Marble Mountain Ranch Water Use Investigation and Alternatives Analysis

1.0 Introduction

Cascade Stream Solutions (Cascade) is working with the Mid-Klamath Watershed Council (MKWC) to identify solutions that, if implemented, bring Marble Mountain Ranch (MMR) into compliance with State Water Resources Control Board (SWRCB) Notice of Violations. Solutions are intended to comply with the SWRCB Notice of Violations and allow Marble Mountain Ranch to remain a viable business. The SWRCB issued a Report of Inspection (undated) containing notes and observations of the inspection conducted on December 17, 2014 and February 12, 2015, findings and corrective actions. SWRCB notes and observations included the following:

- Point of Diversion (POD) lacks a permanent control structure that allows regulation of diversion flows;
- Historic overtopping of diversion flows has resulted in hill slope sloughing and landslides;
- The diversion ditch has the potential to fail and cause erosion of the native slopes; and
- Water discharged from the hydropower facility flows into a pond and then to Irving Creek.

Findings from the Inspection Report include:

- "Diversion flows potentially exceed the claimed pre-1914 appropriative water right";
- "Potential waste and unreasonable use, or waste and unreasonable method of diversion"; and
- "Potential public trust impacts caused by MMR diversions;"

The SWRCB corrective actions listed in the report include:

1. Installation of a water diversion control mechanism at POD;
2. Return diverted water to Stanshaw Creek that is not put to beneficial use or water put to non-consumptive use;
3. Fix all leaks associated with the MMR water treatment system;
4. Water diverted from the POD must be piped or conveyed in a lined ditch to prevent unnecessary ditch loss;
5. Implement NMFS and CDFW by-pass flows and cease impacts to public trust resources and habitat; and
6. Consult with CDFW to determine need and requirements to protect fish from entrainment into the ditch.

To address the SWRCB corrective actions, MKWC proposes the following measures:

1. Suspend diversion of non-consumptive use flows until permitting and funding can be secured to allow for non-consumptive use;
2. Install a fish screen and headgate in the ditch below the point of diversion;
3. Install pipe along the existing ditch to convey flows for consumptive use to MMR~~the Ranch~~;

4. Identify erosion control treatments to prevent unnatural liberation of sediment from the diversion works that negatively impact the public trust.
5. Assess energy consumption, identify options to reduce energy consumption, and identify opportunities for energy production

Although Cascade does not represent Marble Mountain Ranch, it is Cascade's understanding that Marble Mountain Ranch is working towards addressing all the SWRCB corrective actions. They have suspended diversion of all flows that are not consumptively used indefinitely, fixed all leaks associated with the MMR water treatment system, and are prepared to install a fish screen to prevent fish entrainment, install a valve to regulate and control flow into the diversion and install a pipe along the existing ditch alignment. Cascade and Fiori~~e~~ Geosciences are working with Marble Mountain Ranch to identify affordable treatment measures to prevent sediment leaving the managed diversion infrastructure. Marble Mountain Ranch, MKWC, and Cascade are working with The Electrician Inc. to quantify current energy consumption, potential energy efficiency measures, and energy production opportunities.

The SWRCB findings and corrective actions narrowed the alternatives to be analyzed in this report. The original budget and scope of work for MKWC and ~~CSS~~Cascade funding for this project through the National Fish and Wildlife Foundation (NFWF) Coho Enhancement Fund (CEF), which focused on a more robust alternatives analysis, was revised to accommodate the SWRCB findings, and focused on developing short term solutions to comply with NMFS bypass flow recommendations, SWRCB sediment findings, flow measurements of Stanshaw Creek and the MMR water system, and detailed quantification of MMR consumptive uses. This report focuses on solutions that appear to be feasible based on agency and stakeholder input and existing rules and regulations.

This report is organized in six sections. Section 2 describes Cascade's estimate of MMR's current beneficial consumptive water use. Section 3 describes the pipe conveyance calculations. The preliminary design for a fish screen, diversion flow control structure, and conveyance pipe are described in Section 4. Erosion assessment and treatments are described in Section 5. Estimates of energy consumption, energy efficiency measures, and energy production opportunities are described in Section 6.

2.0 Beneficial use calculations

Marble Mountain Ranch currently uses water for several purposes. These purposes include operation of a commercial business that provide outdoor recreation and overnight lodging; consumption by residents and staff; and episodically supports fire~~-~~fighting camps. This analysis estimates beneficial use of water for supporting residents, guests, fire fighters and support staff, domesticated animals, gardens, landscaping, dust control in arenas, and water to maintain a constant level in the pond. Water use estimates were computed on a per unit basis. Cascade computed beneficial use water demand for humans (residents, guests, and fire fighters and support staff) and animals (livestock and pets) on a per unit basis by multiplying the number of individuals within a particular category by a use rate assigned to that category. Marble Mountain Ranch provided the numbers of individuals.

Beneficial water use for irrigation were estimated by identifying areas of use and multiplying the area by a use rate. Cascade identified areas of water use from ortho-rectified aerial imagery available through Civil 3D and Cascade's familiarity with the Ranch from previous visits. Doug Cole, Marble Mountain Ranch owner, and Skyler Anderson with SWRCB, reviewed the delineations. Cascade identified 28 areas where water would support existing vegetation and other land uses. These areas included gardens, landscaped areas, and arenas. To estimate irrigation and livestock consumption, Cascade used use rates published in the State Water Resources Control Board, California Code of Regulations (January 2015). These rates are summarized in Table 1. Dogs and cats were not specifically listed in the Code. Cascade assigned values listed by the Code for 'Livestock – Poultry, rabbits, etc'. These use rates may be low for dogs, but constitute a negligible amount of water, less than 0.00001 cfs per day. The water required to keep the pond at a constant level is not known. Water may leave the pond through infiltration and evapotranspiration. DWR Bulletin 73-79 'Evaporation from Water Surfaces in California' lists the highest monthly pan evaporation rate at the Seiad Valley station as ~~occuring~~occurring in July and is 8.85 inches (225 mm). Using this evaporation rate over the pond surface area of 20250 square feet, results in a consumption of about 0.005 cfs. Cascade assumed a rate of 0.009 cfs to account plant transpiration and infiltration.

Table 1. Beneficial Use Rates

Description	Rate[3]	Units
Homes, Resorts, Motels, Organization Camps - fully plumbed[1]	55 to **75**	Gallons per day per person
Lawn, Garden, Orchard, and Grounds – irrigation[1]	**18.5**	Gallons per day per 100 square foot
Lawn, Garden, Orchard, and Grounds – dust control[1]	7.5 to **10**	Gallons per day per 100 square foot
Livestock – Horses[1]	**30**	Gallons per day per head
Livestock – Goats and hogs[1]	**2.5**	Gallons per day per head
Livestock – Poultry, rabbits, etc.[1]	**0.25**	Gallons per day per head
Dogs[2]	**0.25**	Gallons per day per animal
Cats[2]	**0.25**	Gallons per day per animal

[1] Rate obtained from California Code of Regulations (2015)
[2] Rate obtained from California Code of Regulation (2015) category for 'Livestock – Poultry, rabbits, etc.'
[3] Values in bold represent rates Cascade applied in the analysis

Using the approach described above, Cascade estimated beneficial use of water for typical summer operations of the Marble Mountain Ranch and for episodic use as a fire camp. Cascade estimates typical summer consumption is about 0.183 cfs. About 0.235 cfs is required to meet the needs when fire camps are present. This assumes that fire camp staff and fire fighters use 75 gallons per day per person. It does not include use for supplying water for uses beyond supporting fire camp staff and fire fighters. A map showing delineated areas and tables summarizing the analyses are located in Attachment A.

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3.0 Pipe conveyance calculations

Cascade Stream Solutions calculated pipe flow rates through 4- and 6-inch diameter PVC pipes. Conveyance capacity calculations were performed for two conditions: 1) open channel flow (gravity flow) and 2) siphon flow (pressure flow). Flows were computed from the existing point of diversion (POD) to the existing Pelton Wheel. The proposed pipe alignment follows along an existing ditch and pipeline alignment that is about 3580 ft and has a vertical drop of about 230 feet. The ditch, beginning at the point of diversion and ending at the forebay, has a nearly constant slope of about 0.004 feet over a distance of about 3100 feet. The vertical drop over this distance is about 13 feet. Between the forebay and the existing Pelton wheel, flow is currently conveyed in a 14-inch diameter pipe that drops a vertical distance of about 217 feet in a distance of about 480 feet.

3.1 Open Channel Flow Calculations

Open channel flow calculations assume water in the pipe has a free surface that is not flowing under pressure. Manning's equation was used to compute open channel flow in the pipe. Equation input parameters for each pipe size include a ditch slope of 0.004 and pipe roughness value of 0.011 (typical value for PVC pipe in good condition). Hydraulic characteristics including flow in cubic feet per second, cfs; velocity in feet per second, fps; and depth in feet, ft were calculated. These characteristics are plotted in Figure 1 and Figure 2.

3.2 Siphon Flow Calculations

A siphon is created by the gravitational pull of a liquid, in this case water, to draw water from a higher elevation to a lower elevation. The weight of the water creates a vacuum that 'sucks' water from a source through the pipe. The entire conveyance pipe must be filled with the liquid and devoid of air for the siphon to work (often referred to as primed). Siphoning causes flow to be conveyed through a pipe in a pressure flow state.

Calculations used in this analysis assume a simple siphon beginning at the POD and ending at the existing Pelton Wheel. Minor losses were not directly calculated; however, the estimates assume a few feet of headloss due to minor losses at bends. Calculations were conducted using Bernoulli's Principal and losses in the pipe were estimated using Hazen-Williams equation assuming a roughness or friction coefficient, C, of 150 (a typical value for PVC Pipe in good condition). Headloss, h_f, was solved for in the equations below by adjusting the outlet velocity, V_2 for several outlet pressures.

Although not included in this analysis, conditions at the inlet and vents along the pipeline would need to designed and constructed to prevent entrainment of air and allow air in the pipeline to escape.

Hydraulic characteristics including flow in cubic feet per second, cfs; velocity in feet per second, fps; and depth in feet, ft were calculated. These characteristics are plotted in Figure 1 and Figure 2.

Equation 1. A form of Bernoulli's Equation

$$hf = Z_1 - Z_2 - \frac{P_2}{w} + \frac{{V_2}^2}{2g}$$

Equation 2. Hazen William's Equation, solved for headloss

$$hf = Lpipe * \left(\frac{V_2}{1.318 * C * R^{0.63}}\right)$$

Where:

Z_1 = elevation at POD
Z_2 = elevation at Pelton Wheel
P_2 = Pressure at Pelton Wheel
V_2 = Velocity at Pelton Wheel
h_f = Headloss, ft
Lpipe = Pipe Length, ft
C = Hazen William roughness coefficient

R = Hydraulic Radius, ft
w = ~~specific~~ Specific ~~weight~~ Weight of ~~water~~ Water (62.4 lbf/ft^3)
g = Gravitational constant

Under open channel flow conditions where the pipe is not flowing full, the maximum pipe conveyance capacity is controlled by the slope of the existing ditch, roughness of the pipe, and cross sectional area of the pipe. Maximum pipe conveyance capacities under open channel flow conditions are about 0.15 ~~can~~ and 0.44 cfs for the 4- and 6-inch diameter pipes, respectively. Creating a siphon by replacing all the air in the pipe with water and allowing the weight of the water to 'suck' or pull flow through the pipe can increase the conveyance capacity to a maximum of about 0.75 cfs and 2.16 cfs for the 4- and 6-inch pipes, respectively. Under the siphon condition, the potential maximum pressure at the end of the line decreases as the flow increases. The relationship between flow, pressure, and velocity in the pipe are illustrated in Figures 3 and 4. At maximum flow in the siphon condition, the pressure would not be sufficient to pressurize water through a shower at typical rates of 50 to 60 pounds per square inch.

It is important to note that although siphon conditions are capable of conveying flows well above Cascade's beneficial use estimates for MMR~~the Ranch~~, creation and maintenance of a siphon condition is time consuming and difficult in this setting. Removing the air from 3100 feet of pipe that slopes at 0.4 feet per 100 feet could take several hours to a day. Conditions at the intake could result in ingestion of air that would break the vacuum and require several hours to re-establish the siphon. Water delivery from a siphon in this setting is likely to be unreliable. Cascade recommends using a 6 inch PVC pipe to convey flows in an open channel conditions and use valves near the pipe inlet and outlet to control diversion flows. Cascade recommends installation of a meter that is connected to the internet to record flows and allow for independent monitoring of diversion flows.

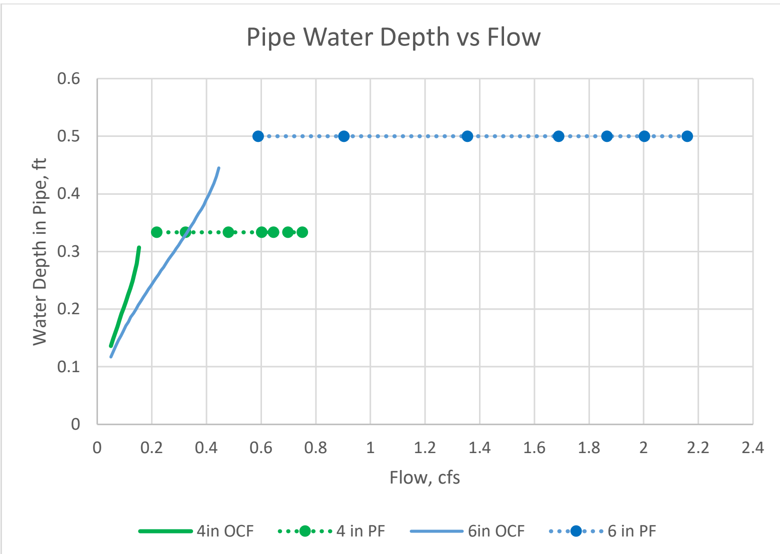

Figure 1. Pipe Flow vs. Water Depth

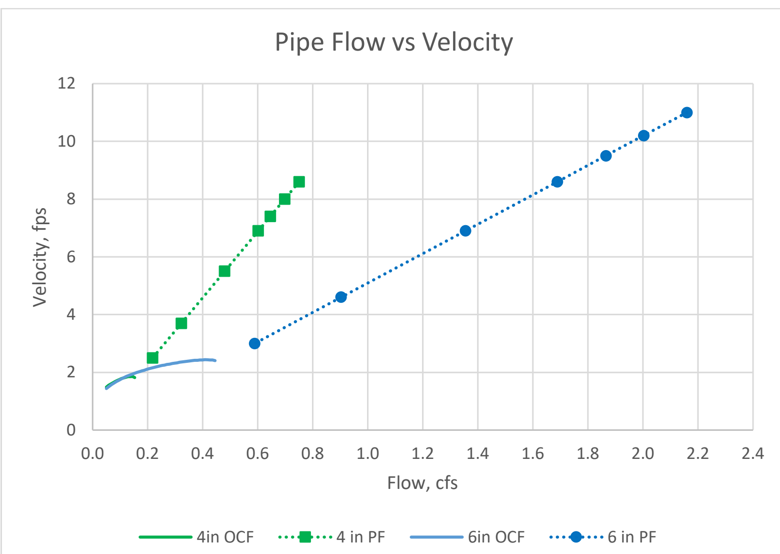

Figure 2. Pipe Flow vs. Velocity

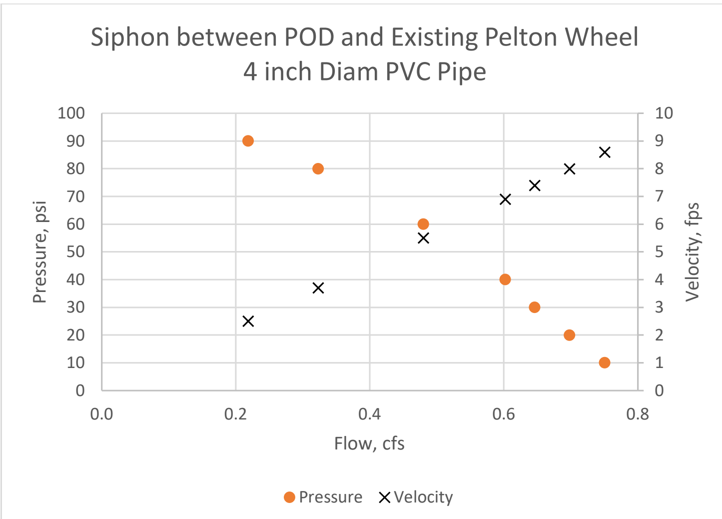

Figure 3. Pressure and Velocity vs Flow in a 4 inch Diameter PVC Pipe

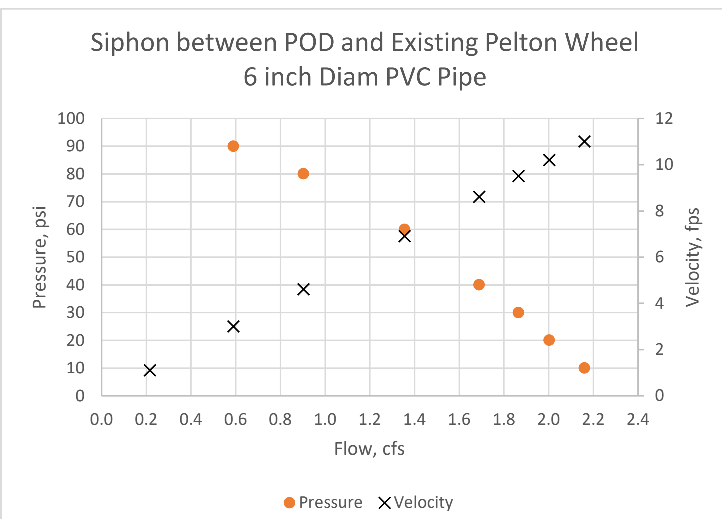

Figure 4. Pressure and Velocity vs Flow in a 6 inch Diameter PVC Pipe

4.0 Preliminary Design

Cascade developed a preliminary design to meet short and long term consumptive water demands for the MMR and allow MMR to comply with California and Federal laws and SRWCB requirements. Design considerations and constrains included developing a project that:

- can be implemented in 2016;
- is affordable for MMR and/or is eligible for grant funds and therefore meets potential funding agencies objectives, such as improving habitat for native fishes;
- allows ~~Marble Mountain Ranch~~MMR to continue commercial operations during summer season when paying guests are present;
- reliably provides water to MMR and allows for control of water flow rates;
- allows monitoring of flows;
- has no or minimal negative impacts to adjacent land or water bodies and avoids lengthy process to obtain permits such as:
  - CDFW 1600 permit
  - USACE 404
  - Section 401
  - SWPPP;

Short term objectives include:

- Complying with issues noted in the SWRCB Notice of Violations;
- Meeting the instream flow requirements; and
- Providing water for beneficial consumptive use in a manner that allows MMR to continue commercial operations.

MKWC and Cascade's understands NMFS and CDFW minimum instream requirements limit MMR's instream diversions for both non-consumptive and consumptive use amounts to be equal or less than ten percent (10%) of the instream flow from May 15 to Octover 31st. NMFS and NOAA may revise these requirements based on additional information that MKWC and others are collecting as part of this project. Under these restrictions, MMR is allowed to divert flows for both consumptive and non-consumptive beneficial use. MMR's only non-consumptive beneficial use is to generate hydropower. Meeting these short term objectives has required MMR to curtail diversions for hydropower generation to avoid discharging non-consumptively used diversion flows to water body other than Stanshaw Creek. ~~Diversions for hydropower will not be permitted when creek flows are low as determined by NMFS and CDFW. When stream flows exceed the minimum required instream flow, MMR may divert water for hydropower production, but must return all water that is not put to beneficial consumptive use to the Stanshaw Creek.~~ Currently, infrastructure to return flow to Stanshaw Creek does not exist; therefore, the maximum flow that can be used to generate hydropower is limited to the amount that can be used beneficially. The current configuration removes water for treatment and potable uses from the ditch before it reaches the hydropower generation facility. Cascade estimates treated water to be about 4 percent of the total diversion flow when MMR is operating at peak occupancy and 25 percent when hosting fire camps. The remainder of the water could be used to generate power and then put to beneficial use. The resulting, which is used for primarily for irrigation could be used to generate power.

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Hydropower effluent would be flowing at or near hydrostatic pressure and would have a pressure of less than about 10 pounds per square inch in irrigate areas. Irrigation would be made more challenging because of the low pressure from the hydropower system. For example, recommended pressures for drip irrigation systems ranges from about 15 to 30 psi.~~.~~

As a long term objective, MMR may consider installing infrastructure that would allow diversion for non-consumptive use to generate hydropower. This infrastructure would require additional infrastructure. This infrastructure includes a fish screen sized to meet the maximum diversion flow rate, canal lining or piping to prevent transmission losses, and a return pipe to return non-consumptive flow back to the creek. A self-cleaning fish screen located in the diversion channel would require a minimum of 2.5 square feet of submerged screen area per cfs diverted, an on stream screen would require a minimum of 3 square feet of screen per cfs diverted. An additional pipe or ~~with a minimum surface area of about 7 square feet, a~~ ditch impervious lining would be required ~~lined diversion ditch or about~~for the 3,100 ~~feet~~ foot long ditch~~of pipe~~ to convey water to the power generation facility. ~~,~~ A~~and a~~bout 2600 feet of pipe would be required to ~~to~~ return effluent to Stanshaw Creek. ~~The~~ Topography dictates locating a significant portion of the the effluent line ~~would need to be located~~ within CalTrans right of way and ~~would be~~ adjacent to existing fiber optic lines. Permitting, design, and construction costs for infrastructure to support hydropower could exceed half a million dollars and public funds to benefit natural resources are unlikely to be available for this project type. Restoring hydropower generation with non-consumptive flow to the MMR may be infeasible because of the cost and challenges. MMR may decide to reduce or eliminate reliance on the existing diesel power generator and consider other options that do not include hydropower. These options are discussed in Section 6 and will be part of a long term plan.

Options considered for meeting diversion of flows for beneficial consumptive use include:

1. Installing a fish screen and 6-inch diameter PVC pipe entirely within the existing ditch line and conveying flows in an open channel flow condition;
2. Installing a fish screen and 4-inch diameter PVC pipe entirely within the existing ditch line and conveying flows in siphon (a pressure flow) condition;
3. Establishing a new point of diversion upstream of the current diversion location and using the increased head to convey flow in a smaller pipe.

Cascade and MKWC considered Option 1 to be the best option because it provided the most reliable means to meet MMR's beneficial consumptive water use needs. Option 2 requires siphon flow through a 4-inch diameter pipe. Starting and maintaining siphon flow is likely to be time consuming and problematic because the siphon would be drawing water from a relatively shallow area and the shallow slope of the upstream 3,100 feet. There is a high potential for air to be ingested in the intake and for airlocks to form over the 3,100 feet. Option 3 was eliminated from consideration, because Cascade and Fiore Geoscience was concerned over the long-term stability of moving the diversion higher up a highly dynamic creek channel and the effort required to maintain a pipeline along the steep hillslope. Furthermore, construction and maintenance of a pipe along the undisturbed hillslope is likely to be scrutinized by the State Regional Water Quality Control Board. Implementation of Option 3 also requires obtaining permits from the US Forest Service and CDFW, which are not required for Option 1. The time required to obtain these permits is likely to prevent construction of the pipeline in 2016.

Cascade developed preliminary plans for Option 1 that involve:

- Installing a Pump-Rite L-250 fish screen;
- Installing about 3,100 feet of 6-inch diameter schedule 40 PVC pipe along the existing ditch invert;
- Constructing a berm in the diversion to prevent creek flows from flowing down the diversion ditch;
- Installing valves at the upstream and downstream end of the pipe to control flows in the pipe;
- And installing a flow meter that is connected to the internet to allow continuous realtime flow monitoring.

Plans in attachment C provide preliminary designs for the intake and pipeline.

5.0 Erosion Assessment and Treatments

6.0 Estimates of Energy Consumption, Energy Efficiency Measures, and Energy Production

Attachment A – Beneficial Use Analysis

Map and spreadsheets

Attachment B – Pipe Flow Calculations

Spreadsheet calculations

Attachment C – Preliminary Design

Plans

PRELIMINARY PLANS FOR

Marble Mountain Ranch

Consumptive Use Pipeline and Intake

July 2016

Approved by:

Landowner: _______________, Date

Mid-Klamath Watershed Council: ______________, Date

Leonard Joey Howard (date)
CALIFORNIA REGISTERED
PROFESSIONAL ENGINEER NO. # 53319
Cascade Stream Solutions, LLC

SHEET INDEX

GENERAL NOTES

1. TOPOGRAPHY IS BASED ON NORTH STATE LAND SURVEYING AND CASCADE STREAM SOLUTIONS SURVEYS CONDUCTED IN 2014. MARBLE MOUNTAIN RANCH MAINTENANCE ACTIVITIES MAY HAVE ALTERED DITCH INVERT ELEVATIONS. CONTRACTOR SHALL NOTIFY MKWC IF CONTRACTOR NOTES DISCREPANCIES BETWEEN THE PLANS AND THE DITCH PROFILE..

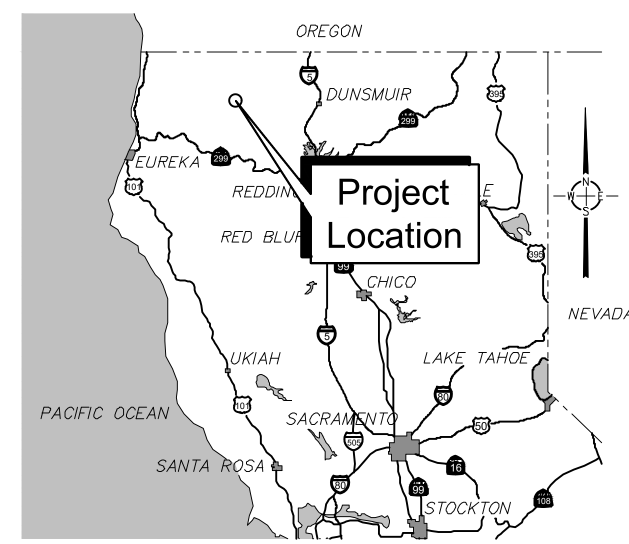
2. CONTRACTOR SHALL NOTIFY USA NORTH AT 811 OR 1-800-227-2600 OR WWW.USANORTH.ORG TO REQUEST IDENTIFICATION AND LOCATION OF EXISTING UNDERGROUND UTILITIES. CONTRACTOR SHALL CONTACT USA NORTH 2 TO 14 DAYS BEFORE PLANNED EXCAVATION DATE.

3. THIS PROJECT MAY BE SUBJECT TO REQUIREMENTS OF PERMITS ISSUED BY VARIOUS REGULATORY AGENCIES. THE CONTRACTOR IS RESPONSIBLE TO UNDERSTAND AND PERFORM ALL WORK IN ACCORDANCE WITH THE REQUIREMENTS OF THE PERMITS. PRIOR TO COMMENCING WORK THE CONTRACTOR SHALL COORDINATE WITH THE OWNER'S REPRESENTATIVE TO VERIFY THE MOST RECENT COPY OF ALL APPLICABLE PERMITS ARE INCORPORATED IN TO THE PROJECT CONSTRUCTION DOCUMENTS.

   THE CONTRACTOR IS RESPONSIBLE FOR PREVENTING SEDIMENT OR POLLUTANTS FROM LEAVING THE WORK AREA.

4. WHEN CONDITIONS IN THE FIELD DO NOT CONFORM WITH INFORMATION IN THESE PLANS AND/OR WHEN UNUSUAL CIRCUMSTANCES ARISE DURING CONSTRUCTION, THE CONTRACTOR SHALL IMMEDIATELY CONTACT THE OWNER'S REPRESENTATIVE.

5. IN THE EVENT THAT ANY ARCHEOLOGICAL ARTIFACTS ARE UNCOVERED DURING CONSTRUCTION ACTIVITIES, THE CONTRACTOR SHALL STOP ALL WORK IMMEDIATELY IN THE AREA AND CONTACT THE OWNER'S REPRESENTATIVE. WORK IN THE AREA SHALL NOT RESUME UNTIL APPROVED BY THE OWNER'S REPRESENTATIVE.



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Drawing Information	
Date	1 April 2016
Status	PRELIMINARY
Designer	jh
Drafter	jh
Checked	
File Name	Marble Mountain Pipeline
Plotted Scale	0 1/2 1

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Revisions		
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PRELIMINARY
NOT FOR CONSTRUCTION

Marble Mountain Ranch
Consumptive Use Pipeline and Intake
Title Sheet

Job Number 2015-115

Sheet Number 1

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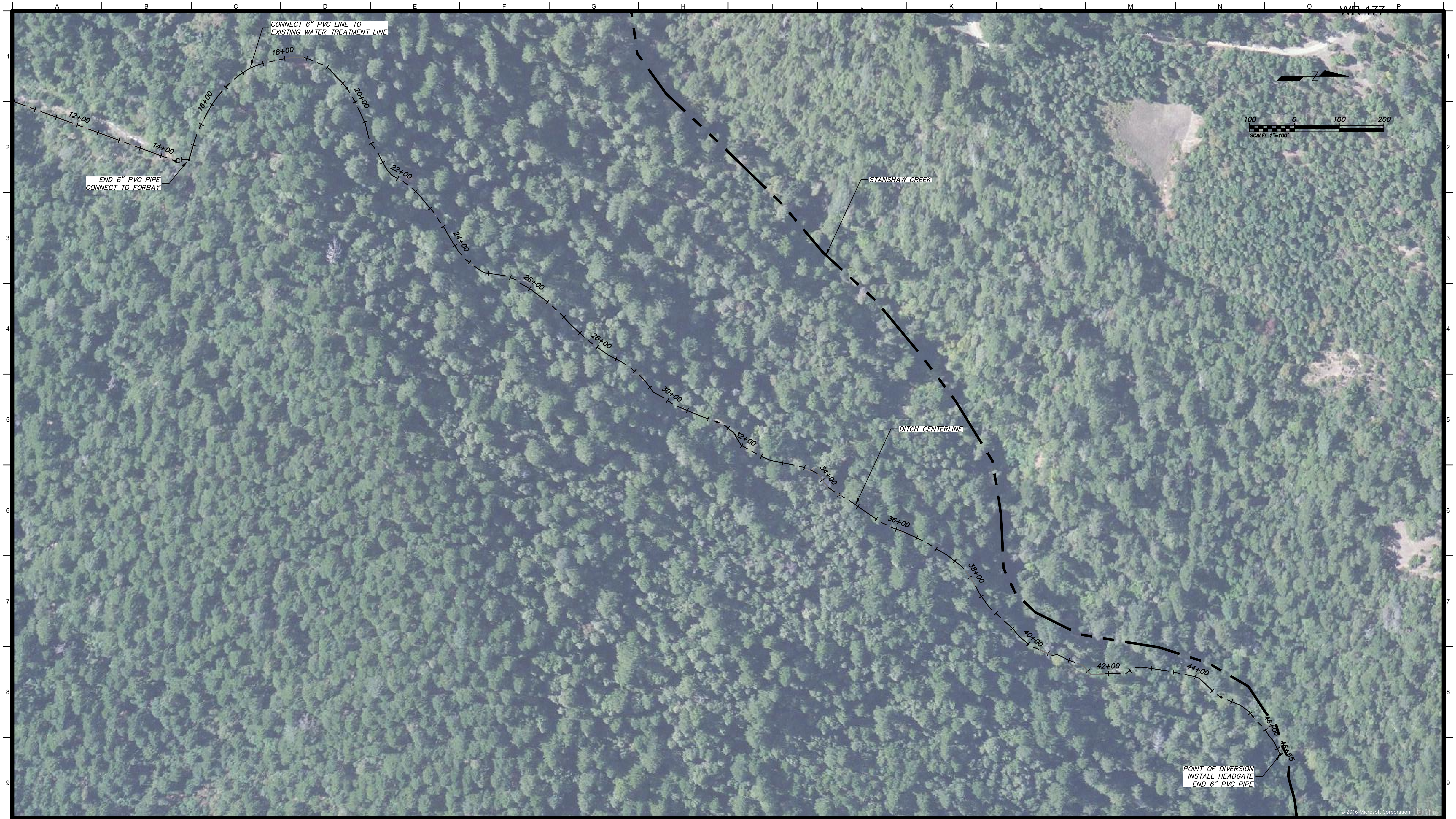

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Cascade
STREAM SOLUTIONS

Drawing Information	
Date	1 April 2016
Status	PRELIMINARY
Designer	jh
Drafter	jh
Checked	
File Name	Marble Mountain Pipeline
Plotted Scale	0 1/2 1

Revisions		
No.	Date	Description

PRELIMINARY
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Marble Mountain Ranch
Consumptive Use Pipeline and Intake
Plan View

Job Number
2015-115

Sheet Number
2

Sheet 2 of 4

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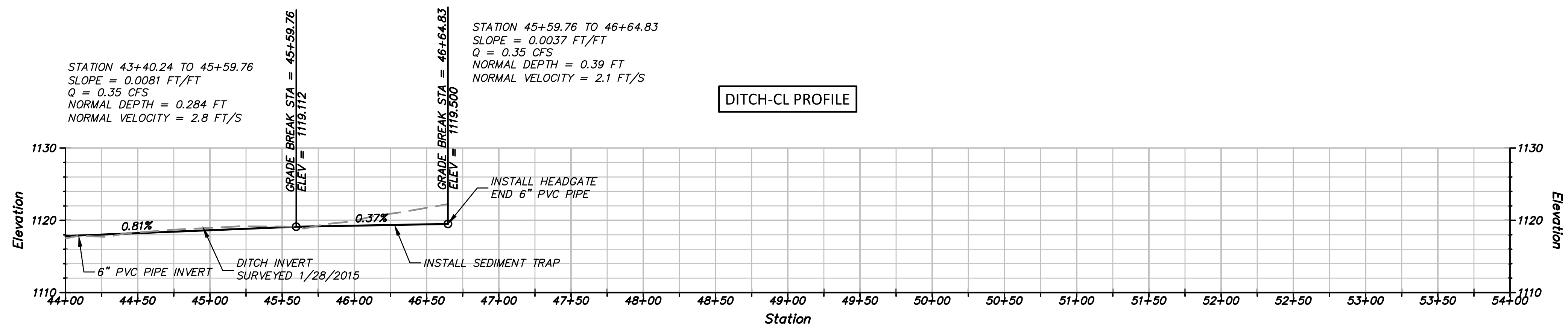

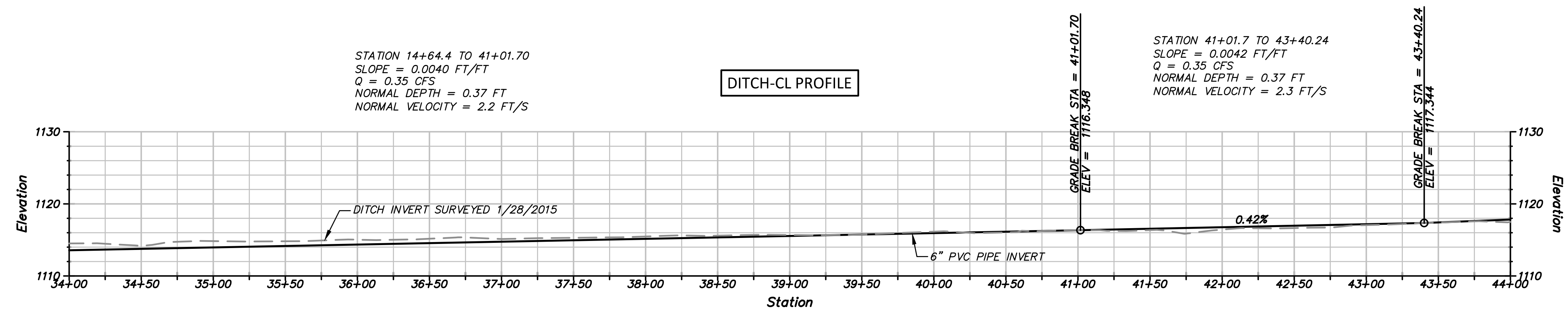

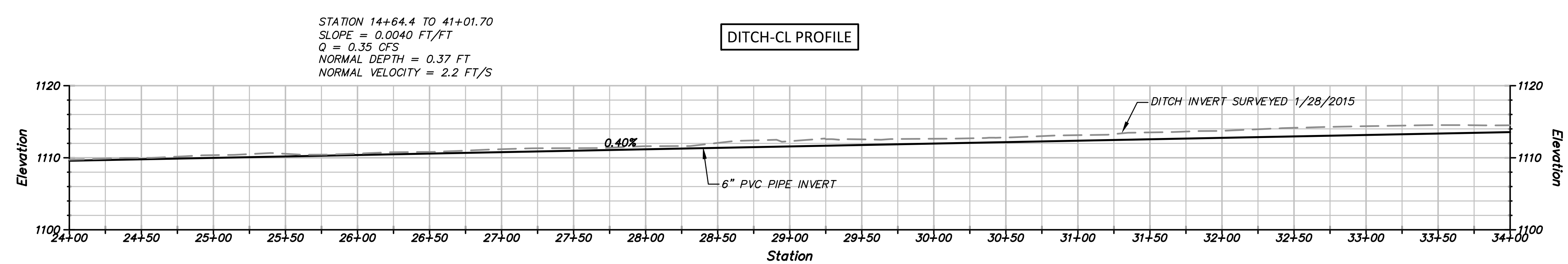

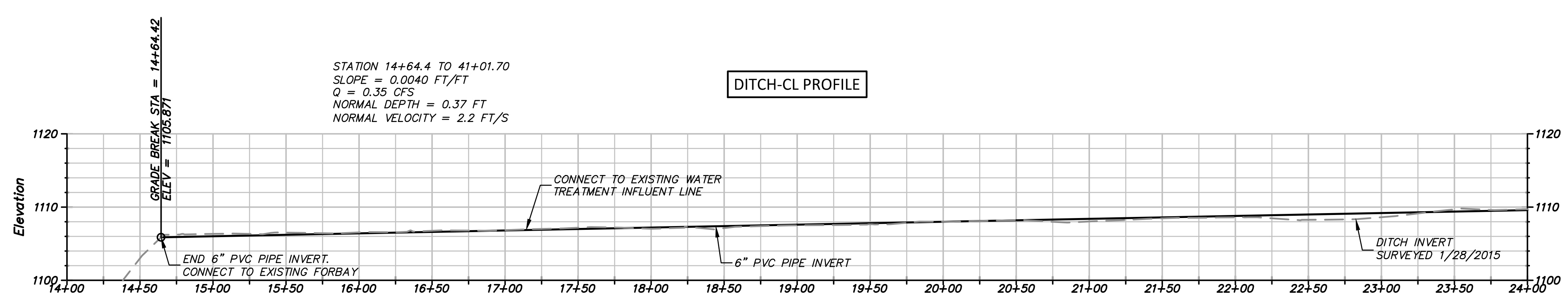

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Drawing Information

Date	1 April 2016
Status	PRELIMARY
Designer	jh
Drafter	jh
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File Name	Marble Mountain Pipeline
Plotted Scale	0 1/2 1

Revisions

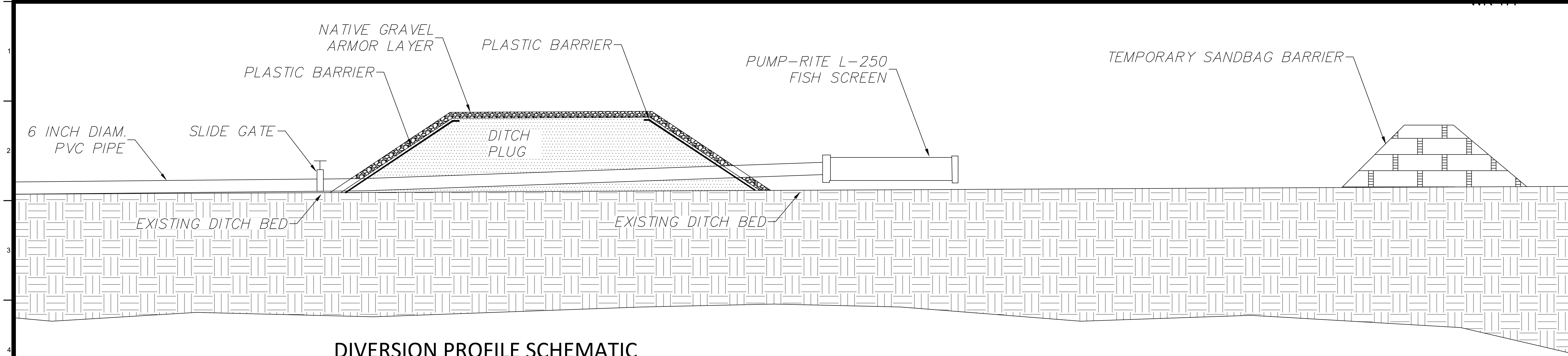
No.	Date	Description

PRELIMINARY
NOT FOR CONSTRUCTION

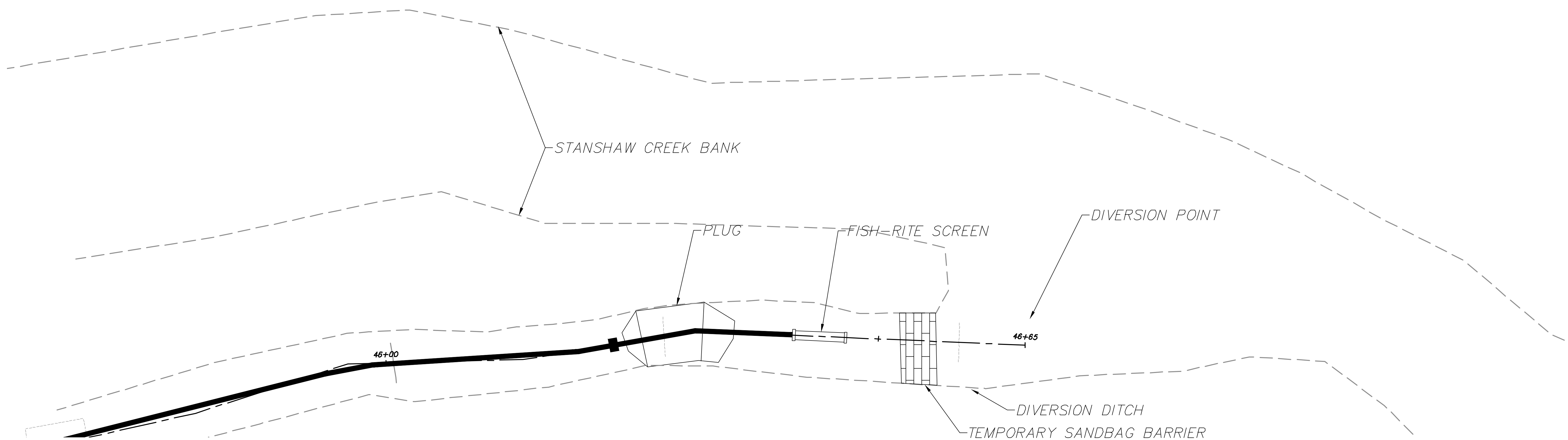
Marble Mountain Ranch
Consumptive Use Pipeline and Intake
Pipe Profile

Job Number 2015-115

Sheet Number 3



DIVERSION PROFILE SCHEMATIC



DIVERSION PLAN SCHEMATIC

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Drawing Information	
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Status	Existing Cond
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Revisions

No.	Date	Description

PRELIMINARY
NOT FOR CONSTRUCTION

Marble Mountain Ranch
Consumptive Use Pipeline and Intake
Intake and Screen Detail

Job Number 2015-115
Sheet Number 4
Sheet 4 of 4