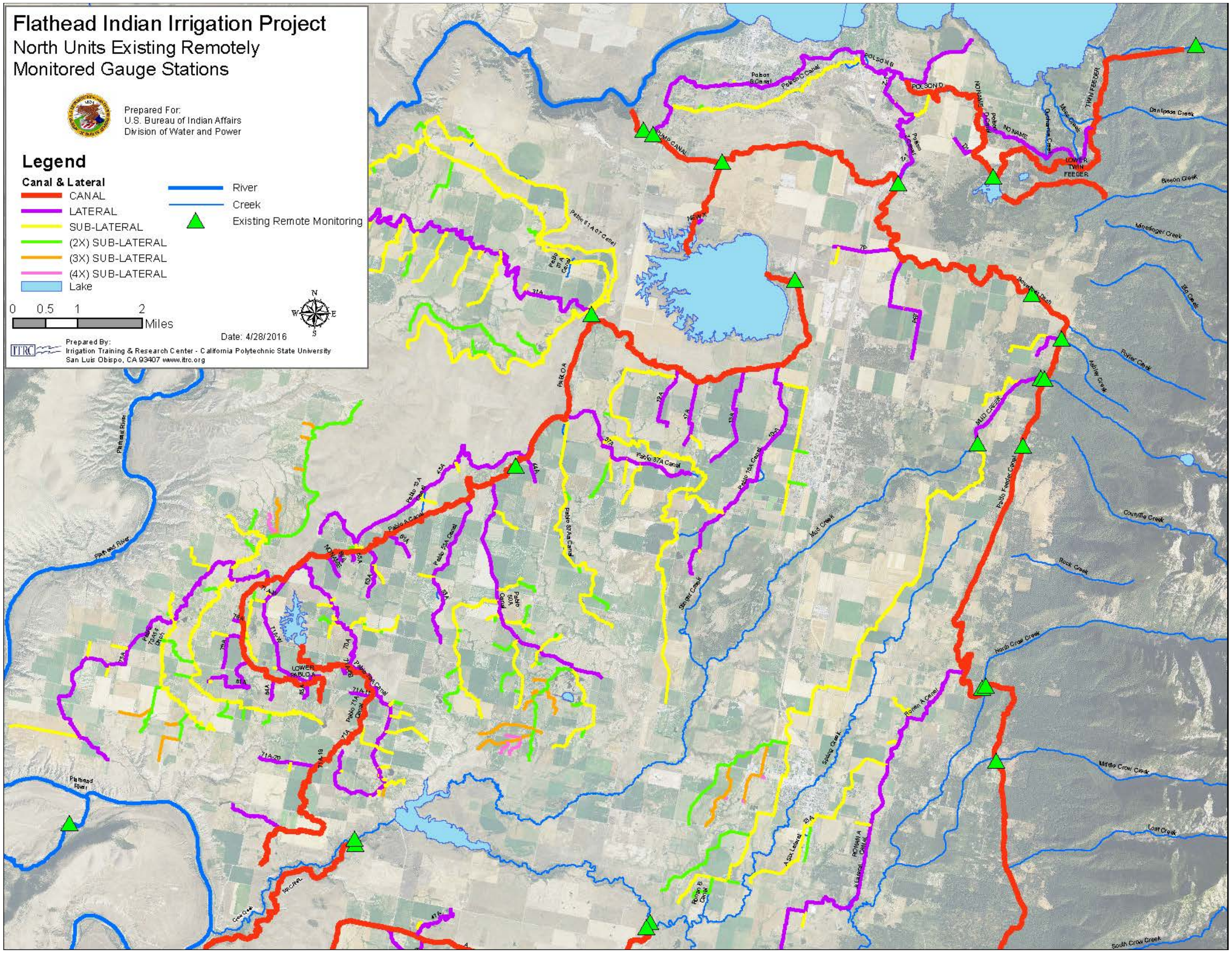


**Figure 5. Existing remote monitoring stations within the northern canal units**

As intended, the existing remote monitoring network currently benefits multiple stakeholders:

- The Tribes, the public and other environmental groups can track and analyze environmental flows
- FIIP staff can access the same data, which likely support operational and management decisions

However, the suitability of the existing remote monitoring system becomes limited once SCADA sites are established for system control purposes. More specifically:

1. The existing Aquarius webserver software, GOES satellite network and Sutron remote station hardware are not compatible with 2-way data transmission, which is necessary for SCADA control applications. It is likely not economically feasible to upgrade these components due to the initial capital investment and recurring costs of alternative satellite network services.
2. Security concerns with SCADA control networks, especially those capable of remote control of reservoir discharges will demand tighter access controls such as physical or intensive software-based separation from externally-accessible networks
3. Many of the proposed SCADA sites are located in new locations that may not provide valuable information for furthering environmental monitoring efforts.

## *Vision of FIIP SCADA*

Supervisory Control and Data Acquisition (SCADA) site locations and major functional requirements are detailed in each canal unit section of this *Modernization Plan*. The purpose of this section is to discuss the proposed SCADA system rather than site-specific details, and outline an implementation roadmap.

### Proposed SCADA Sites

A complete list of the proposed SCADA sites is provided in Table 2. The proposed SCADA sites, excluding radio repeater sites, are illustrated in the maps provided in Figure 6 through Figure 10 on the following pages.

**Table 2. Proposed SCADA sites and general functions**

| Canal Unit | Location | Automatic Control | Remote Manual Control | Remote Monitoring |
|---|---|---|---|---|
| Camas | Hubbart Reservoir | | X | X |
| Camas | Head of Camas A Canal | | | X |
| Camas | Camas A pump to Upper Dry Fork Reservoir | | | X |
| Camas | Upper Dry Fork Reservoir outlet | | | X |
| Camas | Restart of Camas B Canal at Lower Dry Fork Reservoir | | | X |
| Camas | Head of Camas C at Lower Dry Fork Reservoir Outlet | | | X |
| Camas | Camas B/C Pipeline pump and Limited-demand pipeline end of Camas B Canal | X | X | X |
| Camas | Camas C Canal Reservoir | X | X | X |
| Camas | Camas C Canal Spill | | | X |
| Camas | Camas area repeater (collector) | | | |
| Camas | Camas area backhaul repeater | | | |
| Crow Creek | Pablo Feeder Canal at North Crow Creek | X | X | X |
| Crow Creek | Pablo Feeder Canal at Middle Crow Creek | | | X |
| Crow Creek | Pablo Feeder Canal at South Crow Creek | | | X |
| Crow Creek | Pablo Feeder Canal at Post Creek | | | X |
| Crow Creek | Head of Kicking Horse Feeder Canal at Post Creek | X | X | X |
| Crow Creek | Head of South Crow Creek Feeder | | | X |
| Crow Creek | Kicking Horse Reservoir and head of Ninepipe Feeder Canal | | | X |
| Crow Creek | Crow Pump Station at Crow Creek | X | X | X |
| Crow Creek | Post P Canal to Ninepipe Reservoir | | | X |
| Crow Creek | Ninepipe Reservoir; head of Post C and Post D Canal | | | X |
| Crow Creek | Head of Ninepipe Feeder Canal after Post A bifurcation | | | X |
| Crow Creek | McDonald Reservoir | | | X |
| Crow Creek | Crow Creek repeater (collector) | | | |
| Crow Creek | Crow Creek backhaul repeater | | | |
| Jocko | Head of S Canal | | X | X |
| Jocko | Head of K Canal | X | X | X |
| Jocko | Head of D Canal at S Canal | | | X |
| Jocko | K Canal Limited-demand D/R pipeline | | | X |
| Jocko | K Canal Regulating Reservoir | | | X |
| Jocko | K-14 Loop pipeline - southern end near reservoir | | | X |
| Jocko | K-14 Loop pipeline and K Canal pipeline entrance | X | X | X |
| Jocko | S&J Canal Reservoir | X | X | X |
| Jocko | Lower Jocko Lake | | | X |
| Jocko | Upper Jocko Lake | | | X |
| Jocko | Repeater | | | |
| Jocko | Repeater | | | |
| Jocko | Repeater | | | |
| Mission | Head of Dry Creek Feeder at Tabor Reservoir | | | X |
| Mission | Mission Reservoir discharge at Mission A Canal | | | X |
| Mission | Mission A Canal at Ashley Creek | | | X |
| Mission | Head of Mission B Canal | | | X |
| Mission | End of Mission F Canal | | | X |
| Mission | Falls Creek | | | X |
| Mission | Middle Fork Jocko River diversion | | X | X |
| Mission | North Fork Jocko River diversion | | X | X |
| Mission | Placid Canal diversion | | X | X |
| Mission | Repeater | | | |
| Mission H | Pump diversion on Flathead River | X | X | X |
| Mission H | Pump Diversion on Mission Creek | X | X | X |
| Moiese | Head of Moiese A (MA) Canal | X | X | X |
| Moiese | Hillside Reservoir | | | X |
| Moiese | Level Pool and Limited-demand Pipelines | | | X |

| Canal Unit | Location | Automatic Control | Remote Manual Control | Remote Monitoring |
|---|---|---|---|---|
| Moiese | Limited demand pipe inlet - northern | | | |
| Moiese | Limited demand pipe inlet - southern | | | X |
| Moiese | Collector and backhaul link | | | |
| Pablo Feeder | Pump Canal Pump Station at Flathead River | | | X |
| Pablo Feeder | Pump Canal x Pablo Feeder LCW/Pump 1 | X | X | X |
| Pablo Feeder | Pablo Feeder LCW/Pump 2 | X | X | X |
| Pablo Feeder | Pablo Feeder LCW/Pump 3 | X | X | X |
| Pablo Feeder | Pablo Feeder LCW/Pump 4 | X | X | X |
| Pablo Feeder | Pablo Feeder LCW/Pump 5 | X | X | X |
| Pablo Feeder | Pablo Feeder LCW/Pump 6 | X | X | X |
| Pablo Feeder | Pablo Feeder LCW/Pump 7 | X | X | X |
| Pablo Feeder | Limited demand pipe entrance - Polson C | | | X |
| Pablo Feeder | Limited demand pipe entrance - Z-1 | | | X |
| Pablo Feeder | Limited demand pipe entrance - Polson D | | | X |
| Pablo Feeder | Mud Creek x Pablo Feeder Canal | | | X |
| Pablo Feeder | Mud Creek x Ronan B Canal | | | X |
| Pablo Feeder | Pablo Feeder Canal at Pump Canal | | | X |
| Pablo Feeder | Pablo Reservoir at Pablo A Canal | | | X |
| Pablo Feeder | Twin Reservoir | | | X |
| Pablo Feeder | Collector and backhaul link | | | |
| Post | Head of Post F Canal | | | X |
| Post | Regulating Reservoir on Post F Canal | X | X | X |
| Post | Post F Limited-demand pipeline 1 | | | X |
| Post | Post F Limited-demand pipeline 2 | | | X |
| Post | Post F Limited-demand pipeline 3 | | | X |
| Post | Post F Limited-demand pipeline 4 | | | X |
| Post | Post F Limited-demand pipeline 5 | | | X |
| Post | Post F Limited-demand pipeline 6 | | | X |
| Post | Post F Limited-demand pipeline 7 | | | X |
| Post | Post F Limited-demand pipeline 8 | | | X |
| Post | Post F Limited-demand pipeline 9 | | | X |
| Post | Dublin Gulch at 36F | | | X |
| Post | Regulating Reservoir at 25C | X | X | X |
| Post | Collector and backhaul link | | | |
| Horte | Round Butte Road Interceptor Pipeline Pump 1 | X | X | X |
| Horte | Round Butte Road Interceptor Pipeline Pump 2 | X | X | X |
| Horte | Round Butte Road Interceptor Pipeline Pump 3 | X | X | X |
| Horte | Round Butte Road Interceptor Pipeline Pump 4 | X | X | X |
| Horte | Horte Reservoir Flowback Pipeline x 70A | | | X |
| Horte | Horte Reservoir Flowback Pipeline x 71A | | | X |
| Horte | West Pablo Interceptor Pipeline x 73A | X | X | X |
| Horte | West Pablo Interceptor Pipeline x 73A-14 | X | X | X |
| Horte | West Pablo Interceptor Pipeline x 73A-4 | X | X | X |
| Horte | Head of 70A | | | X |
| Horte | Head of Lower Pablo A Canal | | | X |
| Horte | Pump on Lower Pablo A Canal | X | X | X |
| Horte | Horte Reservoir Pumpback Pipeline | X | X | X |
| Horte | Repeater | | | |
| Horte | Collector and backhaul link | | | |
| Valley View | Lateral 31A, 31A-1, 31A-07 headings | | | X |
| Valley View | Regulating Reservoir at 31A | | | X |
| Revais | Pump station | | | X |
| Revais | Head of the Lower J | | | X |
| Revais | Repeater | | | |
| Revais | Collector and repeater | | | |
| Office | Base station | | | |

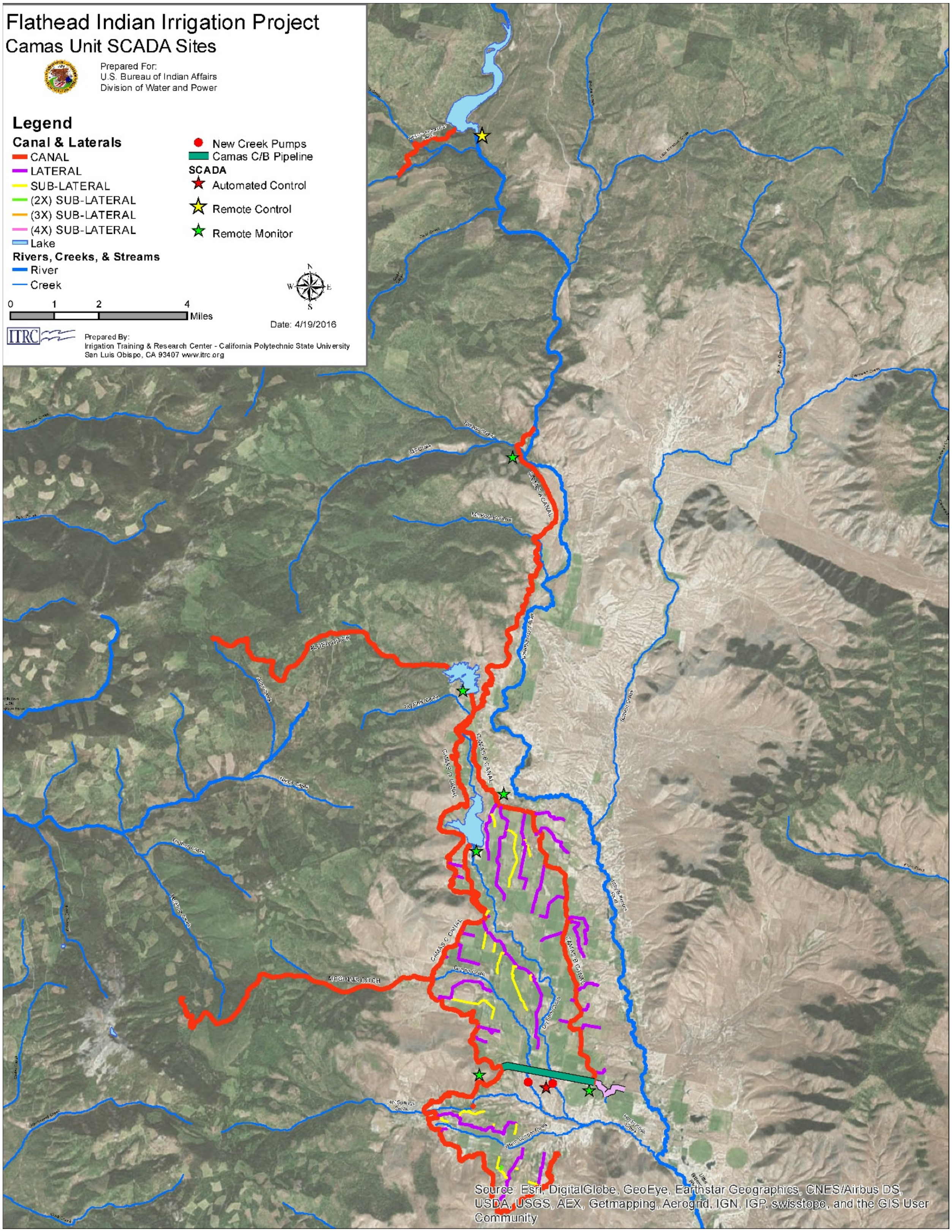


**Figure 6. Proposed SCADA sites within the Camas Canal Unit**

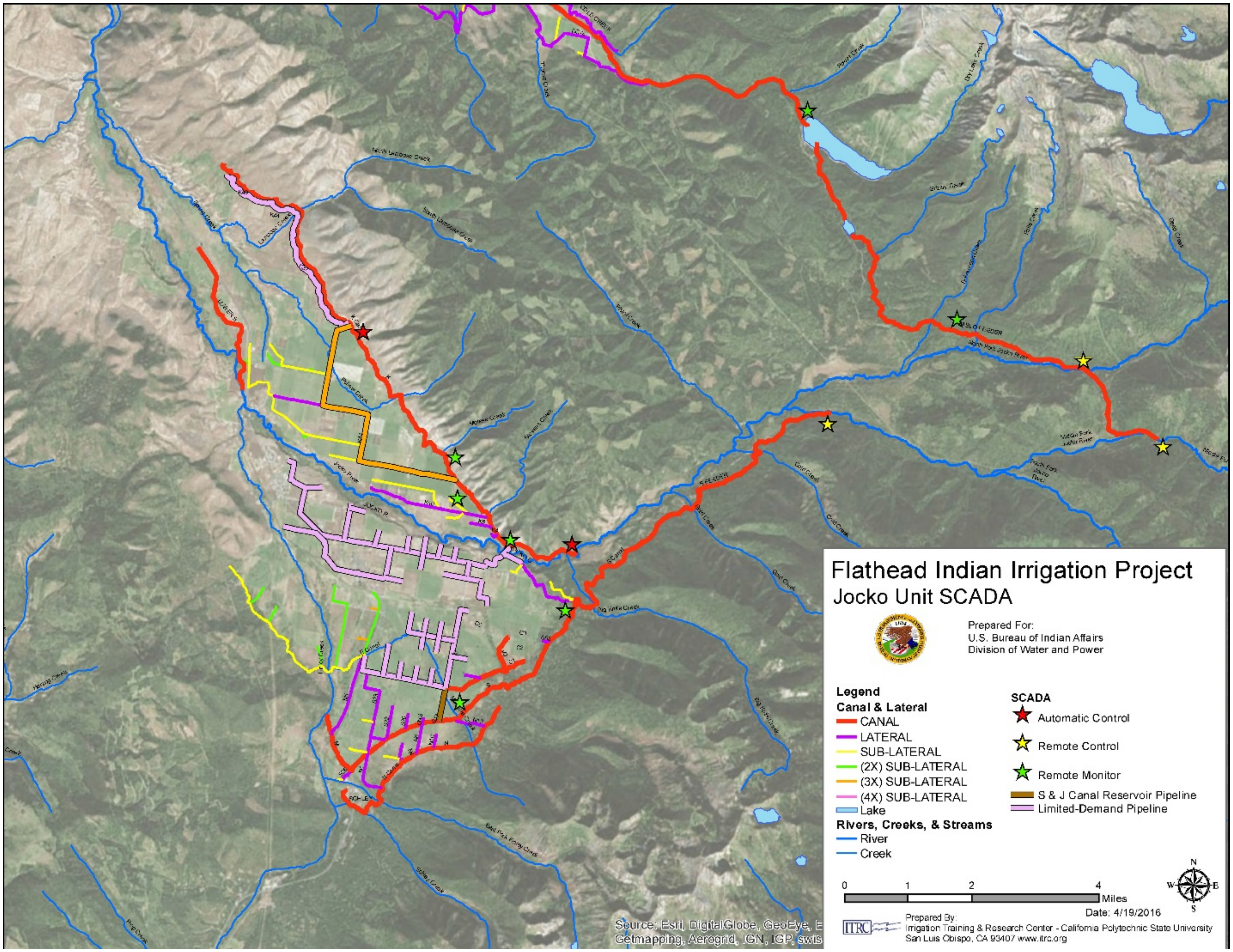


**Figure 7. Proposed SCADA sites within the Jocko Canal Unit**

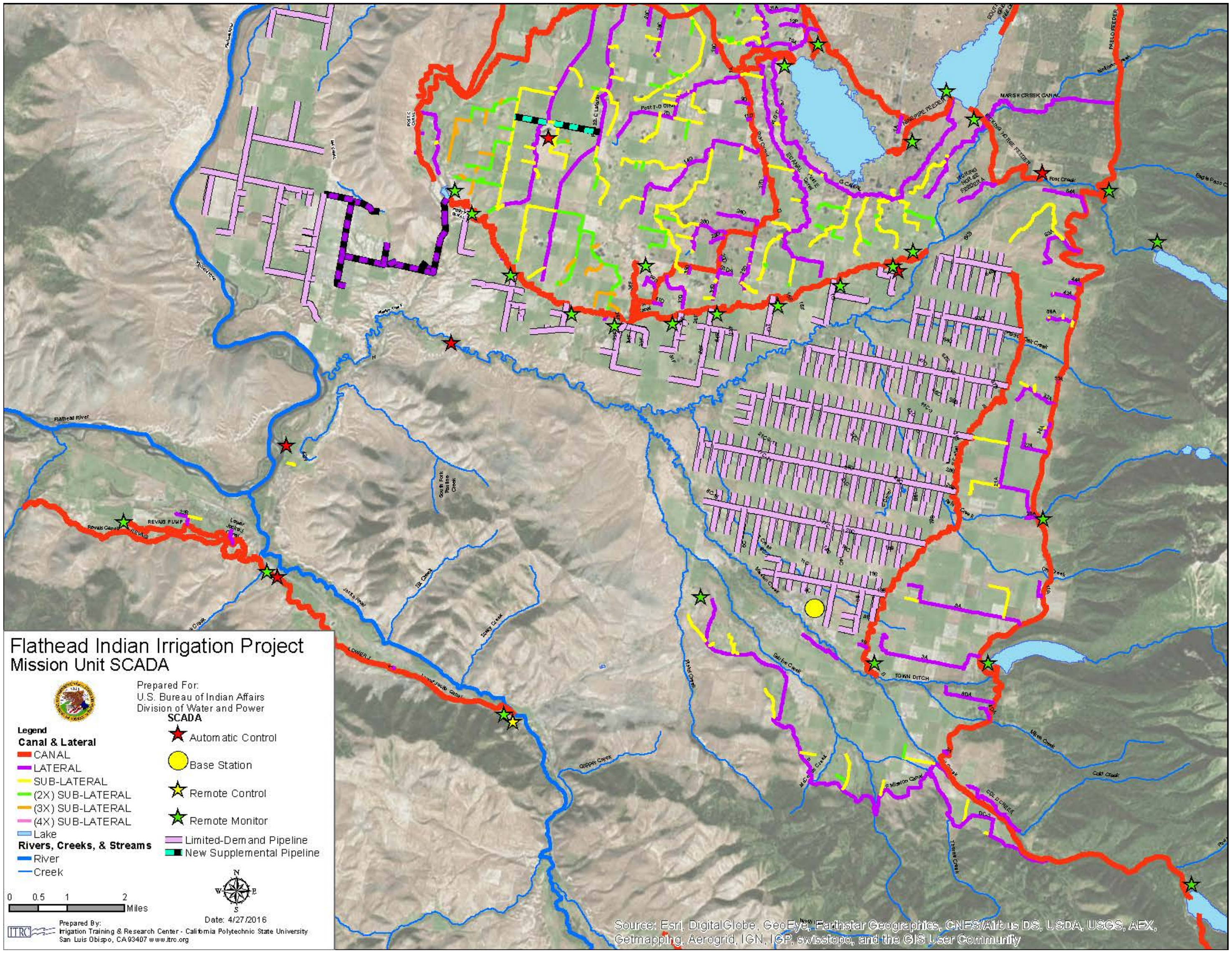


**Figure 8. Proposed SCADA sites within the Mission Canal Unit**

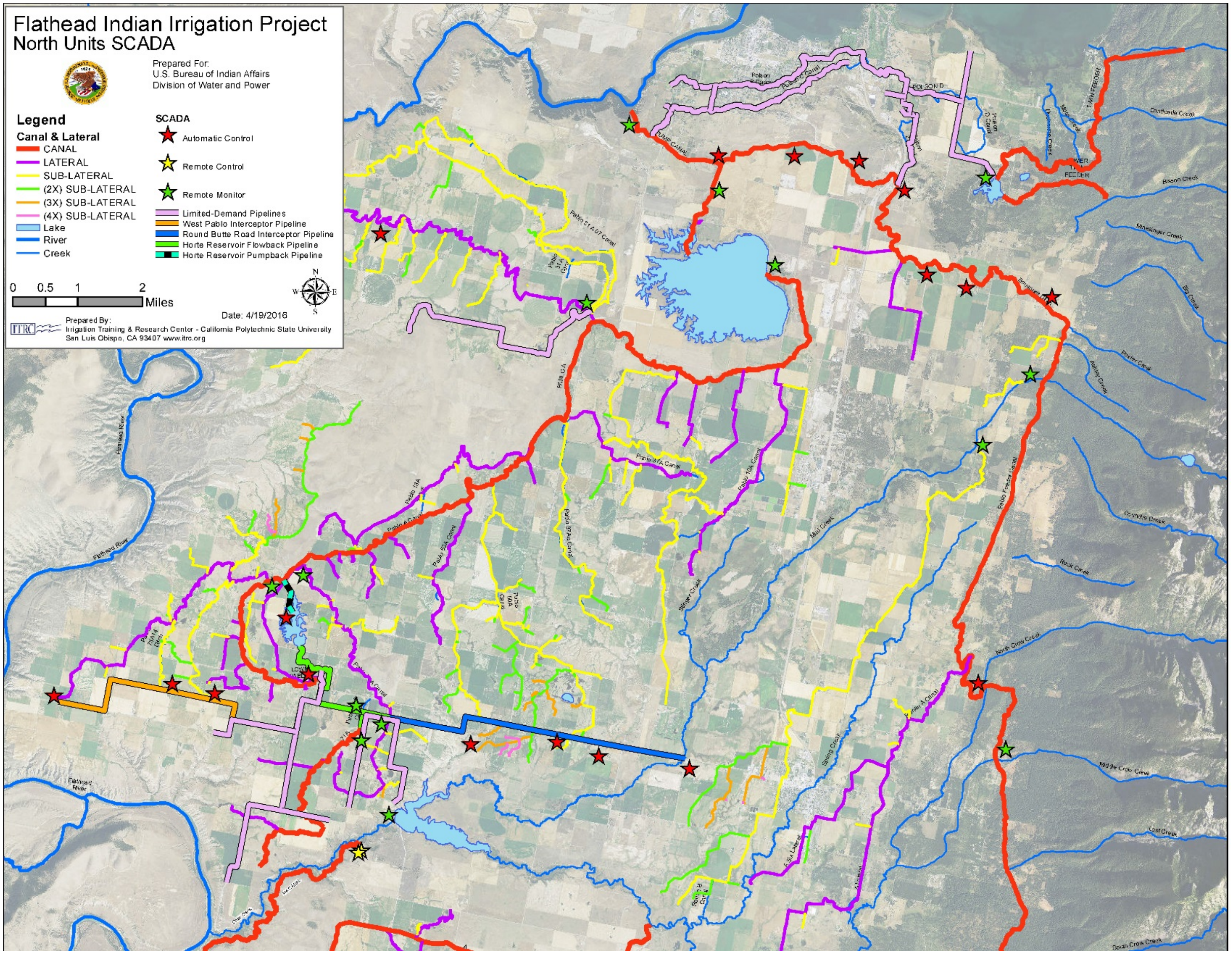


**Figure 9. Proposed SCADA sites within the northern FIIP canal units**

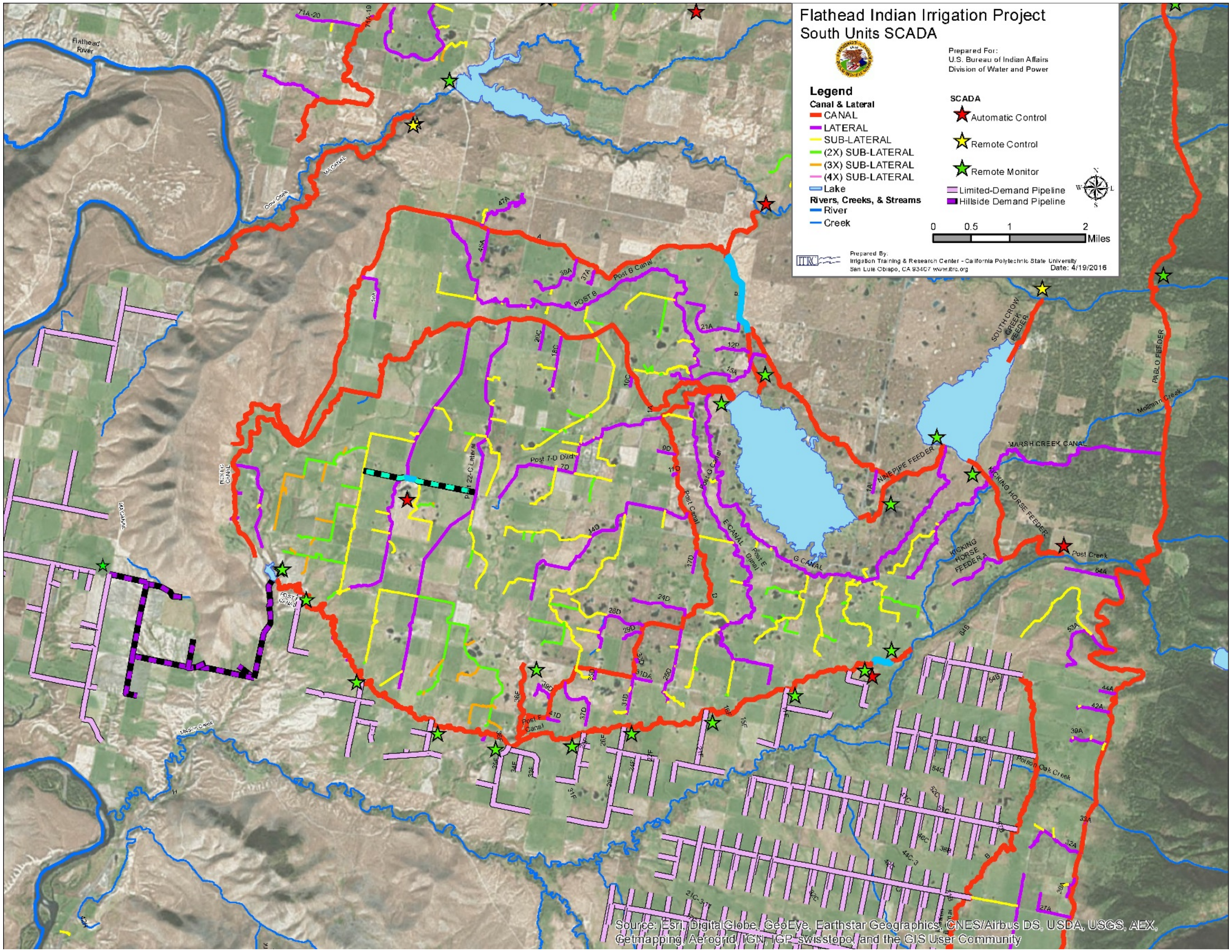


**Figure 10. Proposed SCADA sites within the Pablo Canal Unit**

## SCADA Architecture

The proposed SCADA system will be a stand-alone, secure network. Additional important SCADA system features are:

- The new SCADA system will operate on all new industrial hardware with a commercial Human-Machine-Interface (HMI) software package running on servers housed at the St. Ignatius FIIP office.
- The new HMI software will provide the following components within a single, uniform user interface on one or more office workstations:
    - Display and interaction with all new SCADA sites
    - Display and trending of data from the existing remote monitoring network sites of interest to FIIP
- Automatic alarm notifications via phone, texting and/or email can be sent to a configured sequence of FIIP ISOs and other staff.
- Remote access tablets or laptops will be used by FIIP ISO staff.
- Special security features and policies will be implemented once remote control any of the dams or reservoir outlet structures are integrated in SCADA.
- The HMI software can be configured to automatically export specific data sets to external agencies (e.g. the Tribes) as necessary.
- A 2-way base station will allow remote SCADA site (point-to-multipoint) communications.

A conceptual schematic of various SCADA network communications is provided in Figure 11.

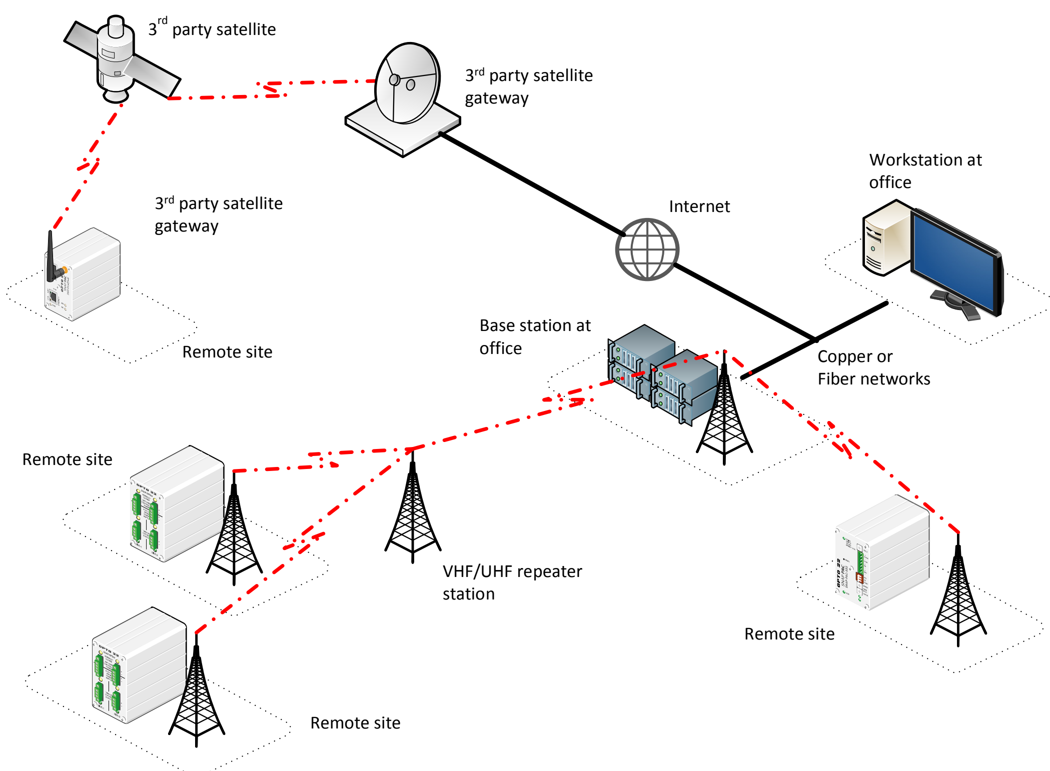


**Figure 11. Conceptual SCADA network diagram. VPN connections and other network security components are not shown.**

## Communications

Due to the wide distribution of sites and generally mountainous topography, it is anticipated that future SCADA networking will require various communication technologies and methods such as:

- Ultra-high frequency (UHF) radio
- Satellite radio
- Possibly a Virtual Private Network (VPN) connection over existing Internet Service Provider (ISP) copper networks

UHF radio connections are preferred for SCADA connections from a security and life cycle cost perspective, but may not always be possible or economically feasible to implement. It is anticipated that most of the valley floor FIIP service area between Polson and the FIIP office in St. Ignatius will be networked via a series of high-speed radio "backbone" radio repeaters.

On the other hand, the SCADA sites in other areas will likely require consideration of alternative SCADA communication technologies, as discussed in the following sections. These alternatives and final recommendations will be provided after in-field radio testing is conducted.

### *Point-to-Point Satellite Connections*

Based on a cursory analysis, the SCADA sites listed in Table 3 will require individual satellite connections (point-to-point) to the proposed SCADA system.

**Table 3. Proposed individual satellite connections to SCADA system**

| Canal Unit | Location |
|---|---|
| Camas | Hubbart Reservoir |
| Crow Creek | McDonald Reservoir |
| Jocko | Head the S Canal |
| Mission | Head of Dry Creek Feeder at Tabor Reservoir |
| Mission | Falls Creek |
| Mission | Middle Fork Jocko River Diversion |
| Mission | North Fork Jocko River Diversion |
| Jocko | Lower Jocko Lake |
| Jocko | Upper Jocko Lake |
| Jocko | Placid Canal Diversion |

### *Other Difficult Areas*

It is anticipated that future SCADA networking to the proposed SCADA sites within the Camas, Jocko and Revais areas may be more complicated than the rest of the proposed SCADA system. Although each area will have multiple SCADA sites that could potentially be linked via traditional radios, these areas are separated from the majority of the SCADA system by substantial hills and mountain ranges.

The SCADA sites within these semi-remote areas will likely be aggregated at a single new SCADA site. The aggregation site will be connected to the SCADA system by one of following alternatives:

1. A single, high-speed satellite radio connection. Life cycle costs will be an important factor when considering this alternative.
2. A hardwire Internet gateway near the town of Arlee, MT connected over the existing hardware Internet Service Provider (ISP) network to the St. Ignatius office base station. SCADA security concerns will be important when considering this alternative.
3. A series of radio repeaters to reach the proposed high-speed radio backbone between Polson and St. Ignatius.

## Roadmap

The points below outline the recommended phased process of implementing the proposed SCADA system:

1. The existing remote monitoring network can be used immediately by FIIP staff to aid in water operations and management decisions
2. Once budget is allocated, a SCADA project will be initiated. The general scope of the first phase SCADA project will include:
    a. The office base station
    b. Some number of high priority SCADA sites, which may coincide with high priority physical infrastructure improvements; for the first project it is recommended to keep the number of sites reasonable
    c. The integration and display of the existing remote monitoring network into the new SCADA interface
3. A consulting firm should be contracted to develop a *SCADA Plan* to outline the project scope and details. Details regarding SCADA plans are discussed in further detail in a later section of this report.
4. Using the *SCADA Plan* and other contract documents as a reference, the first phase SCADA system is implemented.
5. As future budget is allocated, the SCADA system will be expanded.
    a. For each SCADA expansion phase, a project-specific *SCADA Plan* will be developed
    b. The SCADA Plan is implemented using the *SCADA Plan* as a common written reference

## Shared SCADA sites

Existing remote monitoring stations are located at some of the proposed SCADA sites. In many of these cases, new flow measurement structures will be constructed, making existing gauging stations redundant. If the gauging stations were left in operation, the redundant flow rate measurements would almost always be different. Therefore, it is recommended that:

- The existing gauging stations will be abandoned as new flow measurement structures are constructed.
- The Tribes and FIIP/USBIA will "share" data from the new flow measurement structure.

It is anticipated that the details of any future shared use agreement would be discussed and agreed upon in advance between all parties. Two methods of sharing the new flow measurement structures are provided below as a starting point for future discussion:

Option 1: The remote monitoring station is kept on-site adjacent to the new SCADA equipment:
- Water level sensor signals terminate at a single device (PLC or data logger). This device would be:
  - The new SCADA PLC if the flow measurement is used for automatic control purposes.
  - Either the new SCADA PLC or any other data logger if the site is used for remote monitoring only
- The device connected to the sensors will scale the sensors and compute an instantaneous flow rate value.
- The device connected to the sensors will pass the instantaneous flow rate value via a digital signal (RS232, RS485 or MODBUS) to the device not connected to the sensors.

Option 2: The remote monitoring station is removed from the site:
- Water level sensor signals terminate at the SCADA PLC, where flow rate values are computed internally and transmitted to the FIIP base station.
- Data is automatically exported and shared via the Internet to an external webserver.

## Estimated Costs

SCADA-related budgets should include:
- *SCADA Plan*, field radio testing, project design, VFD-pump control buildings, actuators, other initial capital and labor costs as well as project implementation. The estimated total for these costs for all proposed SCADA sites is around $7.9 million. Estimates of these costs are listed in Table 4 for each individual SCADA site. These estimates do not include:
  - Surveying
  - Bringing utility power to the site or solar power
  - Pumps and variable frequency drives (VFDs)
  - New gates and concrete structures
  - Other costs listed below
- Project phasing costs. Additional project costs are associated with phased projects to account for project mobilization. An additional $30,000-$50,000 should be budgeted for each project phase.
- Contingencies. At minimum, a contingencies budget of 15% of each project phase should be included
- Annual operations and maintenance (O&M) costs are expected to be about 20% of the completed total SCADA project costs. As such, once all proposed SCADA sites are implemented a total annual O&M cost for the new SCADA system is expected to be about $1.6 million.

**Table 4. Proposed SCADA sites with general functions and estimated costs**

| Canal Unit | Location | Cost |
|---|---|---|
| Camas | Hubbart Reservoir | $92,000 |
| Camas | Head of Camas A Canal | $51,500 |
| Camas | Camas A pump to Upper Dry Fork Reservoir | $51,500 |
| Camas | Upper Dry Fork Reservoir outlet | $51,500 |
| Camas | Restart of Camas B Canal at Lower Dry Fork Reservoir | $51,500 |
| Camas | Head of Camas C at Lower Dry Fork Reservoir Outlet | $51,500 |
| Camas | Camas B/C Pipeline pump and Limited-demand pipeline end of Camas B Canal | $74,000 |
| Camas | Camas C Canal Reservoir | $136,500 |
| Camas | Camas C Canal Spill | $51,500 |
| Camas | Camas area repeater (collector) | $61,500 |
| Camas | Camas area backhaul repeater | $81,500 |
| Crow Creek | Pablo Feeder Canal at North Crow Creek | $74,000 |
| Crow Creek | Pablo Feeder Canal at Middle Crow Creek | $51,500 |
| Crow Creek | Pablo Feeder Canal at South Crow Creek | $51,500 |
| Crow Creek | Pablo Feeder Canal at Post Creek | $51,500 |
| Crow Creek | Head of Kicking Horse Feeder Canal at Post Creek | $74,000 |
| Crow Creek | Head of South Crow Creek Feeder | $51,500 |
| Crow Creek | Kicking Horse Reservoir and head of Ninepipe Feeder Canal | $51,500 |
| Crow Creek | Crow Pump Station at Crow Creek | $91,500 |
| Crow Creek | Post P Canal to Ninepipe Reservoir | $51,500 |
| Crow Creek | Ninepipe Reservoir; head of Post C and Post D Canal | $51,500 |
| Crow Creek | Head of Ninepipe Feeder Canal after Post A bifurcation | $51,500 |
| Crow Creek | McDonald Reservoir | $53,000 |
| Crow Creek | Crow Creek repeater (collector) | $61,500 |
| Crow Creek | Crow Creek backhaul repeater | $81,500 |
| Jocko | Head of S Canal | $77,000 |
| Jocko | Head of K Canal | $91,500 |
| Jocko | Head of D Canal at S Canal | $51,500 |
| Jocko | K Canal Limited-demand D/R pipeline | $51,500 |
| Jocko | K Canal Regulating Reservoir | $111,500 |
| Jocko | K-14 Loop pipeline - southern end near reservoir | $51,500 |
| Jocko | K-14 Loop pipeline and K Canal pipeline entrance | $74,000 |
| Jocko | S&J Canal Reservoir | $151,500 |
| Jocko | Lower Jocko Lake | $53,000 |
| Jocko | Upper Jocko Lake | $53,000 |
| Jocko | Repeater | $61,500 |
| Jocko | Repeater | $61,500 |
| Jocko | Repeater | $61,500 |
| Mission | Head of Dry Creek Feeder at Tabor Reservoir | $54,500 |
| Mission | Mission Reservoir discharge at Mission A Canal | $51,500 |
| Mission | Mission A Canal at Ashley Creek | $51,500 |
| Mission | Head of Mission B Canal | $51,500 |
| Mission | End of Mission F Canal | $51,500 |
| Mission | Falls Creek | $53,000 |
| Mission | Middle Fork Jocko River diversion | $95,000 |
| Mission | North Fork Jocko River diversion | $85,000 |
| Mission | Placid Canal diversion | $63,000 |
| Mission | Repeater | $61,500 |
| Mission H | Pump diversion on Flathead River | $74,000 |
| Mission H | Pump Diversion on Mission Creek | $74,000 |
| Moiese | Head of Moiese A (MA) Canal | $106,000 |
| Moiese | Hillside Reservoir | $51,500 |
| Moiese | Level Pool and Limited-demand Pipelines | $51,500 |
| Moiese | Limited demand pipe inlet - northern | $51,500 |
| Moiese | Limited demand pipe inlet - southern | $51,500 |
| Moiese | Collector and backhaul link | $61,500 |

| Canal Unit | Location | Cost |
|---|---|---|
| Pablo Feeder | Pump Canal Pump Station at Flathead River | $51,500 |
| Pablo Feeder | Pump Canal x Pablo Feeder LCW/Pump 1 | $124,000 |
| Pablo Feeder | Pablo Feeder LCW/Pump 2 | $124,000 |
| Pablo Feeder | Pablo Feeder LCW/Pump 3 | $124,000 |
| Pablo Feeder | Pablo Feeder LCW/Pump 4 | $124,000 |
| Pablo Feeder | Pablo Feeder LCW/Pump 5 | $124,000 |
| Pablo Feeder | Pablo Feeder LCW/Pump 6 | $124,000 |
| Pablo Feeder | Pablo Feeder LCW/Pump 7 | $124,000 |
| Pablo Feeder | Limited demand pipe entrance - Polson C | $51,500 |
| Pablo Feeder | Limited demand pipe entrance - Z-1 | $51,500 |
| Pablo Feeder | Limited demand pipe entrance - Polson D | $51,500 |
| Pablo Feeder | Mud Creek x Pablo Feeder Canal | $51,500 |
| Pablo Feeder | Mud Creek x Ronan B Canal | $51,500 |
| Pablo Feeder | Pablo Feeder Canal at Pump Canal | $51,500 |
| Pablo Feeder | Pablo Reservoir at Pablo A Canal | $51,500 |
| Pablo Feeder | Twin Reservoir | $51,500 |
| Pablo Feeder | Collector and backhaul link | $111,500 |
| Post | Head of Post F Canal | $51,500 |
| Post | Regulating Reservoir on Post F Canal | $151,500 |
| Post | Post F Limited-demand pipeline 1 | $51,500 |
| Post | Post F Limited-demand pipeline 2 | $51,500 |
| Post | Post F Limited-demand pipeline 3 | $51,500 |
| Post | Post F Limited-demand pipeline 4 | $51,500 |
| Post | Post F Limited-demand pipeline 5 | $51,500 |
| Post | Post F Limited-demand pipeline 6 | $51,500 |
| Post | Post F Limited-demand pipeline 7 | $51,500 |
| Post | Post F Limited-demand pipeline 8 | $51,500 |
| Post | Post F Limited-demand pipeline 9 | $51,500 |
| Post | Dublin Gulch at 36F | $51,500 |
| Post | Regulating Reservoir at 25C | $151,500 |
| Post | Collector and backhaul link | $111,500 |
| Horte | Round Butte Road Interceptor Pipeline Pump 1 | $91,500 |
| Horte | Round Butte Road Interceptor Pipeline Pump 2 | $91,500 |
| Horte | Round Butte Road Interceptor Pipeline Pump 3 | $91,500 |
| Horte | Round Butte Road Interceptor Pipeline Pump 4 | $91,500 |
| Horte | Horte Reservoir Flowback Pipeline x 70A | $51,500 |
| Horte | Horte Reservoir Flowback Pipeline x 71A | $51,500 |
| Horte | West Pablo Interceptor Pipeline x 73A | $91,500 |
| Horte | West Pablo Interceptor Pipeline x 73A-14 | $91,500 |
| Horte | West Pablo Interceptor Pipeline x 73A-4 | $91,500 |
| Horte | Head of 70A | $51,500 |
| Horte | Head of Lower Pablo A Canal | $51,500 |
| Horte | Pump on Lower Pablo A Canal | $91,500 |
| Horte | Horte Reservoir Pumpback Pipeline | $141,500 |
| Horte | Repeater | $61,500 |
| Horte | Collector and backhaul link | $81,500 |
| Valley View | Lateral 31A, 31A-1, 31A-07 headings | $51,500 |
| Valley View | Regulating Reservoir at 31A | $51,500 |
| Revais | Pump station | $51,500 |
| Revais | Head of the Lower J | $51,500 |
| Revais | Repeater | $61,500 |
| Revais | Collector and repeater | $81,500 |
| Office | Base station | $161,500 |
| | **Total** | **$7,850,000** |

# *General SCADA Overview*

This section discusses general SCADA topics related to, but not specific to the proposed FIIP SCADA system.

## The SCADA Plan

A *SCADA Plan* is a critical written reference that augments other SCADA project drawings and contract documents by detailing the following major topics:

- How the SCADA system is supposed to work
- What sites are included in this project phase
- What is to be installed at each site, and how they are to be installed
- The distribution of roles and responsibilities
- Technical specifications for components, software and standards for integration services
- Implementation, verification and acceptance criteria

SCADA plans are typically developed by specialized consultants such as ITRC, and are intended to minimize project risk.

## Functionality

The proposed SCADA system features four categories of SCADA sites with various levels of functionality and user interface capabilities, as listed in Table 5.

**Table 5. Summary of SCADA site categories, functions and capabilities**

| SCADA Site Category | SCADA Functionality | Major local user interface capabilities | Major remote user interface capabilities | Communication frequency to base station |
|---|---|---|---|---|
| Base station | Servers and a workstation running human-machine-interface (HMI) software | View near real-time and historic system performance and statuses. Adjust automatic control target set points. | Various | N/A |
| Monitoring only | Sensor and other signals are processed at each site. Data is sent back to the base station at regular intervals | View instantaneous measurements and alarms. Adjust sensor calibration constants. | Same as local | 1 minute to 6 hours |
| Remote manual control | Same as above, but enable remote adjustment of gate positions and pump status/speed | Same as above, with local manual control | Same as local | 1 minute to 3 hours |
| Automatic control | Same as above, but with a local automatic control setting | Same as above, with local adjustment of automatic control target set points | Same as local | 1 minute to 5 minutes |

Industrial SCADA systems with control capabilities require the seamless integration of numerous devices and components installed in three general locations:

- At each remote SCADA site
- Intermediate points between the remote SCADA sites and the base station to collect and forward communications, also referred to as repeater sites
- Base station (in most cases this is the district operations office)

## Components and Assemblies

### *Remote Site Equipment*

Remote SCADA site equipment provides four general functions:

- Measurement
- Signal processing
- Control command execution
- Communications

### *Measurement*

The measurement of physical parameters is the foundation of a SCADA system; without measurement there would be no numbers to look at. Measurements of physical parameters are provided by sensors, transmitters, transducers, etc., collectively referred to as “instrumentation.

Good, industrial sensors have become readily available from many different manufacturers for many types of applications. The sensors output various types of electronic signals to a remote terminal unit (RTU) for processing. One sensor example is shown in Figure 12.

**Figure 12. Ultrasonic sensor measuring the water level upstream of a weir in West Stanislaus Irrigation District alongside a submersible pressure transducer (not shown)**

### *Signal Processing*

Signal processing and other functions are provided within the RTU. The RTU is a combination of hardware and software housed in an enclosure, as shown in Figure 13.

**Figure 13. RTU cabinet internals example**

Other common components within the RTU enclosure include:

- A programmable logic controller (PLC)
- A user interface panel
- Terminal blocks
- Fuses and relays
- Radio or other modem

Within the PLC, instructions are programmed to (a) recursively scan measurement signal inputs, (b) process these signals into engineering units, (c) sometimes average the engineering units, (d) temporarily store data, and (e) output control signals based on remote manual commands or internal automatic control algorithms.

System operators can view local system parameters and input local set point adjustments or control commands via an Operator Interface Terminal (OIT). The OIT is typically a rectangular color touchscreen (between 4" to 12" diagonally), as shown in Figure 14 that is used for:

- Viewing data
- Manual control commands
- Adjustment of automation set points


**Figure 14. 12 inch touch screen example at San Luis Canal Company**

An alternative approach that is more common in other industries is to install panel personal computers (PC) at each site that enable system operators to monitor and control other SCADA sites.

### *Control Command Execution*

Once a control command signal has been created (e.g., to close a gate), various types of electro-mechanical equipment make physical system changes. Examples related to irrigation SCADA systems include:

- Electronic or hydraulic gate/valve actuators (shown in Figure 15)
- Pump motor control:
  - Single speed contactors
  - Soft starters
  - Variable frequency drives (VFDs)

**Figure 15. Rotork actuator retrofitted to a large, older sluice gate at Santiam Water Control District**

### *Communications*

Various communications equipment is also installed within and external to the RTU, including:

- Radio or other modem
- Mast or tower for antenna (as shown on the right-hand side of Figure 16)
- Ethernet switch
- Small firewall (rare)

Where distances are too great for a single communications link between remote sites and the base station, intermediate radio repeater sites may be needed to split the distance by "storing and forwarding" the data.  Repeater sites typically have larger antennas and towers, as shown in the left-hand photo in Figure 16.

**Figure 16. Large directional antenna mounted outside of a SCADA control building at Shiprock Irrigation District (left) and large antenna tower with multiple types of antennae at San Luis Canal Company**

### *Base Station Equipment*

The main component of the base station is the HMI software that runs on a typical PC (for very small systems) or a dedicated server for larger systems.  Additional IT-related equipment can also be used such as redundant servers, Ethernet switches, a firewall and backup power supply within a dedicated server rack as shown in Figure 17.

.

**Figure 17. Medium-sized SCADA server rack with IT-related equipment**

In most cases, district staff do not interact with the base station servers directly. Instead, data is sent to one or more office workstations by the HMI server. An example of an office workstation is provided in Figure 18.

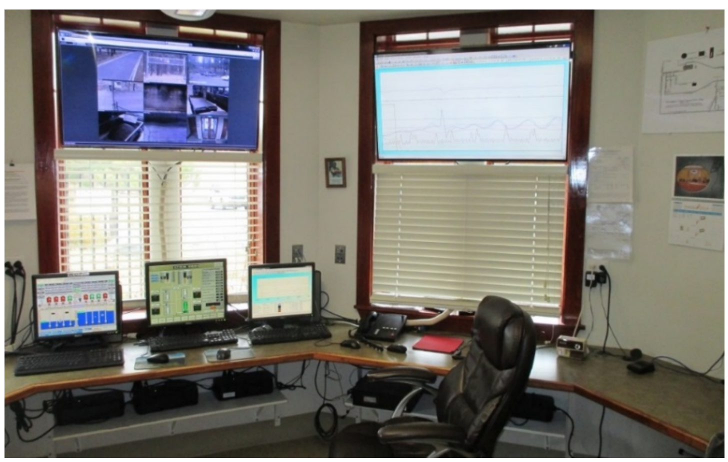

**Figure 18. Base station example with multiple HMI screens and security camera**

Communications equipment is also located at the base station to transfer data to and from remote SCADA sites.

### *Extras*

Other "add-ons" are available, but less common in irrigation SCADA systems:

- Sensor performance tracking – tracking sensor performance to identify faulty sensors
- Scheduling and decision support systems – software to aid water masters in flow routing and scheduling. Many attempts have been made but very few were fully adopted.