WADDLE RANCH
WATERSHED ASSESSMENT PHASE II
SUMMARY REPORT






PREPARED BY:
KEVIN DRAKE, NOAH BRAUTIGAM,
LINDSAY DOWNING, MICHAEL HOGAN

INTEGRATED ENVIRONMENTAL
RESTORATION SERVICES, INC.

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INTEGRATED ENVIRONMENTAL
RESTORATION SERVICES, INC

COMMON GROUND • UNCOMMON SOLUTIONS

P.O. BOX 7559 • 2780 LAKE FOREST ROAD • TAHOE CITY, CA 96145
OFFICE: 530.581.IERS (4377) • FAX: 530.581.0359

TABLE OF CONTENTS

PROJECT SNAPSHOT

The era of dependence on models and best professional judgment as the primary decision tools for environmental projects is slowly winding down. Models and professional judgment are valuable as hypotheses and starting points from which to develop projects. However, actual project outcomes are being shown over and over to differ, sometimes wildly, from models and best professional judgment projections. Relying on predicted outcomes can be very costly when budgets are expended and intended results are not achieved.

The Waddle Ranch SEP Project was designed to develop and demonstrate an outcome-based process that achieves real water quality protection in a cost-effective manner through targeted assessment, test-based treatment implementation and monitoring/feedback to ensure that money/effort directed at restoration is yielding defensible results. This new approach is founded on a field-based adaptive process which has as its primary function, the project outcome and outputs, and not just a reasonable model. This approach differs from many other environmental improvement efforts because it is designed to implement improvements while developing transferrable tools and practitioner-oriented handbooks. This in turn will make future projects more effective.

The products of this approach are:

- Actual field evaluation of watershed condition and water flow connectivity
- Project design based on those actual, field verified conditions
- Increased understanding of existing issues and opportunities for watershed improvement
- Increase in knowledge through field-based learning (what actually worked and didn't)
- Ability to develop and test mitigation measures for areas in need of improvement
- Support in understanding, from the ground up, ecosystem 'resilience' (the ability to withstand and recover from disturbance)
- Effective tools for project management and maintenance

This project is considered a key stepping stone in our ability to manage watersheds for the future delivery of ecosystem services, including water quality and quantity.

PROJECT NEED AND INTENTION

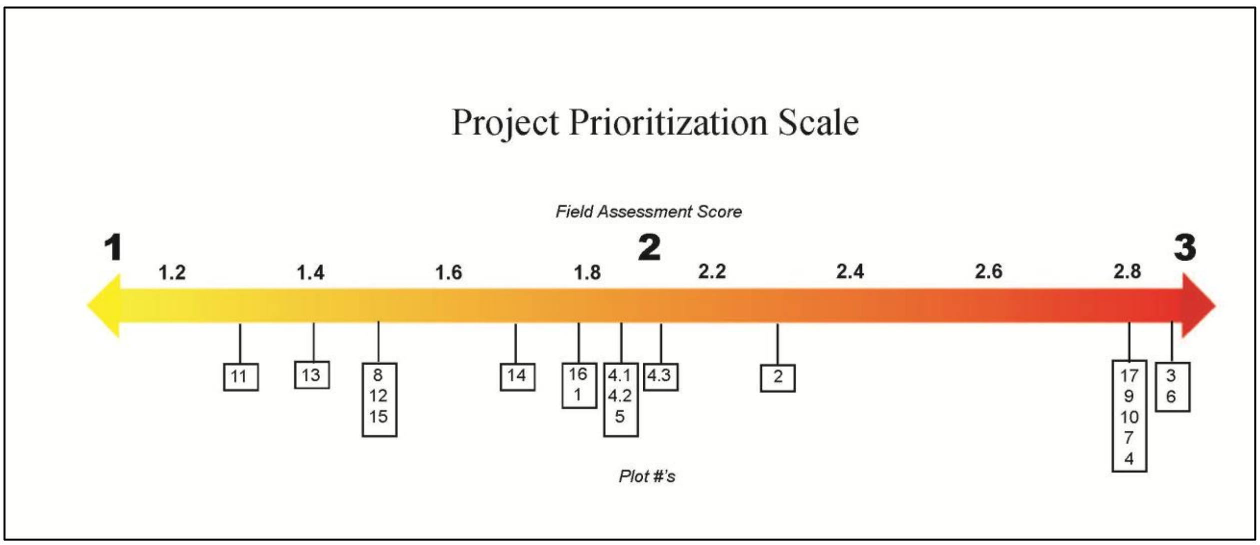
The Waddle Ranch Phase II Watershed Assessment has been published as a result of an enforcement action as a follow-up assessment of erosion hot spots identified during the Supplemental Environmental Program Phase I Watershed Assessment in 2009.

The **primary purpose** of this assessment is to:

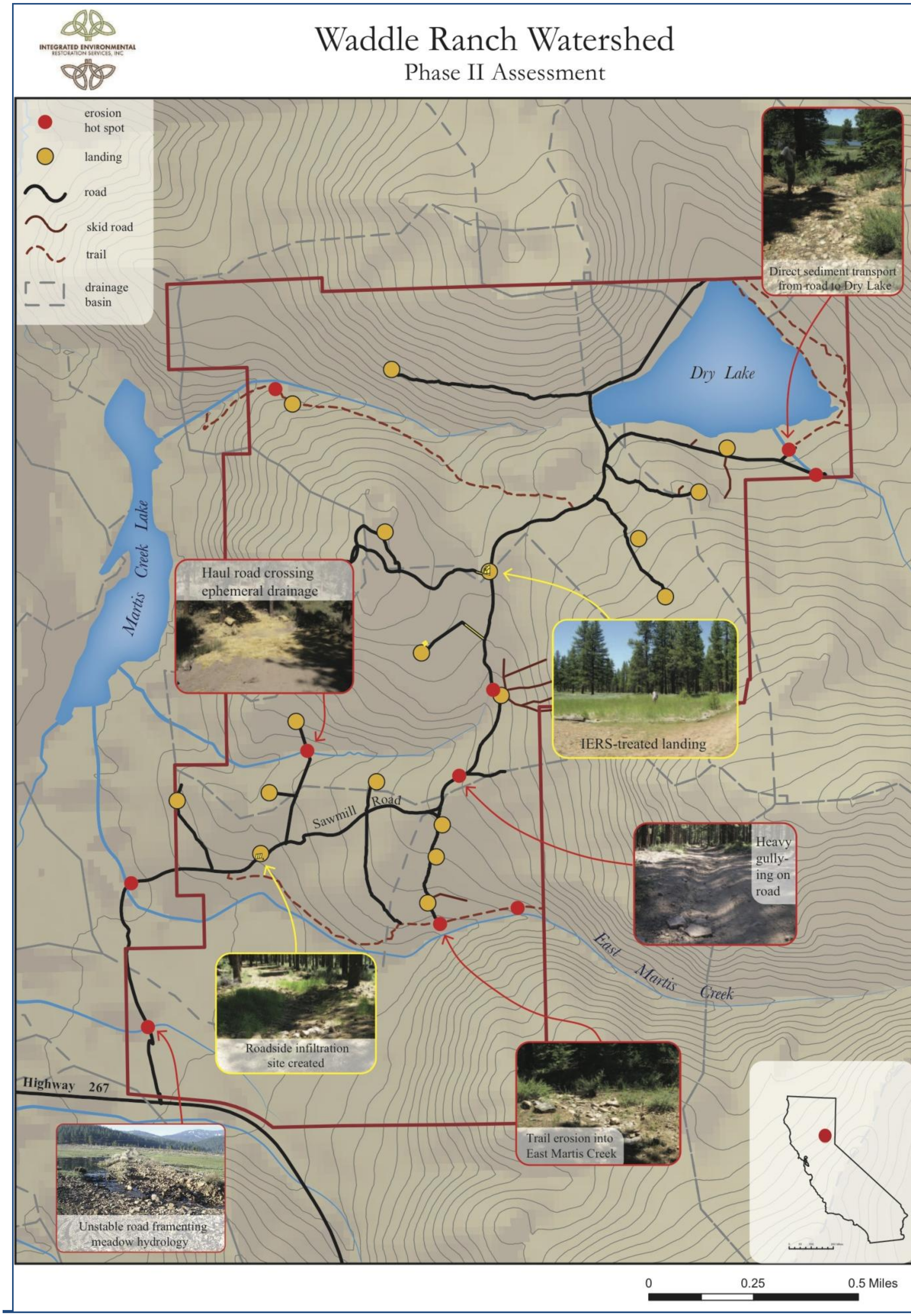
1. To evaluate the site erosion risk and connectivity of each hotspot (known and newly identified) to nearby appropriate drainageways.
2. To prioritize potential projects based on the results of the field evaluation.

The Phase II assessment summary report includes the following **deliverables:**

- Description of Erosion-focused Rapid Assessment (EfRA) Methodology
- Description and photos of hot spots
- Characterization and ranking of each hotspot using the Field Assessment Criteria described in the Year 1 Summary Report
- Treatment recommendations for each hotspot
- Map of hot spots and other high-risk/problem areas
- Map of water flow areas and connectivity to drainageways
- Recommended next steps for Waddle Ranch assessment and restoration project



Graphic summarizing the relative priority of each hotspot/project (1=low priority, 3=high priority. All projects are also shown on the Hot Spot Prioritization Map.



INTEGRATED ENVIRONMENTAL RESTORATION SERVICES, INC
Waddle Ranch Watershed
Phase II Assessment
erosion hot spot
landing
road
skid road
trail
drainage basin
Direct sediment transport from road to Dry Lake
Dry Lake
Martis Creek Lake
Haul road crossing ephemeral drainage
IERS-treated landing
Sawmill Road
Heavy gully-ing on road
East Martis Creek
Roadside infiltration site created
Trail erosion into East Martis Creek
Highway 267
Unstable road framenting meadow hydrology
0
0.25
0.5 Miles

Wattle Ranch Watershed Assessment Hot Spot Prioritization

Site Erosion Potential – Field Assessment Criteria

Hot Spots	Site slope degrees	Total surface cover	Vegetation cover	Soil density	Soil organic matter	Signs of active erosion	Signs of ongoing disturbance	Average
1	2	1	1	1	TBD	1	1	1.2
2	1	3	1	2	TBD	1	1	1.5
3	2	3	3	3	TBD	3	3	2.8
4	1	3	3	3	TBD	3	3	2.7
4.1	3	1	3	2	TBD	1	1	1.8
4.2	3	1	3	2	TBD	1	1	1.8
4.3	3	1	1	3	TBD	3	1	2.0
5	1	3	3	1	TBD	3	3	2.3
6	3	2	3	3	TBD	3	3	2.8
7	1	2	3	3	TBD	3	3	2.5
8	1	1	1	1	TBD	1	1	1.0
9	1	3	3	3	TBD	3	3	2.7
10	1	3	3	3	TBD	3	3	2.7
11	2	1	1	1	TBD	1	1	1.2
12	1	1	1	1	TBD	1	1	1.0
13	1	1	3	1	TBD	1	1	1.3
14	1	1	3	1	TBD	1	1	1.3
15	1	1	1	1	TBD	1	1	1.0
16	1	2	3	3	TBD	3	1	2.2
17	1	2	3	3	TBD	3	3	2.5

Risk to Beneficial Uses – Field Assessment Criteria

Hot Spots	Proximity to drainageway	Connectivity of drainageway	Average
1	3	2	2.5
2	3	3	3.0
3	3	3	3.0
4	3	3	3.0
4.1	2	2	2.0
4.2	2	2	2.0
4.3	2	2	2.0
5	2	1	1.5
6	3	3	3.0
7	3	3	3.0
8	3	1	2.0
9	3	3	3.0
10	3	3	3.0
11	2	1	1.5
12	3	1	2.0
13	2	1	1.5
14	2	2	2.0
15	2	2	2.0
16	2	1	1.5
17	3	3	3.0

Overall priority (0=low, 3=high)

Hot Spots	Combined Average
1	1.8
2	2.3
3	2.9
4	2.8
4.1	1.9
4.2	1.9
4.3	2.0
5	1.9
6	2.9
7	2.8
8	1.5
9	2.8
10	2.8
11	1.3
12	1.5
13	1.4
14	1.7
15	1.5
16	1.8
17	2.8

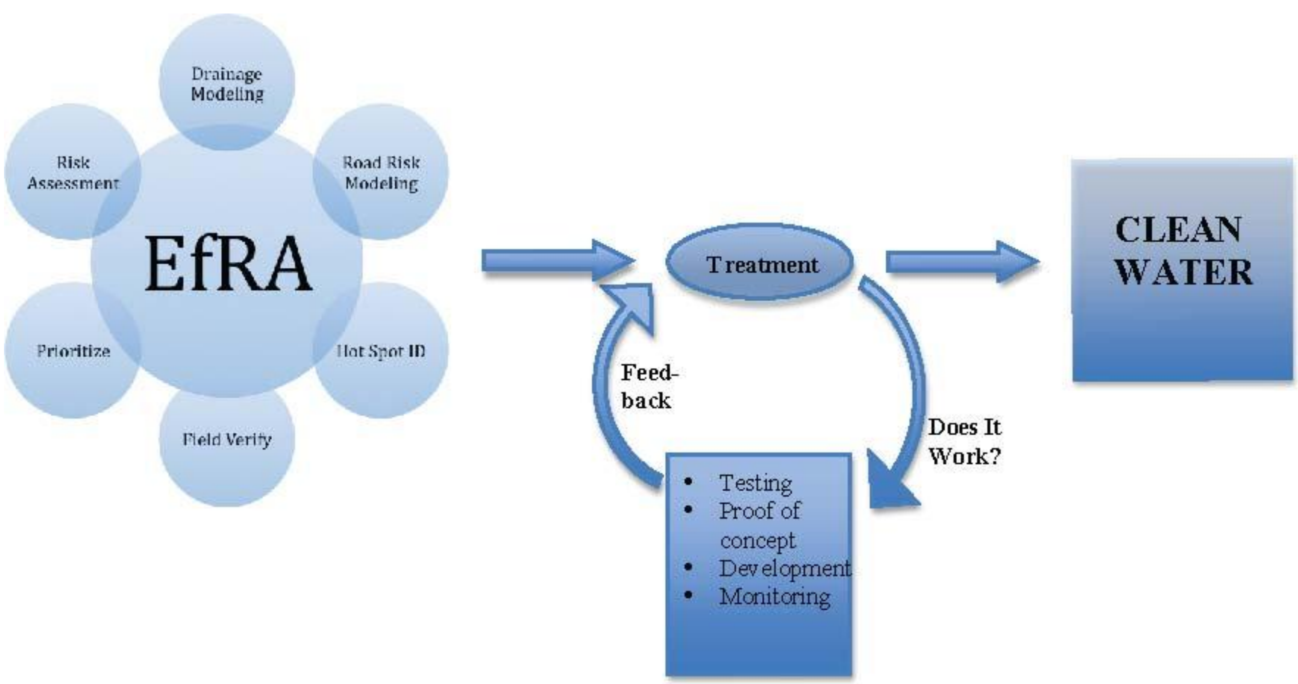
THE EROSION-FOCUSED RAPID ASSESSMENT (EfRA) PROCESS

PROBLEM STATEMENT: WHY EfRA?

YEARS OF SCARS: Watersheds in the west wear the scars of years of impacts from logging to road building to development. All of these impacts have the potential to reduce water quality and quantity, habitat value and many of the other ecosystem services that watersheds provide. However, even after decades of efforts to address these impacts, we have not developed a systematic, accessible, strategic methodology to repair those watersheds nor the ability to really understand whether restoration efforts are achieving the desired results.

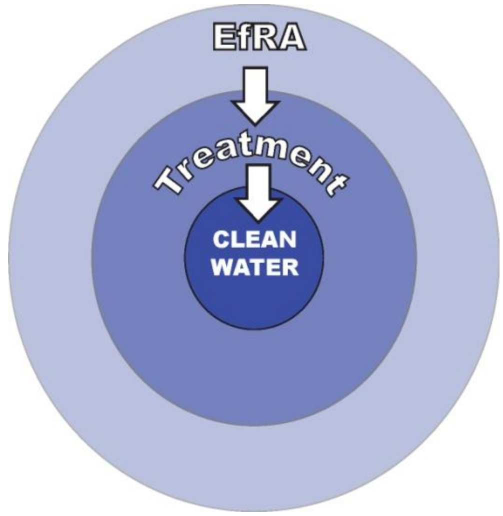
THE COST OF NOT KNOWING: Millions of dollars continue to be spent throughout the west on watershed repair and restoration efforts. Without a highly useful, simple, transparent and effective process to achieve our restoration and water quality protection goals, we will continue to spend large amounts of dwindling resources and still not be able to quantify the return on our investments.

A DIRECT SOLUTION: The EfRA process is designed to expand understanding of watershed condition, watershed linkages, watershed repair and management approaches and especially to provide a foundation for assessing the outcomes of watershed repair and management efforts. In this way, the EfRA is designed to fill a critical gap that we have recognized can be directly addressed in a relatively simple and cost-effective manner and can allow more individuals and groups to move more quickly into watershed repair.



EfRA GOALS

- To document drainage patterns in the watershed as a context for large-scale understanding of connectivity and potential water quality liability
- To define watershed conditions relative to sediment sources, sinks and water quality
- To identify sediment source areas and restoration opportunities
- To prioritize, group and sequence restoration treatment opportunities into projects for implementation
- To define/suggest tests to develop effective treatment types and techniques
- To define monitoring protocols that assess treatment effectiveness (cost and environmental)
- To establish a framework for future assessment, treatment and monitoring actions



OUTCOMES

1) Understanding of watershed sediment sources and linkages (hydrologic, geomorphic)
2) Understanding of erosion potential for identified problem areas
3) Understanding of sediment delivery risk level for erosion problem areas
4) Improved ability to prioritize and target project implementation plans (linked to 1- 3, above)
5) Improved ability to assess project outcomes and benefits
6) Improved ability to respond when project outcomes fall short of goals

OUTPUTS

1) Mapped problem areas and hydrologic linkages
2) Project prioritization framework based on site condition and sediment delivery risk for each site
3) Phased project implementation plan
4) Adaptive management process to asses actual project outcomes relative to goals

STEP-BY-STEP METHODOLOGY

1. **Define the goals of the watershed assessment and restoration effort**

2. **Describe watershed setting**
    a. Location/ownership/land use
    b. Elevation/aspect/topography
    c. Geology/soils
    d. Hydrology – hydrologic regime, dominant erosion and sediment transport processes
    e. Channel geomorphology – drainage classification (e.g. perennial/ephemeral or stream order), channel type, sediment transport process
    f. Vegetation
    g. Roads/Transportation

3. **Identify potential hot spots**
    a. GIS-based hot spot analysis: overlay hydrology, road/trail features, and GIS-modeled flow accumulation areas to identify potential erosion hot spots. Specifically note areas of road-drainage interaction and potential connectivity to drainageways.
    b. Identify road segments with high erosion potential using GIS analysis, see Table 1.
    c. Aerial photo analysis (human disturbance patterns, timing)
    d. Literature reviews, written records, public records (logging, grazing, mining)
    e. Talk to locals, historians, First Nations

4. **Conduct targeted field assessment of <u>potential</u> problem areas and interconnections**
    a. Use results from Step 3 to target field assessment efforts
    b. Start in drainages and work upslope
    c. Inventory additional features important for understanding watershed processes (i.e. roads, seasonal/ephemeral drainages, large depositional areas)
    d. Identify actual problem areas and interconnections
        i. Document visible erosion issues and identify connecting features
        ii. Trace erosion problems to their source and document site conditions
    e. Assess the geomorphic context of drainages and problem areas
        i. Historic drainage patterns during episodic events (refer to historic photos, impacts)
        ii. Coarse sediment supply (primary design consideration)
    f. Assess stream channel condition
        i. Determine location(s) and magnitude of sediment loading to stream

ii. Evaluate effects of sediment loading on different stream reaches (macro-invertebrates, spawning habitat, bank stability, etc)

5. **Define restoration opportunities**
   a. Define potential restoration projects based on hydrologic/geomorphic interconnections between problem areas (a.k.a. linkage analysis)
   b. State objectives – how to address problems identified in Step 4
   c. Develop project selection criteria
   d. Develop treatment alternatives for different sites

6. **Conduct site condition and connectivity assessments**

   Site condition and connectivity assessments should include, at a minimum:

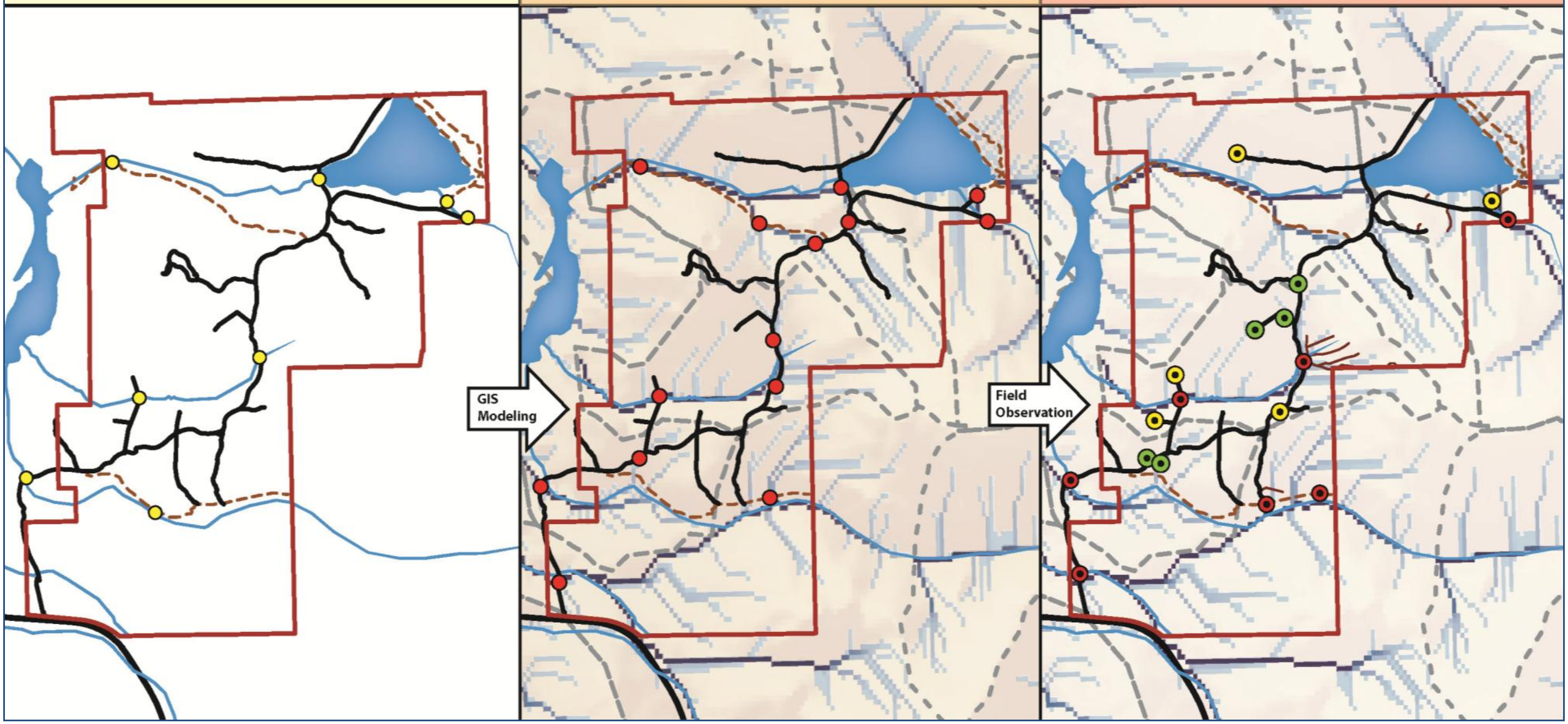
   a. Slope
   b. Surface cover
   c. Vegetation cover
   d. Soil density
   e. Soil organic matter
   f. Signs of active erosion or ongoing disturbance
   g. Proximity and connectivity to drainageways and/or surface waters

The map on the following page illustrates steps 3 through 6.

7. **Develop phased restoration plan**
   a. Prioritize projects
   b. Develop adaptive management plan for each project, including:
      i. Goals
      ii. Knowns/unknowns (based on site condition assessments)
      iii. Treatment alternatives (based on site condition assessments)
      iv. Test opportunities
      v. Implementation plan/schedule
      vi. Monitoring plan and success criteria
      vii. Review, feedback and information sharing strategy

Erosion Focused Assessment Methodology: GIS to Field Assessment at Waddle Ranch

Step 1	*Step 2*	*Step 3*
Create an overlay of existing roads and the best hydrological data available to target potential erosion hot spots. In many cases, stream data is incomplete or misleading. The data generally does not distinguish between active and ephemeral channels.	A Digital Elevation Model (DEM) takes the data and generates a flow accumulation model, which can be an important complement to limited stream data. The model can also identify drainage pathways that are usually inactive, yet flow during large rain-on-snow events.	GIS modeling allows us to identify potential problem areas before going into the field, which saves time and energy. Once we visit the field, we can assess the erosion potential of modeled hot spots. We then prioritize hot spots and take action.



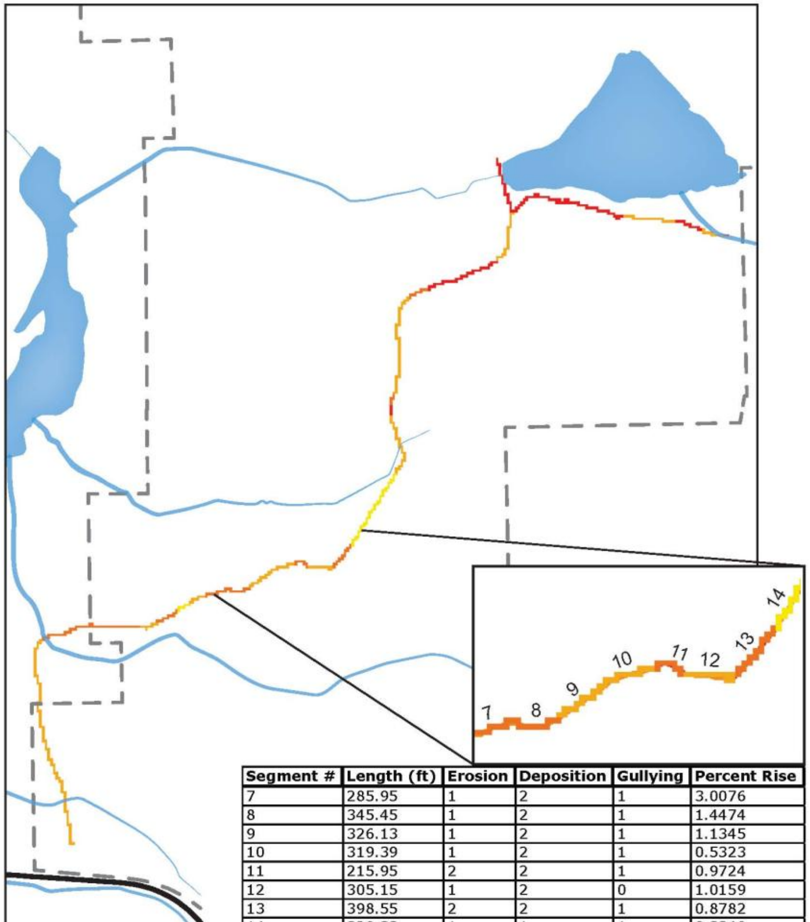
Road Erosion Risk Assessment – GIS Modeling Methodology

1.	The roads to be analyzed (those with the greatest importance in the watershed) are chosen and mapped if data is not available. This process could be expansive and include multiple transportation routes, roads, trails, train tracks, etc. For the Waddle Ranch property only Sawmill Road was used.
2.	“Flow breaks” along the road are found. This is where runoff either leaves the road on its own, or is channeled by a waterbar or other manmade feature. For Waddle Ranch, these breaks were identified in the field. However, flow breaks can also be identified in the GIS prior to field work. To do this, the gradient of the road is found, and points where the road slope nears zero are selected. Identification in the field is more accurate, but GIS-based analysis is very useful to gain a general sense of the erosion potential. However identified, the flow breaks are then used to break the road into discrete segments in the GIS.
3.	On the Waddle Ranch property, additional attributes further describing each road segment were collected at the same time as flow breaks were established. These attributes were **erosion** (of the road about the flow break), **deposition** (at the flow break), and **gullying** (of water off of the road at the flow break). These attributes were scored on a scale from 0-2. The scale was kept very simple in order to maintain the simplicity of the model, and allow for a margin of error in observation. These attributes were assigned to each road segment in the GIS. Without field observation, one could rely on other GIS-based input factors, but field verification of road erosion characteristics is important for a truly useful assessment of erosion potential.
4.	Once the road is broken into segments and attributed as described above, the **gradient** and the **length** of each road section is calculated in the GIS. The longer and steeper a section of road, the more likely it is to channel runoff and erode.
5.	The three variables (in this case **gradient, length,** and **erosion attributes**) are given a value between 1 and 3, and combined. At this step, the variables can be weighted differently based on how much they are known or believed to contribute to overall erosion potential. This is user-defined, and should be based on site-specific conditions. The output is symbolized as a color ramp, where each road segment is assigned a score based on the inputs above.

Table 1. Road Erosion Risk Assessment - GIS Modeling Methodology

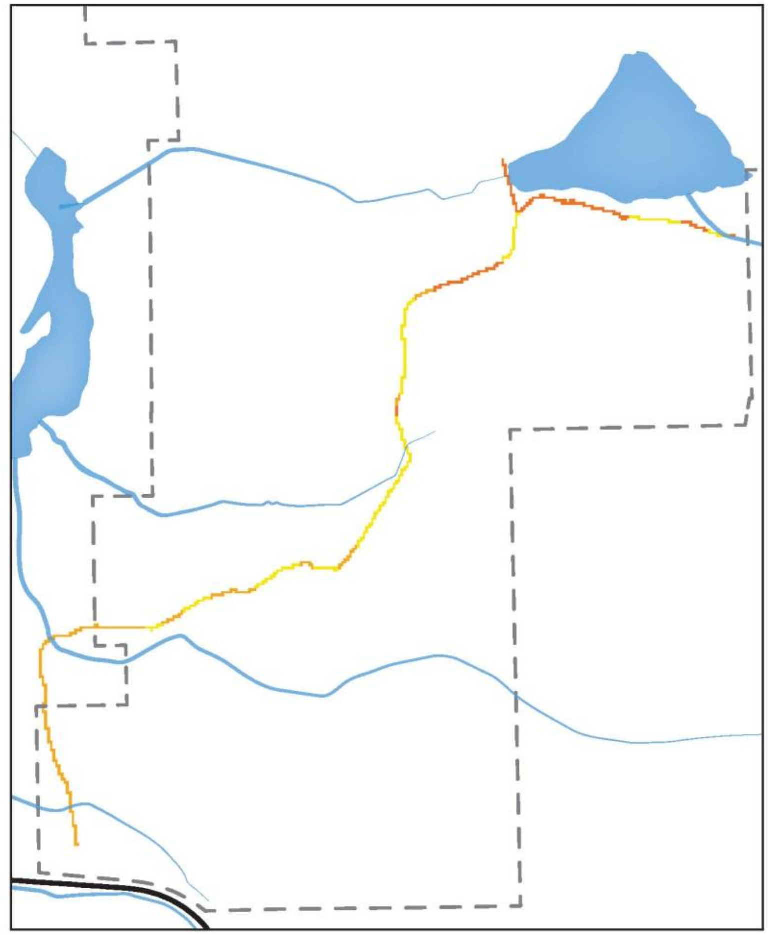
Road Erosion Risk Assessment: Waddle Ranch

Pre-Treatment



Segment #	Length (ft)	Erosion	Deposition	Gullying	Percent Rise
7	285.95	1	2	1	3.0076
8	345.45	1	2	1	1.4474
9	326.13	1	2	1	1.1345
10	319.39	1	2	1	0.5323
11	215.95	2	2	1	0.9724
12	305.15	1	2	0	1.0159
13	398.55	2	2	1	0.8782
14	329.33	1	1	1	0.3340

Post-Treatment (hypothetical)



RESULTS – PRIORITIZED PROJECTS

EROSION HOT SPOTS AND TREATMENT OPPORTUNITIES

The purpose of this section is to present and describe areas of accelerated erosion, which we will refer to as "hot spots." As part of the EfRA process at Waddle Ranch (describe in detail in the previous section), known and potential hot spots were identified using GIS analysis, local field knowledge, historical records and aerial photos. These hot spots were then mapped for field investigation. For instance, initial hot spots may include areas where roads intersect drainages or known areas of historic land disturbance. Further field investigation revealed other hot spots and provided insights on the hydrologic interconnection between hot spots.

We use a two-tiered risk-based strategy to prioritize treatments at Waddle Ranch. The first tier is based on a site's erosion potential. The second tier is based on a site's risk to beneficial uses of nearby water bodies (proximity and connectivity). In order to develop a phased implementation plan for Waddle Ranch, both of these assessment elements will be linked to operational priorities (such as recreational access or fuels management plans) and regulatory requirements (such as permit conditions or archaeological constraints) by engaging with individuals who are familiar with and have a stake in the project and its outcomes. In this way, we link and balance need and reality and front load the project plan with important information that too often gets overlooked.

SITE EROSION POTENTIAL – FIELD ASSESSMENT CRITERIA

Treatment actions are often based on standard, often untested practices (BMPs), expert opinion or 'common sense' actions that are embedded in long-standing repletion. Typically, plans are based on very little understanding of site conditions. The purpose of conducting a Site Erosion Potential Assessment is to understand as much of the site as possible prior to taking action so that treatment actions are targeted, cost-effective and likely to achieve the project goals. This assessment framework is also used to evaluate treatment effectiveness after project implementation. Post-project assessment creates a critical, but typically overlooked/underfunded feedback loop that improves future project outcomes. Typically,

Site Erosion Potential – Field Assessment Criteria			
	Low = 1	**Med = 2**	**High = 3**
Site slope	0-5%	5-15%	>15%
Total surface cover	>75%	50-75%	0-50%
Vegetation cover	>20%	10-20%	0-10%
Soil density (cone penetrometer depth-to-refusal)	>6"	3-6"	0-3"
Soil organic matter	>6%	3-6%	0-3%
Signs of active erosion (rills, deposition, etc)	No		Yes
Signs of ongoing disturbance (e.g. vehicle tracks)	No		Yes

regulatory requirements do not incentivize or encourage innovation and improvement. The process described here incentivizes the delivery of successful project outcomes in fact (vs. success in meeting requirements only) and improvement in projects over time. The recommended criteria for conducting a Site Erosion Potential Assessment are presented in the table.

RISK TO BENEFICIAL USES – FIELD ASSESSMENT CRITERIA

All watershed improvement projects take place in the context of the watershed/drainage basin in which it they are located. Understanding the hydrologic connectivity in the overall watershed and the interconnectedness of individual problem areas is key in understanding problems, issues, and constraints. When prioritizing restoration projects on a watershed or property-wide scale, it is important to consider a site's connectivity to drainages and surface waters. That is, what is the likelihood that sediment leaving a site will be conveyed to surface water? Assessing the connectivity between sediment sources and surface waters is an inexact science since it incorporates a large range of variables. This complexity is the main reason that watershed models do not capture actual, complex runoff patterns. However, the ability to understand this connectivity in real-time is, in many ways, the crux of sediment-focused watershed restoration efforts. The best opportunities to assess and understand connectivity at Waddle Ranch and in most alpine watersheds is in the field during peak spring snowmelt, as evidence of erosion, deposition and hydrologic connection tend to disappear quickly by early summer. The framework below was used in the recent Phase II assessment at Waddle Ranch to assess connectivity of sediment source areas (hot spots) to surface waters.

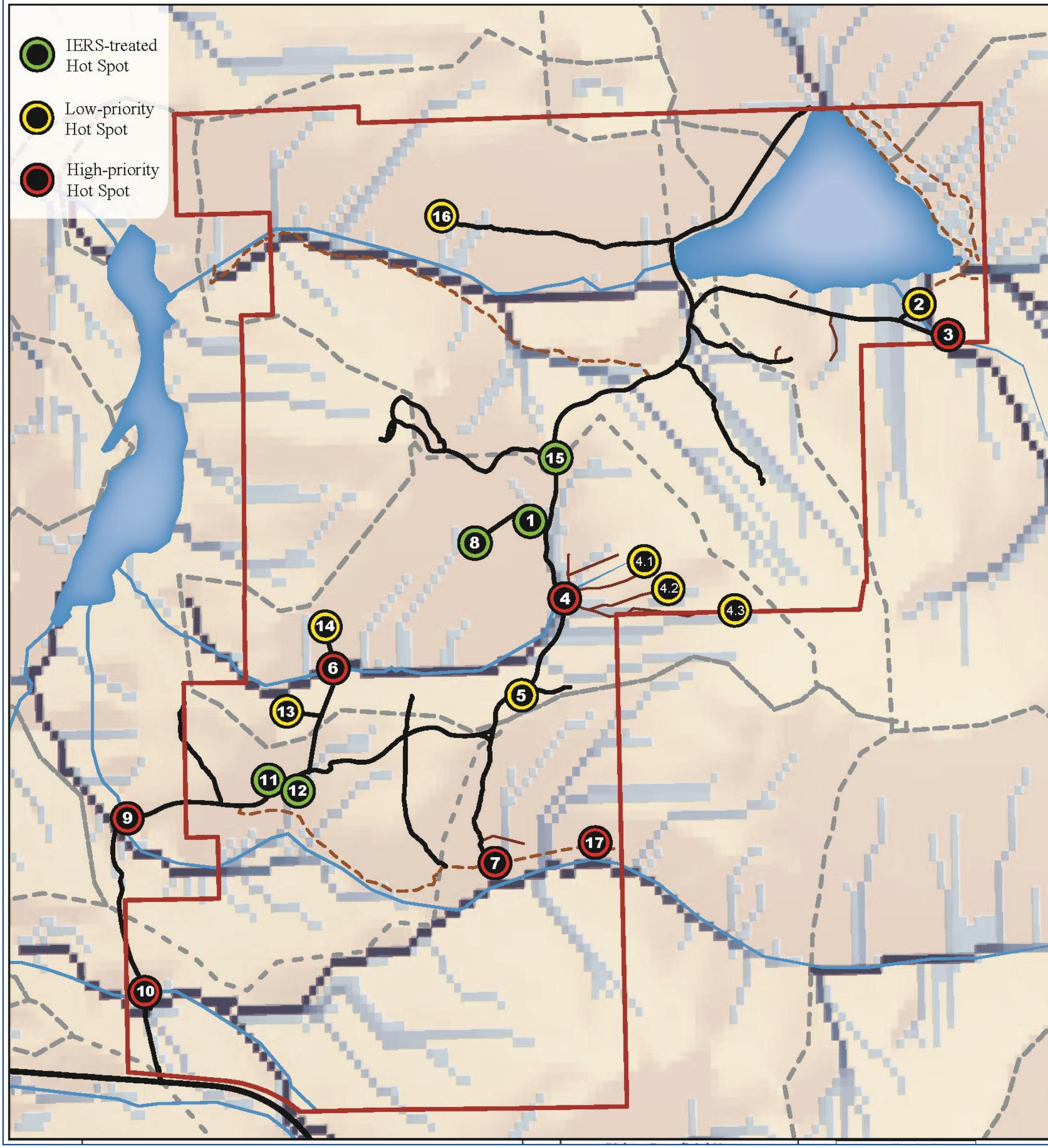
Risk to Beneficial Uses – Field Assessment Criteria			
	Low = 1	**Med = 2**	**High = 3**
Proximity to drainageway[1] (within same catchment)	>500 ft	100-500 ft	<100 ft
Connectivity of drainageway	Broad topographic definition; accumulated duff/litter; well-established vegetation; no sediment deposition	Defined channel; visible sediment deposition; mostly rock substrate; may have some vegetation. Steeper roadways functioning as drainageways may also be included in this category.	Perennial or ephemeral stream channel

[1] A drainageway is defined as any feature that could collect and convey runoff water toward a surface water

Site Erosion Potential – Field Assessment Criteria									Risk to Beneficial Uses – Field Assessment Criteria				Overall Priority (1=low, 3=high)	
Hot Spots	Site slope degrees	Total surface cover	Vegetation cover	Soil density	Soil organic matter	Signs of active erosion	Signs of ongoing disturbance	Average	Hot Spots	Proximity to drainageway	Connectivity of drainageway	Average	Hot Spots	Combined Average
1	2	1	1	1	TBD	1	1	1.2	1	3	2	2.5	1	1.8
2	1	3	1	2	TBD	1	1	1.5	2	3	3	3.0	2	2.3
3	2	3	3	3	TBD	3	3	2.8	3	3	3	3.0	3	2.9
4	1	3	3	3	TBD	3	3	2.7	4	3	3	3.0	4	2.8
4.1	3	1	3	2	TBD	1	1	1.8	4.1	2	2	2.0	4.1	1.9
4.2	3	1	3	2	TBD	1	1	1.8	4.2	2	2	2.0	4.2	1.9
4.3	3	1	1	3	TBD	3	1	2.0	4.3	2	2	2.0	4.3	2.0
5	1	3	3	1	TBD	3	3	2.3	5	2	1	1.5	5	1.9
6	3	2	3	3	TBD	3	3	2.8	6	3	3	3.0	6	2.9
7	1	2	3	3	TBD	3	3	2.5	7	3	3	3.0	7	2.8
8	1	1	1	1	TBD	1	1	1.0	8	3	1	2.0	8	1.5
9	1	3	3	3	TBD	3	3	2.7	9	3	3	3.0	9	2.8
10	1	3	3	3	TBD	3	3	2.7	10	3	3	3.0	10	2.8
11	2	1	1	1	TBD	1	1	1.2	11	2	1	1.5	11	1.3
12	1	1	1	1	TBD	1	1	1.0	12	3	1	2.0	12	1.5
13	1	1	3	1	TBD	1	1	1.3	13	2	1	1.5	13	1.4
14	1	1	3	1	TBD	1	1	1.3	14	2	2	2.0	14	1.7
15	1	1	1	1	TBD	1	1	1.0	15	2	2	2.0	15	1.5
16	1	2	3	3	TBD	3	1	2.2	16	2	1	1.5	16	1.8
17	1	2	3	3	TBD	3	3	2.5	17	3	3	3.0	17	2.8

Green cells indicate that the hot spot has already been treated (in 2009). Yellow cells indicate lower priority sites. Red cells indicate higher priority sites. For the sake of simplicity, straight averages were used to generate this prioritization matrix. No weighting was done to prioritize these sites, but could certainly be added to revise this prioritization framework prior to implementation.

Wattle Ranch Watershed Assessment Hot Spot Prioritization

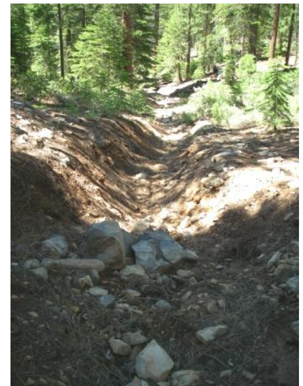


HOT SPOT SUMMARY

Below is a summary of key erosion hot spots identified at Waddle Ranch. Problem descriptions, treatment options, applicable treatment tools and photos are provided for each hot spot. This is not intended to be an inclusive list of all hot spots or potential restoration opportunities at Waddle Ranch. However, the projects described below provide a robust starting point for taking action.

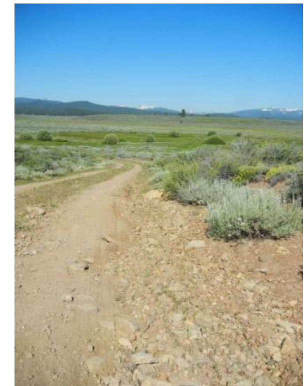
HOT SPOT	PROBLEM	TREATMENT OPTIONS	APPLICABLE TREATMENT TOOLS[1]	PHOTO 1	PHOTO 2
1	unit 3 haul road - compacted and eroding	treated by IERS in 2009 (several test plots)	1c, 1d, 2a, 2b, 2c		
2	old abandoned road crossing ephemeral drainage from Sawmill Rd just above dry lake; small head cut caused by grade change at road crossing	remove head cut; recontour and stabilize crossing	2c, 3a		

[1] Refer to Treatment Tool Matrix in next section for further description.

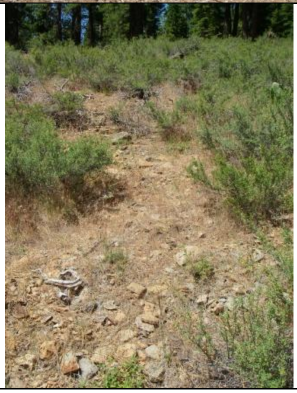
3	Concentrated drainage (from heavily incised skid trail) crossing haul road above dry lake. Substantial sediment transport evident. Drainage channel cris-crosses haul road in several locations en route to Dry Lake	stabilize crossing(s); reroute drainage to minimize road-drainage interaction; road surfacing	1 (all), 2a, 2b, 2c, 3a		
4	Road drainage routed directly to ephemeral drainage via water bar. Scouring and deposition evident directly below road.	Manage road drainage upslope (water bars and infiltration areas, road surfacing, etc).	1 (all), 3a, 3b, 3c		
4.1	Steep skid trail above HS 4. Mulch accumulation, shrub establishment, some soil development. Moderate compaction but no signs of recent erosion. Water bars in place.	targeted loosening (tier 2); add infiltration/sediment capture areas at water bars	2a, 3c		

4.2	Steep skid trail above HS 4. Mulch accumulation, shrub establishment, some soil development. Moderate to high compaction but no signs of recent erosion. Water bars in place.	targeted loosening (tier 2); add infiltration/sediment capture areas at water bars	2a, 3c		
4.3	Long, steep skid trail above HS 4. Defined drainage channel down center of trail. Sediment-coated pine needles accumulated at water bar - evidence of erosion and concentrated flow. Very rocky surface.	targeted loosening (tier 2); add infiltration/sediment capture areas at water bars	2a, 3c		
5	Gully observed on road in 2009 removed via road grading, but active erosion still present. Old skid trail intersects road just upslope of this spot - likely contributing to ongoing erosion.	Road surfacing; road drainage management (water bars, infiltration areas). Treat skid trail adjacent to roadway.	1 (all), 2a, 2b, 2c, 3b, 3c		

6	Haul road crossing ephemeral drainage. Steep road drains to this crossing. Evidence of high energy flows in drainage, large material deposited, scouring, etc.	Manage road drainage upslope of crossing (add infiltration areas at water bars, road surfacing, etc).	1 (all), 3b, 3c		
7	Dished trail coming downhill outslopes where it flattens out and runoff flows directly to East Martis Creek.	recontour trail to prevent drainage to creek; trail surfacing; infiltration areas	1b-1f, 3b, 3c		
8	recently used, compacted, bare landing (unit 3 landing c)	treated by IERS in 2009 (several test plots)	2a, 2b		2011 photo needs to be taken

9	unstable road-stream (ephemeral) crossing along Sawmill Rd with gullying along steep road upslope	Stabilize/formalize crossing; manage road drainage upslope (water bars and infiltration areas, road surfacing, etc).	1 (all), 3a-3d, 3f		
10	Access Road has fragmented meadow hydrology. Historical wet meadow to west is drying out and vegetation composition is shifting to upland. Concentrated water crosses road in one location due to undersized/ unmaintained drainage culverts under roadway. Road itself is eroding and has significant cheatgrass established.	stabilize/formalize crossing and or add appropriately sized/location culverts under road; road surfacing	1 (all), 3a, 3d		
11	recently used, compacted, bare landing (Landing A)	treated by IERS in 2009 (several test plots)	2a, 2b		

12	Concentrated road drainage causing scouring/deposition at water bar	Road infiltration test/demonstration area implemented by IERS in 2009	2b, 3b, 3c		
13	Recently used landing covered in wood chips. Relatively low connectivity to stream. No signs of runoff/erosion. Lower soil density than unmulched landings.	Additional mulching, targeted loosening (tier 2)	1c, 2a-2c		
14	Recently used landing covered in wood chips. No signs of runoff or erosion. Connected to drainage via access rd. Moderate soil density.	Additional mulching, targeted loosening (tier 2)	1c, 2a-2c	No photos available	
15	Heavily compacted, bare landing at Beacon Road-Sawmill Rd intersection	treated by IERS in 2009 (several test plots)	1c, 2a, 2b		

16	Landing north of dry creek. Partial wood chip coverage. Large, heavily eroded cut slope and significant cut/fill.	Additional mulching and targeted loosening (tier 2); full restoration (tier 3); recontouring	1c, 2a-2c		
17	Trail has captured drainage. Runoff is directly connected to East Martis Creek.	reshape trail to prevent drainage to creek; trail surfacing	1b-1f, 3b, 3c		

TRANSFORMING LANDINGS INTO RESERVOIRS

Waddle Ranch has a long history of mining and logging. Individually, each landing may not seem to have a substantial impact on watershed hydrology and erosion. However, the cumulative effect of recent and historic landings is not well understood and worthy of serious consideration. Cost-effective treatments, such as tilling wood chips into compacted soil, can functionally transform the numerous landings at Waddle Ranch (and throughout the region) into water storage reservoirs.

Eighteen landings have been mapped at Waddle Ranch to date. Here is an example of the impact that a *landing-to-reservoir treatment effort* at Waddle Ranch could have. Assume that the 18 landings we have mapped are approximately 100 x 100 sq ft, totaling 180,000 sq ft. Based on more than a decade of testing and monitoring, compacted soil in landings can store approximately 8% water by volume, or 14,400 cubic feet for the 18 landings. Treated landings (tilled to 24" with wood chips), can store approximately 40% water by volume, or 72,000 cubic ft. Based on our research, treatment of these 18 landings alone could increase reservoir (water storage) capacity in the upland area of Waddle Ranch by 57,000 cubic ft.

In the future, we hope to treat these Waddle Ranch landings, measure the results, and also to use satellite imagery and remote sensing techniques to identify other landings not yet found. Transformation of landings into reservoirs has great potential to become a cost-effective tool for combating climate change and enhancing the many watershed services we depend on.

TREATMENT TOOLS

The matrix below provides a brief menu and framework for evaluating and selecting treatment tools that can be used to address water quality threats identified in this assessment (as described in the hot spot matrix in the previous section). The treatment tools below are focused on the types of treatment opportunities identified at Waddle Ranch. A broader range of tools are intended to be developed and demonstrated within this project and included in the Watershed and Forestry Handbooks. Other categories of tools might include planning/communication, assessment/monitoring as well as additional treatment tools for forestry and watershed management.

The draft treatment tools matrix below includes several factors that should be considered when evaluating treatment options for different sites. Factors included in this matrix include:

- **Erosion effectiveness** – how effective is this treatment/practice at minimizing erosion and sediment transport? This has been directly measured for some but not all of these practices.
- **Hydrologic effectiveness** – how effective is this treatment/practice at optimizing infiltration, water holding capacity and minimizing surface runoff? This has been directly measured for some but not all of these practices.
- **Installation cost** – cost to construct/install each treatment
- **Maintenance cost –** cost of maintenance/upkeep required to maintain treatment effectiveness (often not adequately considered)

This matrix is intended to offer an example of the type of framework that would be used to evaluate and select the most effective tools for different types of watershed restoration, management and assessment/monitoring needs. Question marks and blank cells indicate the need for additional testing.

Draft Treatment Tools Matrix

ID	Treatment Tool	Erosion effectiveness (1=low, 5=high)	Hydrologic effectiveness (1=low, 5=high)	Installation cost ($-$$$)	Maintenance cost ($-$$$)
1	**Road/Landing/Trail Surfacing**				
1a	Bare dirt	1	1	$	$$$
1b	Rock	3?	3?	$$	$
1c	Wood chips	3?	2?	$	$
1d	Asphalt grindings	3?	3?	$-$$	$
1e	AC	5	1	$$$	$
1f	Chip seal	4?	1	$$-$$$	$$
2	**Road/Landing/Trail Removal**				
2a	Targeted loosening (tier 2)	4-5	4-5	$	0 - $
2b	Full restoration treatment (tier 3)	5	5	$$	0 - $
2c	Hydrologic reconnection (recontouring)	4-5	5	$$$	0 - $
3	**Drainage Management**				
3a	Arizona crossing	?			
3b	Water bars/rolling dips	2-3			
3c	Infiltration areas	3-5			
3d	Culverts				
3e	Outslope/inslope roads	3-5	2-5	$$$	$-$$
3f	Realign steep roads				

YEAR 1 CONCLUSIONS AND NEXT STEPS

CONCLUSIONS

NEED TO EXPAND UNDERSTANDING OF HOW FOREST MANAGEMENT PRACTICES AFFECT WATERSHED CONDITIONS AND FUNCTIONS: The era of reliance on watershed models and best professional judgment as the primary basis for management decisions is coming to a close. **This project offers the opportunity to demonstrate a robust and straight-forward model for water-quality based watershed management** and the ability to transfer knowledge and tools developed at Waddle Ranch to other land managers throughout the region.

WADDLE RANCH PROPERTY IS HEAVILY IMPACTED: Waddle Ranch has been heavily impacted by several waves of logging activities over the past 50 years with little focus on long-term stewardship. **The property has an extensive and poorly maintained road network and an array of legacy impact areas that have only begun to be inventoried and understood**.

LEGACY IMPACTS ARE PERSISTENT: Even after 50 years, historic landings and skid trails have not "recovered" and still represent water quality liabilities in the watershed. Preliminary monitoring results show **that impact areas can slowly recover but that vegetation alone is not a sufficient indicator of recovery.**

HIGH CONNECTIVITY BETWEEN HOT SPOTS AND DRAINAGES: A combination of GIS-based flow accumulation modeling and field observation indicates that Waddle Ranch has a highly connected network of roads and drainages. Evidence of recent water flow was observed in many ephemeral drainages believed to carry little to no flow. Further, many road segments are effectively linking hot spots and concentrating flow during even minor runoff events.

NEXT STEPS

MONITOR EXISITING MITIGATION TREATMENTS: We have already implemented a range of mitigation treatments designed to treat road runoff, alter road drainage and answer other management questions at Waddle Ranch in 2009. Monitoring these existing mitigation measures is the **first step to developing cost-effective mitigation measures to protect water quality** where unacceptable impacts are identified. Some of these treatments may be critical management tools for roads and other types of disturbances.

TEST AND DEVELOP ADDITIONAL MITIGATION TREATMENTS: Once initial monitoring of existing mitigation measures is completed, additional mitigation treatments will be identified and implemented. These measures will be based on monitoring data from existing mitigations and input from technical advisory group members.

CREATE PHASED IMPLEMENTATION PLAN FOR WADDLE RANCH: Work with TTAD and other stakeholders to develop an phased implementation plan that incorporates landowner input and regulatory priorities.

CONDUCT WATERSHED ASSESSMENT DURING SPRING SNOWMELT: To fully understand and map the hydrologic impacts, connectivity and water quality risk of roads and legacy impacts at Waddle Ranch, we need to conduct on-the-ground assessment during 1-2 spring snowmelt periods (recommend starting in 2012). This opportunity was missed in 2009-11 due to project start and end dates.

CONDUCT TARGETED WATER QUALITY MONITORING DURING SPRING SNOWMELT PERIODS: Unfortunately, no continuous stage or turbidity measurements were collected during spring snowmelt periods due to project start and end dates. We strongly recommend installing a pressure transducer and turbidimeter at EM50, resume targeted grab sampling for TSS and particle size distribution, and collection of discharge measurements for 1-2 additional snowmelt periods. This would enable **accurate characterization of sediment loading** and discharge patterns and subsequent **calculation of peak daily and annual sediment loads**.

SUPPORT TRANSFER OF NEW KNOWLEDGE AND TOOLS: The next steps listed above will provide the information and experience necessary to develop the two handbooks originally intended to be produced by this project: the **Watershed Evaluation, Treatment and Monitoring Handbook** and the **Forestry Forest Fuels Treatment/Water Quality Protection Handbook.** These handbooks will practitioners and land managers practitioners to confidently manage their watersheds **using field-tested tools to achieve regulatory goals** and the level of water quality protection and improvement intended by those regulations.

APPENDICES

APPENDIX A: PROJECT BACKGROUND & OUTCOMES

APPENDIX B: HUMAN DISTURBANCE & ITS EFFECTS ON WATERSHED FUNCTION

APPENDIX C: SEDIMENT SOURCE MONITORING SUMMARY REPORT

APPENDIX D: WATER QUALITY MONITORING SUMMARY REPORT

APPENDIX E: TEST PLOT AS-BUILT REPORTS

APPENDIX A: PROJECT BACKGROUND & OUTCOMES

SEP BACKGROUND

The Waddle Ranch Supplemental Environmental Project (SEP) was developed as a response to alleged water quality violations incurred by East West Partners in 2006. The SEP was crafted and cleared by a number of participants including Lahontan Water Board staff and the Truckee River Watershed Council. The intent of the SEP was to use fine money to create beneficial environmental improvements that would offset impacts from East West's actions. Further, this SEP was designed to leverage work done on the ground to produce user-accessible guidance documents for watershed assessments and forestry/fuels work. Both documents are designed to target water quality protection as their primary goals. The guidance documents or 'handbooks' are intended to engage the process of adaptive management to bring a new and highly effective approach to water quality protection that currently isn't embedded in the regulatory process.

PROJECT OUTCOMES

Site-specific project outcomes for the Waddle Ranch SEP includes:

- Understanding of East Martis Creek watershed sediment loading patterns and contribution to Truckee River
- Understanding of management impacts and mitigation treatment effectiveness in watershed
- Better understanding of legacy impacts
- Greater understanding of watershed and site resilience

Transferrable project outcomes for the Waddle Ranch SEP include:

- Understanding of management impacts and mitigation treatment effectiveness
- Better understanding of legacy impacts
- Development and demonstration of a systematic approach to watershed management and improvement
- New field-tested, whole-watershed strategies for TMDL implementation throughout Tahoe/Truckee River watersheds

PROJECT OUTPUTS

Site-specific project outputs for the Waddle Ranch SEP include:

- Map of problem areas and restoration opportunities
- Restoration projects implemented
- Set of field-tested treatment and mitigation tools for Waddle Ranch
- Long-term treatment implementation and management plan for Waddle Ranch
- Accurate and defensible sediment yield values for roads, skid trails, landings and other ongoing and legacy impacts

- Accurate and defensible sediment loading estimates for East Martis Creek

Transferrable project outputs for the Waddle Ranch SEP include:

- Model of cost-effective erosion-focused watershed assessment process
- Model of assessment-to-implementation watershed protection and improvement process
- Scientifically-derived, transferable tools for watershed protection and improvement
- Cost-effective monitoring methodologies for forestry impacts and watershed protection/improvement
- Watershed Evaluation, Treatment and Monitoring Handbook
- Forest Fuels Treatment/Water Quality Protection Handbook
- Information-rich water quality monitoring protocols

ORIGINAL TIMELINE

The original SEP had laid out a long term, sequential timeline so that projects could be planned, implemented and monitor within a true adaptive management process. This is in stark contrast to most water quality improvement projects, which are designed and built on a very short timeline and rarely monitored in a meaningful manner. The Waddle Ranch/Northstar SEP was designed to model true adaptive management using a longer timeframe with a much higher level of output than is typically seen in watershed improvement projects.

Year One was designed to collect information about the watershed (particularly drainages and drainage patterns, erosion hot spots and potential restoration project sites), implement some treatment test areas for monitoring in **Year Two**. Information was to be shared with and processed by the Steering and Technical Committees. The Technical Committees were to develop frameworks within which to assess and analyze the information and data and then the Steering Committee was to offer input and feedback on plans for **Year Two**.

Thus, in **Year Two**, decision-making frameworks and supporting baseline data would be in place and projects would be targeted to maximize effectiveness of treatment, management and monitoring efforts. In **Year Three**, the bulk of the restoration effort would be scaled up and largely completed in **Year Four**.

Due to unforeseen circumstances, the Waddle Ranch SEP came to an abrupt and premature end in March 2010, less than one year after the project began.

The purpose of this report is to summarize the information collected and lessons learned thus far and offer an example of how the different elements of this project can be integrated to provide a new model and tools for water quality-based watershed management.

NEXT STEPS

Once the current information is processed and considered, the next steps for the Waddle Ranch SEP are to:

- Monitor existing mitigation treatments implemented in 2009.
- Conduct targeted watershed assessment during spring snowmelt periods.
- Implement additional mitigation treatments in priority erosion hot spots based on monitoring results and watershed assessment during snowmelt.
- Scale up restoration treatment efforts using information gained.
- Conduct targeted water quality monitoring during spring snowmelt periods.
- Begin handbook preparation based on previous handbook planning sessions, input from technical groups and current data/information.

ORIGINAL INTENTION

The intention of the SEP was to use the Waddle Ranch property to test, demonstrate and develop the key elements of two transferable adaptive management-based handbooks to support improved watershed management practices throughout the region:

1. **The Watershed Evaluation, Treatment and Monitoring Handbook**
2. **The Forest Fuels Treatment/Water Quality Protection Handbook**

The Waddle Ranch property offers a unique opportunity to develop and demonstrate this 'whole watershed' approach to water quality improvement. Using on-the-ground treatments as a foundation, we intend to develop two handbooks that will guide other managers to understand, implement and learn from each project. The target is to use assessment as the context and direct link to a range of watershed improvement projects. Currently, most watershed assessments are aimed at characterizing watershed conditions with little or no direct linkage to developing projects. The Waddle Ranch SEP is designed to create a new process that enables us to achieve (and measure) real watershed improvement in a much more cost-effective manner.

WATERSHED SETTING

LOCATION, OWNERSHIP AND LAND USE

Waddle Ranch is directly underneath the flight path of aircraft landing on runway 28 at Truckee Tahoe Airport. Waddle Ranch is an important piece of open space in the Truckee region as it is visible to several major traffic corridors, creating a large buffer of land between the Truckee Tahoe Airport, Northstar-at-Tahoe, and the residential communities of Juniper Hills and Glenshire.

The Truckee Donner Land Trust acquired the Waddle Ranch property in fall 2007 in fee title for protection of open space resource values in the Martis Valley after decades of litigation over private ski and golf resort development. As stated in the Waddle Ranch Long-Term Management Plan, "The Land Trust is committed to managing the property for public access and non-motorized recreation, exemplary forest health and forest stand maturity, scenic-byway view shed protection, water quality and quantity protection and enhancement, and wildlife habitat protection and enhancement. The long-term goal for management of Waddle Ranch is preservation of existing conservation values, enhancement of any degraded conditions, and conveyance of title to the Truckee Tahoe Airport District for long-term management."

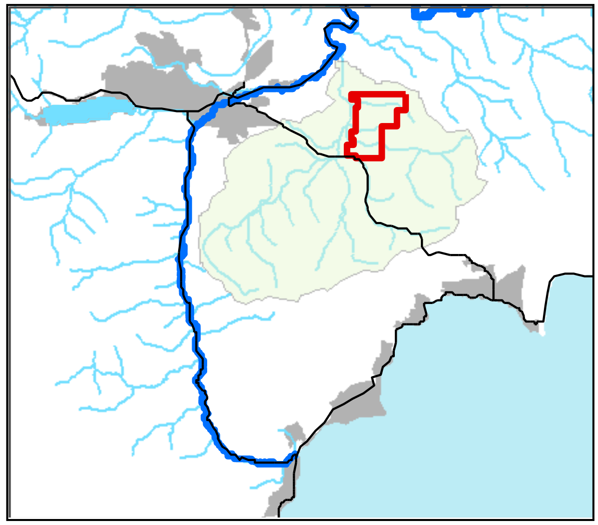


Figure 1. Waddle Ranch location map.

ELEVATION, ASPECT AND TOPOGRAPHY

Elevations on the property range from approximately 5800 feet along East Martis Creek on the southern portion of the property to 6600 feet at the peaks near Dry Lake. The watershed drains primarily to the west and therefore, slopes are predominately north- and south-facing with some gentle west-facing slopes on the west side of the property where it transitions into the Martis Valley floor. The topography on the property is rolling and fairly gentle with isolated pockets of steep terrain along stream channels and ridge tops.

GEOLOGY AND SOILS

The higher elevation areas of Waddle Ranch are underlain by potassium-rich andesite that is roughly 1 million years old and has been glaciated, leaving relatively old and well-developed volcanic soils in most of the upper watershed. Many past and current land uses (such as road-building and logging) have diminished the infiltration capacity and overall function of the soils while increasing runoff and nutrient transport to streams. The relatively fine-grained soils at Waddle Ranch are prone to erosion when disturbed, which has resulted in some incision in channels downstream of disturbed areas. The lower portion of the property transitions into the Martis Valley with alluvial fans at the mouth of East Martis Creek that mix with layered glacial outwash and mixed volcanic deposits.

HYDROLOGY

The hydrologic network on the Waddle Ranch property includes one perennial stream (East Martis Creek), several primary ephemeral drainages and one lake (Dry Lake). Nearly all drainages terminate at Martis Creek Lake, just west of the property, with the exception of several small ephemeral channels the drain to Dry Lake. East Martis Creek is the primary drainage for roughly the southern third of the property and is the only perennial stream passing through Waddle Ranch. Stream flow is East Martis Creek ranged from approximately 0.5 – 8 cubic feet per second during this project's monitoring period. Two primary ephemeral drainages collect water from the majority of the property. One of these drainages runs between Dry Lake and Martis Creek Lake. No evidence of recent surface flow was observed in this channel during the assessment, suggesting that it only carries flow during large episodic events. Similarly, the other primary ephemeral drainage in the middle of the property exhibited no signs of recent flow. Both of these ephemeral channels are well-defined and have the potential to route surface runoff directly to Martis Creek Lake in a large runoff event during periods of saturated soils, such as a rain-on-snow event.

Average annual precipitation at Waddle Ranch is approximately 30-40 inches, 75% of which falls between November and March in the form of snow or mixed rain/snow storms. Precipitation in the summer months is isolated and primarily associated with convectional cell thunderstorms.

ADAPTIVE MANAGEMENT PROCESS: COMMITMENT TO OUTCOME

Adaptive management is an extremely powerful tool to help protect and improve water quality. It differs from current regulatory framework but is also complimentary. Adaptive management is relatively flexible but requires engagement and commitment on behalf of the project managers. It also requires accountability while supporting innovation. Given the myriad challenges to water quality today, this process can move us from compliance to competence.

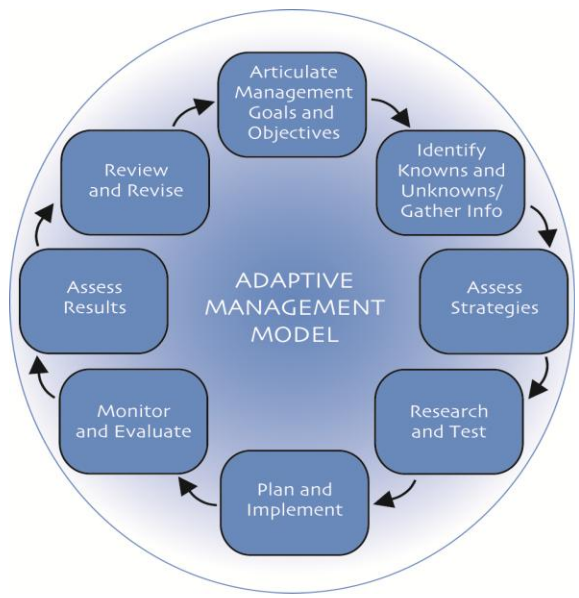


Figure 2: The Adaptive Management model

The Waddle Ranch portion of the SEP is designed within this framework and is designed to model a highly effective adaptive management process that has been evolving over fifteen years in and around the Tahoe-Truckee region. The handbooks are intended products of this effort, and are designed to define and share this adaptive process with other watershed managers throughout the region. Currently, there are no guidance documents that fill this critical need.

Adaptive management differs from a number of other planning processes in that adaptive management is **linked directly to an outcome, rather than to a plan**. Well developed and well considered plans are the first step to an outcome. Adaptive management, when properly and completely applied, incorporates planning and guides the user to outcome. While this statement may seem basic, most environmental regulations and projects focus on the plan and the associated projection. Much less attention is paid to the actual outcome. The commitment of the Waddle Ranch SEP is to a tangible, measureable and transferrable outcome. That outcome includes environmental improvement, sharing/transfer of knowledge and a project delivery model that fills a large void in planning, implementing and understanding/measuring outcomes of all types of environmental projects.

VEGETATION

The vegetation communities on the Waddle Ranch property have been shaped by a long history of human use including logging, grazing and more than 100 years of fire suppression. Most of the property is heavily forested with an overstory dominated by Jeffrey pine. Other tree species on the property include Ponderosa pine, white fir, red fir, juniper, lodgepole pine and sugar pine. Fire suppression has led to fir encroachment in many areas of the property. The understory is dominated by shrubs such as antelope bitterbrush, greenleaf manzanita and various sagebrush species. Most of the legacy areas have been colonized by these hearty shrubs, which are better able to tolerate compacted soil conditions than most native grasses and forbs.

Figure 3. Historic landing colonized by manzanita.

East Martis Creek, which flows along the southern portion of the property, has an intact and robust riparian vegetation corridor. The upper reaches are dominated by aspen, willow and alder, which shade the stream channel. The lower depositional reaches are dominated by riparian grasses (sedges, rushes) which transition to upland shrubs at the outer reaches of the floodplain.

Figure 4. Historically wet meadows are now dominated by shrubs, due in part to hydrologic fragmentation caused by roads.

The southwest corner of the property is characterized by a mix of wet meadow and shrubland. Roads have interupted the natural flooding patterns of East Martis Creek, altering the hydrology of the seasonal wet meadows and causing a long-term vegetation shift from mesic grasses to more drought-tolerant shrubs.

APPENDIX B: HUMAN DISTURBANCE & ITS EFFECTS ON WATERSHED FUNCTION

TIMELINE OF HUMAN USE AND ASSOCIATED IMPACTS

The Martis Valley has an incredibly long and rich history of human use. Prehistoric habitation of the Martis Valley dates back roughly 9000 years. The Washoe Indians occupied the Martis Valley into the early 20th century. It is not a stretch to say that 100% of the Martis watershed (including Waddle Ranch) has been influenced by human activities and use patterns over the past several hundred years. The graphic below (Figure 1) depicts an approximate timeline of human activities in the Martis Valley over the past 200 years. Legacy impacts from the post European settlement activities can still be found throughout the watershed. Table 1 summarizes the types of land disturbances and legacy impacts associated with these historic activities.

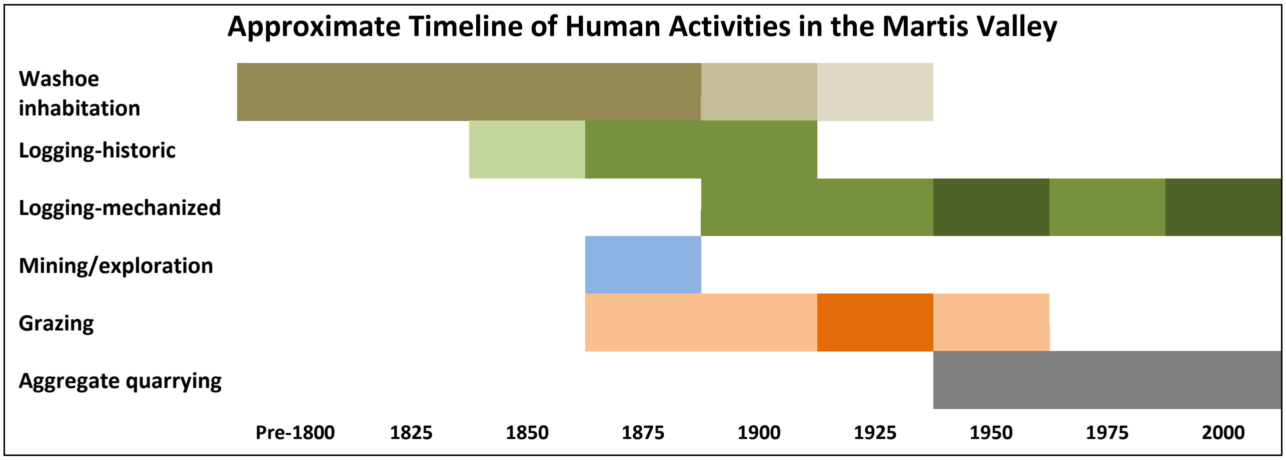


Figure 1. This graphic illustrates an approximate timeline of human activities in the Martis Valley over the past 200 years. ***Note: The spectrum of color saturation corresponds to the intensity of the activity. The greater the saturation, the more intensive the activity.***

Table 1. Summary of types of disturbances and legacy impacts associated with human activities in the Martis Valley.

Human Use/Activity	Associated Land Disturbances	Legacy Impacts
Logging-historic	Construction of flumes, millponds, haul roads.	Flumes and haul roads are still present today.
Logging-mechanized	Construction of haul roads, skid trails, landings, railroad beds.	Haul roads, skid trails, landings, railroad beds.
Mining/exploration	Digging, tunneling; abandonment of spoils; vegetation clearing for buildings/structures.	None observed in Year 1 assessment.
Grazing	Soil disturbance and compaction. Changes to vegetation structure and composition. Dewatering of meadows.	Meadow hydrology still impacted, as is vegetation.
Aggregate quarrying	Large-scale changes to vegetation, soil and hydrology.	Abandoned quarries and spoils. Vegetation change.

EFFECTS OF HUMAN IMPACTS ON WATERSHED FUNCTION

Nearly all of the persistent impacts on watershed function identified at Waddle Ranch to date are rooted in the removal of timber resources, which we will herein refer to broadly as logging. The Waddle Ranch property was likely cleared for timber resources in the early part of the 20th century. Logging is believed to have occurred again in the 1950s. More recently, targeted logging operations have been conducted on the property in 1994-95 and again in 2009. Logging practices have changed a great deal from the days of historic hand cutting and removal with horses to modern day mechanized logging and vegetation management practices. The intensity and extent of the impacts associated with logging practices have also varied greatly over time. However, all known logging activities at Waddle Ranch – historic and recent – have created some of the same basic features:

- **Roads** – created to access harvest areas, whether by animal or machine
- **Skid trails** – the result of dragging logs to a central point
- **Staging areas** – centralized points used to stage logs for processing and distribution, such as landings (modern) and millponds (historic).

These common features provide a useful framework for assessing and describing the primary impacts of human activities on watershed function at Waddle Ranch.

ROADS

Of all the human-created features at Waddle Ranch, roads have had by far the greatest impact on watershed hydrologic function. Like many watersheds, the existing road system at Waddle Ranch has been created on a project-by-project basis over a long period of time, not in a deliberate manner. The result is a road system wrought with water quality liabilities and restoration opportunities. Specific, ongoing impacts of the road system on watershed processes include:

- **Hydrologic impacts** – roads are capturing and routing runoff, which has altered watershed hydrology and drainage patterns.
- **Erosion impacts** – roads are persistent and controllable sources of accelerated erosion by both water and wind.
- **Road-drainage interaction** – haul roads cross several ephemeral drainages, creating abrupt grade breaks and the potential to transport large volumes of sediment in large runoff events.

HYDROLOGIC IMPACTS

Forest roads have a natural tendency to capture and concentrate runoff unless they are thoughtfully designed and regularly maintained. Road surfaces tend to be highly compacted and nearly impermeable to water, resulting in accelerated runoff, scouring of road surface sediment and the need for regular maintenance of the road surface condition and drainage patterns. By capturing and routing surface runoff, many roads at Waddle Ranch have become default ephemeral drainages. Figure 2 shows an example of a relatively steep section of Sawmill Road with heavily compacted soil and a concave cross-section, resulting in concentration of surface runoff and formation of a gully. Shortly after this photo was taken, the road was smooth graded to accommodate 2009 forestry operations, temporarily erasing the gullies. However, the impacts of the road on catchment drainage patterns were not addressed during the re-grading. Figure 3 shows a far more acute example of the same situation. To fully understand and map the hydrologic impacts and connectivity of roads at Waddle Ranch, we need to be onsite during the spring snowmelt period

Figure 2. Water capture and gully formation on Sawmill Road.

Figure 3. Used as a haul road in 1994-95, the entire road bed has since been eroded down to rock due to capture and concentration of surface runoff. In 2009, this road was allowed to be regraded for use as a haul road once again.

and/or several summer/fall rain events. This is one of the primary purposes of the proposed Phase II assessment.

EROSION IMPACTS

Compacted soil + no surface cover + rain/snowmelt = erosion. Forest roads are a perfect storm for erosion. However, signs of erosion can be difficult to identify even days after a rainstorm due to vehicle traffic, wind and road grading. Signs of recent erosion were observed on most road segments at Waddle Ranch, such as the sediment deposition shown in Figure 4. Where signs of active erosion were not present, road conditions were such that erosion risk was believed to be high. This hypothesis was tested by IERS using simulated rainfall to measure erosion rates at several locations at Waddle Ranch. The haul road plot produced 22 times more sediment (2,817 lbs/acre/in) than a nearby legacy logging plot (129 lbs/acre/in) before logging in 2009. Following road grading and hauling in 2009, sediment yield at the same haul road plot increased by 9 times and produced 205 times more sediment (26,193 lbs/acre/in) than the legacy logging plot. Typical runoff sediment yields for undisturbed or restored areas with similar soil types are less than 300 lbs/acre/in. This monitoring confirms that roads are indeed a relatively high erosion risk and that grading can substantially increase the water quality liability associated with forest roads (see the

Figure 4. Sediment deposition on Sawmill Road following fall rain event.

Figure 5. Dust cloud generated by vehicle traffic on recently graded haul road.

Sediment Source Monitoring Report in Appendix D for more information).

In addition to water erosion, road grading practices leave behind thick layers of non-cohesive fine soil particles, increasing the probability of air and water pollution from roads via dust generation and wind erosion. This process is exacerbated by vehicle traffic, as shown in Figure 5.

ROAD-DRAINAGE INTERACTION

Haul roads cross directly through ephemeral drainages in at least three known locations at Waddle Ranch. At all of these locations, the road surfaces create grade breaks that would likely result in head-cutting and large amounts of sediment being mobilized in large runoff events. It is not known how long the roads have intersected these drainages, but all were smooth graded, used for hauling in 2009 and left unprotected at the end of the season.

Figure 6. Haul road crossing ephemeral drainage (hot spot 6). Straw was spread on the road surface at the crossing as a BMP.

Figure 7. Haul road crossing ephemeral drainage near Dry Lake (hot spot 3). Filled in crossing is a potential source of sediment.

SKID TRAILS

Historic skid trails are widespread at Waddle Ranch, continuing to alter drainage patterns by concentrating runoff into a semi-hidden network of erosion-prone gullies. Skid trails are created by dragging felled trees over the ground to a central point. The primary land disturbances associated with skidding are displacement of duff and topsoil, soil compaction, and reshaping of the forest floor into linear swale-like features.

Skid trails can be difficult to identify if you are not looking for them, as many are covered in mulch from years of needle cast. However, an initial subset of skid trails were identified and mapped in Phase I of this watershed assessment. Most skid trails run to or from historic landing areas, which are often located along historic or active roads, increasing the hydrologic connection between these legacy impacts and their potential impacts on watershed function during episodic events. Even after decades of no human use, many of these historic skid trails are "smoking guns," exhibiting clear evidence of long-term water capture and erosion (as shown in Figure 8). One particularly high-risk skid trail was identified terminating just upslope of East Martis Creek (shown in Figure 9). The upslope origin of this skid trail was barely noticeable, but the trail became much more defined downslope as the slope angle increased. Based on field observations, concentrated runoff and sediment from this skid trail is likely to reach East Martis Creek during episodic events such as fall rainstorms and peak spring snowmelt. Inventorying additional skid trails and assessing their risk to water resources is proposed as part of the Phase II watershed assessment at Waddle Ranch.

Figure 8. Historic skid trail with rocky surface due to water capture and long-term erosion.

Figure 9. End of historic skid trail that terminates just upslope of East Martis Creek (hot spot 7).

LANDINGS

Landings are centralized locations where logs are staged for processing and distribution. More than 20 landings have already been inventoried at Waddle Ranch, and there are believed to be many more. Most landings identified to date are historic landings and some were re-used and further impacted during 2009 logging operations. The physical appearance of landings varies widely. Many historic landings have been colonized by vegetation (primarily shrubs) but are still very compacted (see Figure 12). Figure 10 and Figure 11 show a historic landing before and after reuse during 2009 logging operations.

Results of initial monitoring in 2009 indicate that historic landings and other legacy impacts (e.g. old logging roads and skid trails) continue to remain relatively compacted despite the increasing vegetation on those sites (see Sediment Source Monitoring Report in Appendix D). Soils that are compacted tend to remain in that state for a long period of time with some reduction in soil density occurring but not enough in most cases to return the site to original levels of infiltration or productivity. Most landings at Waddle Ranch are low in slope angle and therefore, may not be perceived as a high erosion risk. However, the cumulative impacts of these large compacted areas on watershed hydrology (not to mention vegetation composition) should not be underestimated, especially since they are typically connected to roads and skid trails, which are very efficient at conveying the increased runoff from these areas and exacerbating erosion and drainage issues downslope.

Figure 10. Historic landing before 2009 logging (monitoring site).

Figure 11. Historic landing after 2009 logging (monitoring site).

Figure 12. Persistent soil compaction at this historic landing has limited natural recolonization by vegetation.

APPENDIX C

WADDLE RANCH
2009 SEDIMENT SOURCE
MONITORING SUMMARY REPORT

PREPARED BY MICHAEL HOGAN AND RACHEL ARST

INTEGRATED ENVIRONMENTAL RESTORATION SERVICES, INC.

APRIL 2011

INTEGRATED ENVIRONMENTAL
RESTORATION SERVICES, INC

COMMON GROUND • UNCOMMON SOLUTIONS

P.O. BOX 7559 • 2780 LAKE FOREST ROAD • TAHOE CITY, CA 96145
OFFICE: 530.581.IERS (4377) • FAX: 530.581.0359

This report is a key component of a Supplemental Environmental Project (SEP) that was originally designed to develop a model for effective and accessible watershed management in the Sierra Nevada. Work described in this section is intended to be included in the SEP-supported **Watershed Evaluation, Treatment and Monitoring Handbook** and the **Forestry Forest Fuels Treatment/Water Quality Protection Handbook**.

NEED FOR AND PURPOSE OF MONITORING

Many forest practices associated with fuels reduction that are currently being used in the Lahontan region are assumed to have either little impact or a great deal of impact on water quality and soil condition, depending on whose perspective is being presented. A primary reason for this apparent conflict is the fact that there is little site specific field data to support or refute either point of view. Scientific findings, when they are available, tend to be generalized and are usually obtained from other regions and soil types. Further, there has been little local scientific inquiry into actual soil impacts of forest practices in terms of compaction, loss of organic matter, plant response (beyond tree production) or other components that can affect water quality. In an attempt to respond to this potentially critical lack of information, the Waddle Ranch Supplemental Environmental Project has been designed to directly address this issue in a systematic, whole watershed manner. We have designed this project to use a dynamic and adaptive approach to assessing impacts, measuring soil and water changes, and identifying mitigation measures that will support fuels reduction work while protecting and even improving soil and water quality.

Through this program, we are defining a process that is more accurate, user friendly and productive than other assumption-based programs of planning and implementing. This program is designed as a model to assist others to implement and monitor projects in a cost and environmentally effective manner. This process will help assure that we aren't engaged in practices that we assume have little impact when in fact they do, and vice versa.

Monitoring serves to test a range of hypotheses as well as providing the foundation for a sound, site specific management approach. Monitoring can also suggest and test defensible mitigation measures where impacts do exist, thus supporting ongoing forest fuels reduction work that produces minimal impact on water and soil quality.

As forest practitioners move toward the mandates of forest and soil resiliency and true ecological sustainability, monitoring and adaptive management will play a critical and substantial role in expanding our understanding of what those terms mean in an operational sense.

The following sections discuss these advantages further:

DETERMINE FOREST PRACTICE IMPACTS IN SPECIFIC CONDITIONS

Forest practices are based on experience and research that tends to assume that generalized knowledge applies evenly to a range of sites. In reality, each site is slightly different and will respond differently to treatment. Understanding of impacts must be done on an individual site basis. While some suggest that individual project assessment is costly, we suggest that site assessment can be done at a minimal cost once we understand the nature of the soil and the impacts on that soil more fully. Currently, most assessments are based on a myriad of untested assumptions. [1] [2]

DEVELOP BASIS FOR MITIGATION MEASURE COMPARISONS

Impacts from logging and vegetation management are inevitable. Some of those impacts may actually be beneficial from an ecological standpoint while others are likely to be detrimental and still others may be insignificant. For detrimental impacts, cost effective mitigation measures will support ongoing vegetation management rather than resulting in further restrictions. Where mitigation measures can be implemented and their effectiveness quantified, the likelihood of those measures being accepted is much higher.

DEVELOP SITE-SPECIFIC, COST EFFECTIVE MONITORING TOOLS

Monitoring will continue to increase in importance as responses to forest practices come under increased scrutiny from regulatory agencies and public interest groups, and as ecosystem services come under increased pressure. Thus, cost effective monitoring tools that use a small portion of the overall project budget will be critical. This SEP project is working to identify the cost-effectiveness of a range of monitoring tools.

DEVELOP BASIS AND INPUT FOR USERS HANDBOOK

The work thus far at Waddle Ranch was originally intended to form the foundation for two user-guides: one for watershed assessment and monitoring and the other for fuels reduction/soils erosion protection. Both handbooks intend to fill gaps in the need for cost effective, accessible and easy to use guidance that will allow users to achieve tangible results in water quality protection and improvement. Results of this monitoring provide the foundation for process as well as a number of treatment tool potentials.

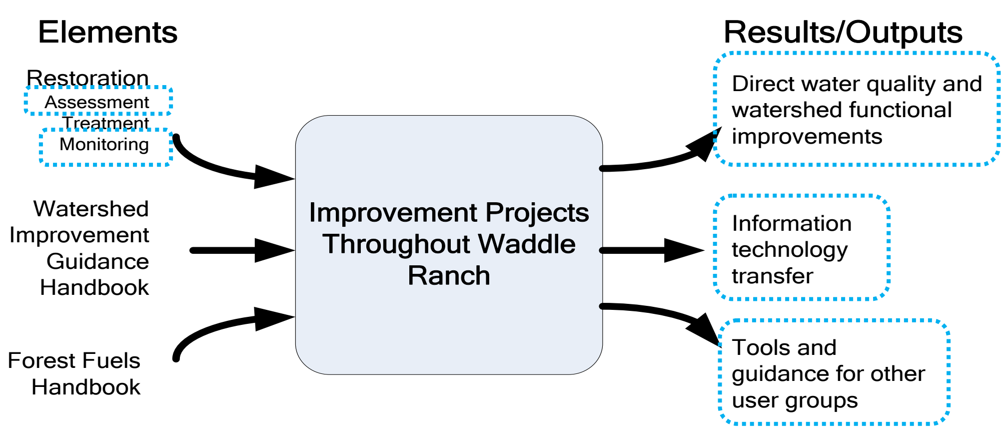


FIGURE 1: RELATIONSHIP OF MONITORING ELEMENTS TO OVERALL OUTPUTS OF PROJECT; BLUE FRAMES SHOW MONITORING-SUPPORTED AREAS (FROM ORIGINAL SEP PROPOSAL)

[1] DeLuca, T.H. and Archer, V. 2009. Forest soil quality standards should be quantifiable. *Journal of Soil and Water Conservation* 64: 117A-123A.

[2] Napper, C. et al. 2009. Soil-Disturbance Field Guide. USDA Forest Service. p.4

BACKGROUND

In 2009, tractor logging was conducted at Waddle Ranch in order to reduce fuel loading. This type of logging includes skidding the sturdiest trees to the landings, chipping the entire tree, and then hauling away the chips. Smaller trees, which would have broken during skidding, are instead felled and masticated in place.

Soil condition and runoff monitoring was conducted in 2009 by IERS before and after forest thinning/logging operations in order to assess the changes in soil and vegetation as a result of the logging. Monitoring was also intended to serve as the foundation for assessing the effectiveness of mitigation measures in cases where mitigation may be indicated. Further monitoring was to be conducted in 2010 at areas where restoration treatments were implemented in 2009. Given bankruptcy proceedings for East West Partners/Northstar Mountain Properties, that monitoring did not take place.

Soil compaction, soil infiltration, and total cover assessments (vegetation and mulch, see Methods section, below) were used to evaluate differences between treatments pre and post implementation and to determine what level of impact was associated with each type of activity. Pre-logging monitoring was conducted in July, 2009 and post-logging monitoring was conducted in September, 2009. Most of the data was collected within logging Unit 3.

A reference or comparison area, referred to as the 'control' in this report, was selected near Unit 4 that represented the least-disturbed sites at Waddle Ranch (Figure 2 2 and 9). Note that Waddle Ranch has been extremely heavily impacted since European settlement. Those impacts are described in more detail in another related report. Impacts include mining, several eras of logging, gravel extraction, hydrologic manipulation and grazing. Thus, while the Waddle Ranch property is considered by some to be 'pristine', it is, in fact, similar to many watersheds throughout the Sierra that are so heavily impacted it is difficult to find an area that hasn't received some sort of soil and vegetation disturbance.

SITE DESCRIPTIONS

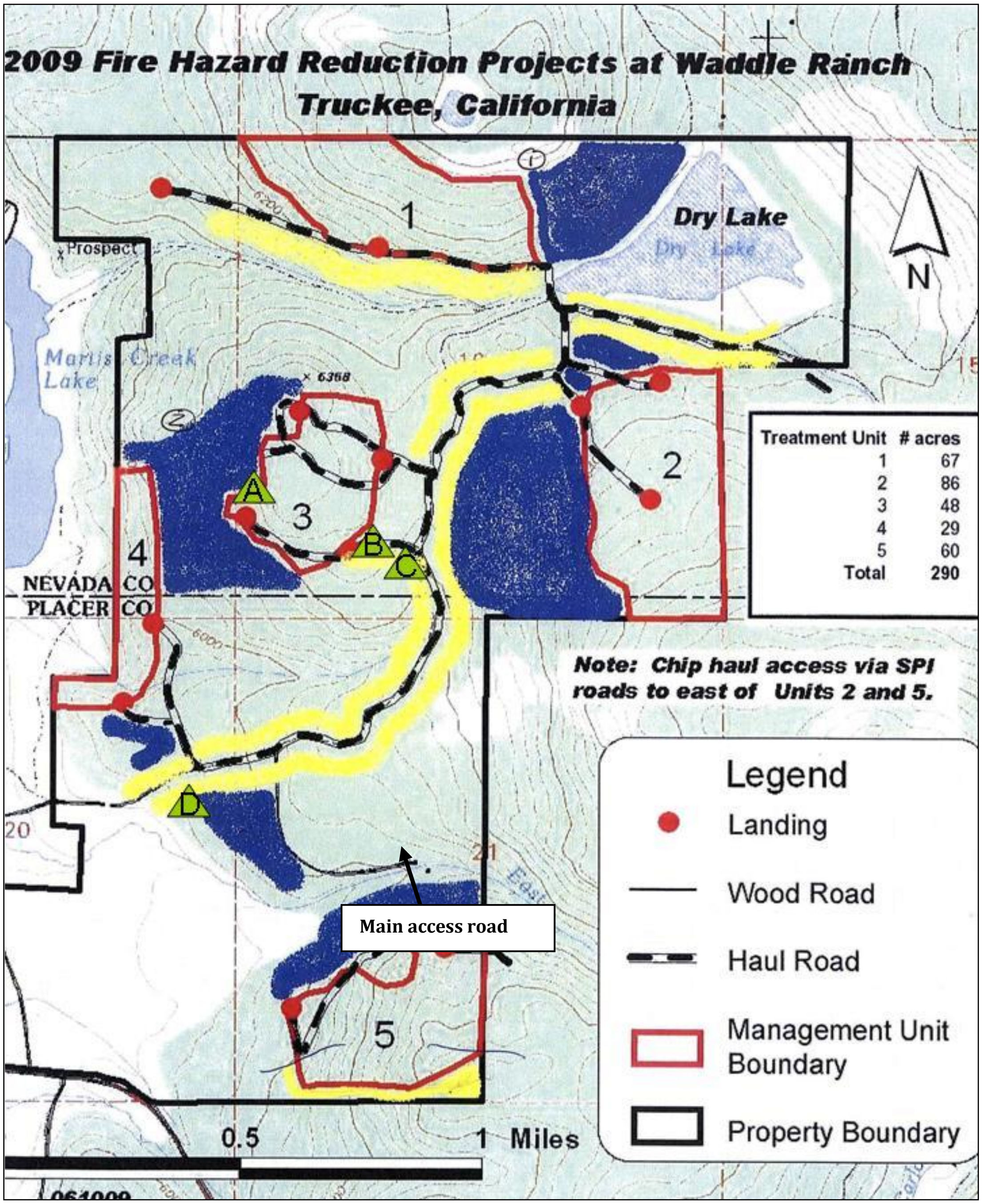


FIGURE 2. MAP SHOWING LOCATIONS OF ALL 2009 WADDLE RANCH LOGGING UNITS, INCLUDING UNITS 3 AND 4. THE MONITORING PLOTS ARE MARKED WITH GREEN TRIANGLES. A=UNIT 3 LANDING, B=UNIT 3 HAUL ROAD, C=UNIT 3 15 YEAR PLOT, D=UNIT 4 CONTROL LOGGING PLOT.

UNIT 3 PLOTS (15 YEAR PLOT, HAUL ROAD, AND LANDING PLOTS)

Three plots with different management uses and disturbances were chosen at Unit 3: the 15 year plot, haul road, and landing (See Figure 3 through 8). Before logging, all Unit 3 plots were dominated by mature native shrubs and surrounded by dense forest.

15 YEAR PLOT

The 15 year plot was disturbed during prior logging (either 1994 or 1995) and may have served as a turn-around or landing during that time. Disturbance did not occur in 2009 in the 15 year plot and restoration treatments will not be implemented. This plot served as a comparison for the haul road and landing, which were both used during prior logging operations (either 1994 or 1995) and during the 2009 operations. The 15 year plot, which is south-facing gently sloped (less than 15%), is dominated by mature native shrubs and is surrounded by dense forest. The access road runs along one side of the plot (Plot C in Figure 2). This plot was only monitored before logging, since it was not disturbed during logging operations.

HAUL ROAD AND LANDING

The haul road and landing plots were disturbed during prior logging (either 1994 or 1995). These plots were subsequently disturbed during logging in 2009. Mitigation treatment was implemented after monitoring in 2009.The haul road and landing plots were chosen for their high level of disturbance in 2009 as they represent the maximum expected level of impact. Both the haul road and landing were chosen to determine whether or how the type of use affects erosion and other soil parameters as well as the existing vegetation. The haul road is south-facing and gently sloped (less than 15%), while the landing is relatively flat. Both plots were dominated by mature native shrubs and surrounded by dense forest before logging. The haul road spurs off of the main access road (Plot B in Figure 2), while the landing is several hundred feet uphill of the access road along the haul road (Plot A in Figure 2).The haul road and landing were monitored before and after logging.

FIGURE 3. 15 YEAR PLOT FROM THE ACCESS ROAD.

FIGURE 4. 15 YEAR PLOT LOOKING TOWARD THE ACCESS ROAD.

FIGURE 5. HAUL ROAD PLOT BEFORE LOGGING.

FIGURE 6. HAUL ROAD PLOT AFTER LOGGING.

FIGURE 7. LANDING PHOTO POINT BEFORE LOGGING.

FIGURE 8. LANDING PHOTO POINT AFTER LOGGING.

UNIT 4 PLOT (CONTROL LOGGING PLOT)

The Unit 4 plot, which contained legacy logging impacts most likely from the 1950s, is located along the main access road, near the Unit 4 haul road (Plot D in Figure 2) intersection. This plot was not disturbed during logging in 2009 and mitigation treatment was not conducted (Figure 9). The control logging plot appears less disturbed than the 15 year plot in Unit 3, most likely because logging did not occur as recently at this plot. It contains mature trees, deep litter, and rich, dark soil compared the Unit 3 plots. The Unit 4 plot is south-facing and gently sloped (15%) with sparse mature trees and few shrubs or forbs. This plot was only monitored before logging, since it was not disturbed during 2009 logging.

FIGURE 9. CONTROL LOGGING PLOT.

KEY RESULTS

COMPARING RELATIVE CHANGES:

When assessing impacts from logging, fuels thinning and other forest activities, we are attempting to look at the overall change in functional condition from pre to post logging or treatment activity. In this way, we will be able to indicate whether treatments can potentially affect water quality in the short and long term. Further, where a TMDL exists and improvement is required, this relative change will be key to understanding whether logging activities can help meet the TMDL mandates.

The following section summarizes key results. The Results and Data section below provides additional detail that supports these findings.

ROADS

SEDIMENT: Sediment was clearly lowest in the control plot (129 lb/ac/in). The 15 year plot sediment yield was an order of magnitude higher than the control (1325 lb/ac/in), suggesting that unmitigated impacts from logging can continue to impact soil and runoff quality for many years. The stabilized haul road, pre logging, produced approximately twice as much sediment as the 15 year plot and 20 times more than the control (2817 lb/ac/in). Following logging, the haul road increased sediment output by an order of magnitude (26,193 lb/ac/in).

COMPACTION/DEPTH TO REFUSAL: All areas exhibited higher than 'native' compaction as measured by a cone penetrometer. This condition suggests that soils do not fully recover within a 60 year time window, from impacts. The control plot had an average depth to refusal (DTR) of 4", though the site exhibited a great deal of variability. Unit 3 haul road had almost 3" DTR and the 15 year plot had almost 2”. Again, all areas exhibited a great deal of variability, suggesting localized influence of biological factors such as vegetation and perhaps ground disturbing rodents and other animals. Common DTRs in native and restored sites can be as high as 24”.

Coincidentally, a great deal of dust was noted after road grading by all traffic using the road. That dust represents medium to fine soil particles which are most easily moved by water as well as wind, thus create a source for both water and wind erosion.

COVER: The control plot had the highest total cover, with 100 percent total, of which 8% was made up of shrub and other cover. Note that the control plot also had a 70%+ canopy cover to total *plant* cover which was quite high. The 100% mulch cover likely contributed to the low sediment yield from the control site. The 15 year plot had a high level of total cover as well at approximately 93%. The shrub component made up 47% of that cover. The 15 year plot had a small percentage of bare ground (+/-5%). The haul road had approximately 85% total cover of which 17% was made up of vegetation.

Following logging, the haul road decreased total cover to less than 10% with approximately 93% bare ground, suggesting a potential large increase in sediment and linking to the sediment yield data shown above.

NUTRIENTS: Nutrients, especially organic matter and nitrogen, indicate the soil capital. That capital drives a number of processes in the soil and while alone, it isn’t sufficient to define ‘resilience’, adequate capital is foundational for other recover processes to occur. Thus, understanding nutrients in the soil is key for understanding whether a site will recover rapidly.

The Control clearly contained a greater amount of nutrients with total organic matter of approximately 6%, which is within the range of native values derived from other research around the Tahoe and Truckee region. The 15 year plot and the haul road were similar at slightly over 4%. Total N followed the same pattern with the control at over 1400 ppm and the other sites ranging from between 600 to 800 ppm. These data suggest that the site that has been recovering from logging 60 years ago is reaching a similar nutrient status as many native sites in the region.[3]

ROADS SUMMARY: This simple, first year study shows a clear pattern of residual effects of legacy impacts and suggests a recovery trajectory. Cleary, nutrients have recovered in the 60 year control plots to something similar to a native area. However, compaction has not fully recovered in any of the sites, even after 60 years, despite vegetation cover that would seem to indicate that some recovery had occurred. These findings are similar to other observations from around the Lake Tahoe-Truckee region where legacy logging roads that are covered by native shrubs still exhibit high rates of compaction. This condition is reflected in the runoff and sediment yield values which are highest in the recently disturbed and become less the older the disturbance. The control site did not demonstrate a large amount of runoff. However, it is also clear that since the soil is higher density, pore space will be less and runoff will occur sooner in spring runoff and extended rainfall conditions on the control (60 year) site.

[3] Claassen, V.P. and M.P. Hogan. 2002. Soil Nutrients Associated with Revegetation of Disturbed Sites in the Lake Tahoe Basin. *Restoration Ecology* 10, no. 2: 195-203.

LANDINGS

Landings are not typically regarded as major sources of sediment. However, give their large size and tendency toward high compaction, they have the potential to capture and route water to nearby roads and drainages. This is the case in a number of locations at Waddle Ranch. Typically, landings are not treated after use due to the belief that they will be used again in a future logging operation. They have become 'sacrifice' areas and been overlooked as sources of sediment. However, landings have been observed to be sources at Waddle Ranch and several other nearby locations. We have begun monitoring these landings in an attempt to determine their sediment and runoff contribution as well as their propensity for self repair. We have laid out a number of potential low cost mitigations that we intend to apply at Waddle Ranch and measure the soil and water quality response to those treatments.

SEDIMENT YIELD AND RUNOFF: Sediment yield and runoff were not measured during this first season given the low angle nature of the landings. Techniques developed in 2010 will allow us to compare infiltration rates on the various treatments on landings in 2011, which will provide important management information for treatment of future landings.

COMPACTION: compaction on the unit 3 landing was quite high both before and after logging operations. Depth to refusal (DTR) was less than 2 inches and was twice as compacted as the control plot. An interesting note is that post logging, DTR increased slightly to 2 inches. This condition is observed frequently when a compacted area is impacted by heavy equipment. The disturbance from lugged tires and grousered tracks loosen up the top of the soil. Unfortunately, this loosened soil overlays highly compacted material and when runoff occurs, it tends to carry the newly loosened material to nearby roads, drainageways and creeks. When this material is deposited, is also creates sediment dams that result in additional cutting, and erosion, thus starting a 'domino effect' in the watershed.

One of the purposes of this monitoring and research is to determine methods of redeveloping soil and hydrologic function in landings so that in the 15-60 year return period, those landings can be stabilized and not continue to be a source of sediment.

COVER: the unit 3 landing exhibited similar trends to the haul road. The landing has approximately 85% total cover before use with 30% of that made up of vegetation. Post logging, the landing had over 90% bare ground with no vegetation remaining. The small amount of cover (<10%) was made up of residual mulch.

NUTRIENTS: the unit 3 landing contained about 3.5% organic matter, which is on the low end of the range of native sites. Total N measured approximately 600 ppm, which is on the very low end of 'normal' and suggests that N fixing shrubs would likely colonize the site. This is what we observe, with ceanothus and bitterbrush the dominant shrubs on site. These data suggest that the landings may be slightly nutrient limited for resilience.

LEGACY IMPACTS

Initial testing clearly suggests that legacy impacts (old logging roads, skid trails and landings) continue to remain relatively compacted despite the increasing vegetation on those sites. Soils that are compacted remain in that state for a long period of time with some lessening of soil density occurring but not enough in some cases to return the site to original levels of infiltration or productivity. This information can form the foundation of managing 'invisible' impacts in watersheds where most of the perceived threats to water quality are thought to be from recent, visible impacts. Understanding legacy impacts will be key to understanding whole watershed response to runoff forces and will also help make informed management decisions as to how much and what type of impacts a watershed can withstand without causing unacceptable downstream water quality impacts.

VEGETATION RESPONSE AND IMPACTS

Baseline monitoring results suggest that vegetation can return to areas that are impacted by previous management activities but that vegetation may not be highly accurate indicators of watershed hydrologic function.

UNDERSTANDING THE LIMITING COMPONENTS

These data have been collected in order to determine whether a range of sites, once damaged, can spontaneously return to a condition that is highly functional and protects water quality and which variables are 'limiting'. Initial assessment suggests that clearly, even in 60 year old sites, full function has not been restored. Especially in landings and logging roads, high compaction, low vegetation and accelerated erosion is clearly seen. Data shows that while some variables such as nutrients may be adequate, compaction still remains and runoff is higher than background in most sites.

These findings set the stage for implementing mitigation measures in order to determine how to replace that function so that water quality is protected, soil function is rebuilt and vegetation growth can be accelerated. Ultimately, we seek to integrate the pieces of the system back to 'whole cloth' or full function. In this way, system such as this one can regain maximum resiliency and can withstand natural disturbance regimes and flourish.

RESULTS AND DATA

Summary data is presented in the previous sections. We have kept the presentation of data relatively short and to the point in order to clarify the findings and to point out next steps needed to complete the development of watershed assessment and vegetation management for erosion protection handbooks. Below, we include graphs which present the data in an easy to understand format.

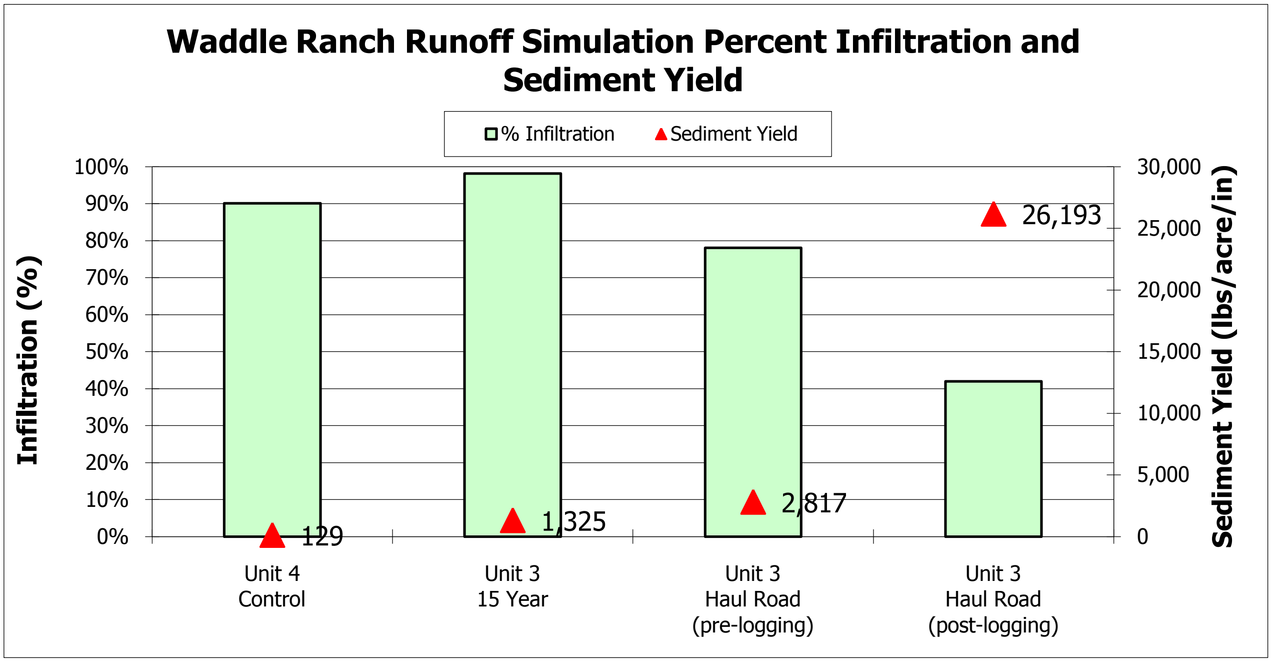


FIGURE 10. WADDLE RANCH RUNOFF SIMULATION PERCENT INFILTRATION AND SEDIMENT YIELD. SEDIMENT YIELD WAS LOWEST AT THE CONTROL LOGGING PLOT, 129 LBS/ACRE/IN AND HIGHEST AT THE HAUL ROAD AFTER LOGGING (26,193 LBS/ACRE/IN).

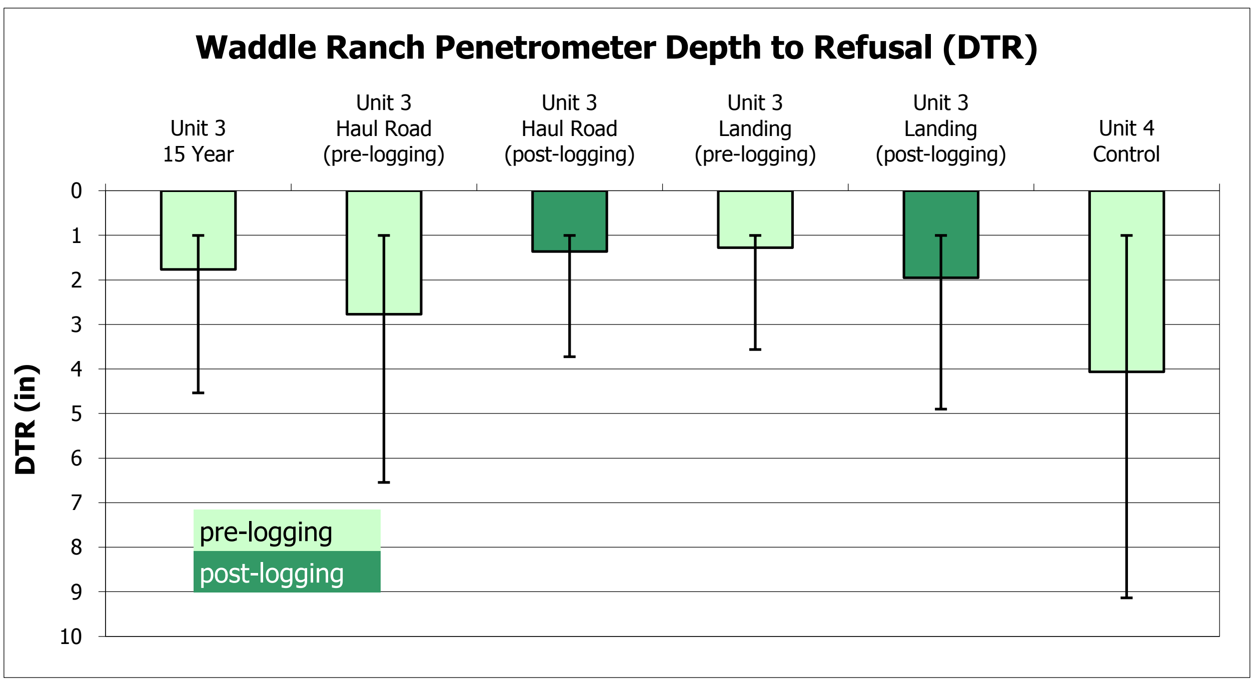


FIGURE 11. WADDLE RANCH PENETROMETER DEPTH TO REFUSAL (DTR). PENETROMETER DTRS WERE BELOW 3 INCHES FOR ALL THE UNIT 3 PLOTS, WHILE THE DTR FOR THE CONTROL LOGGING PLOT WAS 4 INCHES. DTRS DID NOT CONSISTENTLY DECREASE OR INCREASE AFTER LOGGING.

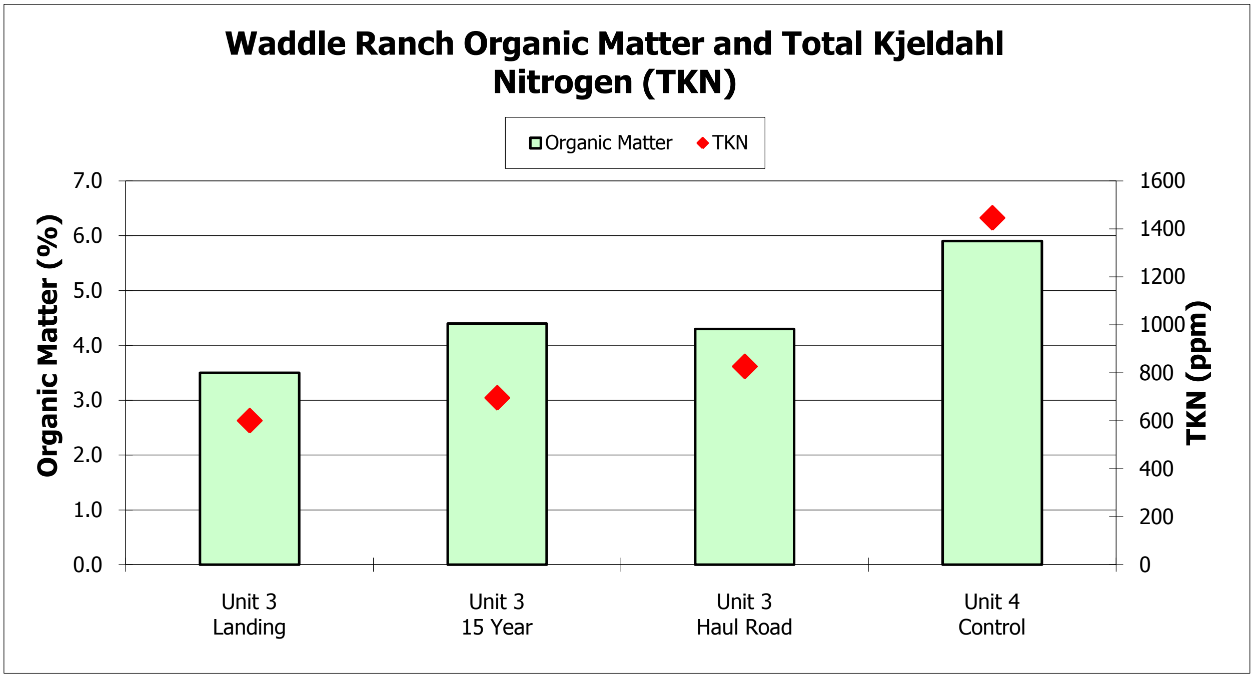


FIGURE 12. WADDLE RANCH ORGANIC MATTER AND TOTAL KJELDAHL NITROGEN (TKN). BOTH ORGANIC MATTER AND TKN WERE HIGHER AT THE CONTROL PLOT (5.9% AND 1,446 PPM) COMPARED TO THE PLOTS WITH HISTORICAL LOGGING DISTURBANCE (3.5-4.3% AND 600-826 PPM).

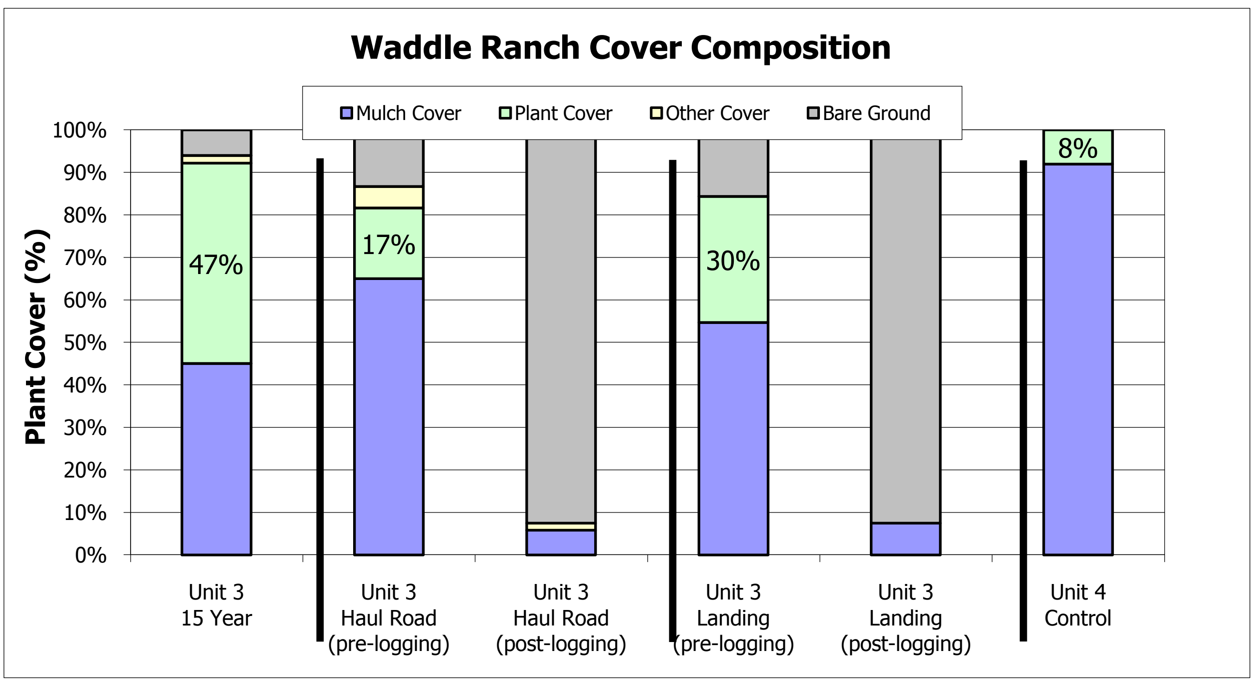


FIGURE 13. WADDLE RANCH COVER COMPOSITION. AFTER LOGGING, PLANT COVER COMPOSITION DECREASED FROM 17 TO 30% TO ZERO AT THE HAUL ROAD AND THE LANDING, WHILE BARE SOIL INCREASED FROM UNDER 20% TO GREATER THAN 90%.

METHODS

Monitoring methods implemented at Waddle Ranch included: soil compaction testing with a cone penetrometer, cover point monitoring for vegetation and total soil cover, soil nutrient sampling, and runoff simulation (to determine soil infiltration rates and sediment production). Combined, these methods provide insight into general conditions in the soil, soil erosion potential and vegetation conditions in each plot.

RUNOFF SIMULATION

Runoff simulation is used to determine soil infiltration rates and sediment yields and was conducted at the Unit 3 haul road before and after logging. It was also conducted at the 15 year plot before logging only, as this plot was not disturbed during logging and was not expected to change. Runoff simulation was not possible at the Unit 3 landing because of its flat nature. Runoff simulation was also conducted at the control logging plot at Unit 4 before logging. It was not conducted after logging for the same reasons as the 15 year plot in Unit 3.

The runoff simulator consists of a PVC pipe water manifold and a collection frame (Figure 14). An even flow of water across the entire width of the manifold is produced. The rate of water applied ranges from 1 to 2 L/min, depending on plot slope. A collection trough is installed 2 meters down slope from the runoff pipe and all runoff, including sediment, is collected. The steady state infiltration rate is calculated and the collected samples are analyzed for sediment.

SOIL NUTRIENT SAMPLING

Soil samples were collected at each plot before logging to determine nutrient composition, which is an indicator of soil resilience. Soil nutrient composition was not expected to change as a result of the logging. Subsequent samples, originally intended to be collected in 2010, were designed to test this assumption.

Three soil sub-samples were collected at each plot from the mineral soil beneath any mulch layer to a depth of 12 inches (30 cm; Figure 15). These sub-samples were combined and sieved to remove any material larger than 0.08 inches (2 mm) in diameter, and sent to A&L Laboratories in Modesto, California for total Kjeldahl nitrogen (TKN) and organic matter analysis. Total Kjeldahl nitrogen (TKN) is a measure of readily available nitrogen. Total Kjeldahl nitrogen and organic matter were used as indicators of soil function in this study.

FIGURE 14. THE RUNOFF SIMULATOR AND PLOT. THE WATER DISPERSER IS AT THE TOP OF THE PHOTO AND THE COLLECTION FRAME IS AT THE BOTTOM.

FIGURE 15. SOIL SAMPLE COLLECTION.

TOTAL COVER

Total cover is measured to determine total soil cover composition (including bare, plant, mulch, and 'other' cover which includes, gravel, rocks, and logs. Since surface cover plays an important role in water flow and sediment movement, cover composition can indicate whether there is a potential for erosion. Plots with higher proportions of bare soil tend to be more prone to erosion.

Total cover was measured at all of the plots before logging and at the haul road and landing after logging. Cover was not expected to change at the 15 year plot or the control logging plot; therefore it was not measured after logging at either of these plots.

Total cover is measured using a statistically based cover point method along randomly located transects.[4] The cover pointer consists of a metal rod with a laser pointer mounted 3.3 feet (1 m) above the ground surface. After the rod is leveled in all directions, the button on the laser pointer is depressed and the cover measurements are recorded below the 1 meter level (Figures 16 and 17). The first item hit is recorded, whether it be in the overstory or understory below the 1 meter level. The first hit is placed into one of four categories: plant, litter/mulch, bare, or other (includes gravel, rocks, and logs). Tree canopy cover is not included in this measurement.

[4] Hogan, M. 2003. Luther Pass Monitoring Report: Plant and Soil Cover Monitoring for Evaluating Sediment Source Control Success in the Lake Tahoe Basin. Lahontan Regional Water Quality Control Board, South Lake Tahoe, CA.

FIGURE 16. COVER POINTER IN USE ALONG TRANSECTS.

FIGURE 17. COVER POINTER ROD WITH HIT BY THE LASER POINTER. THE LASER POINTER HIT IS CIRCLED IN RED.

CONE PENETROMETER

Penetrometer depth to refusal (DTR) is an index for soil density. Soil density can be used to assess a plot's potential for erosion. Plots with shallow DTRs may be more likely to erode.

Cone penetrometer measurements were taken at all of the plots before logging. Penetrometer DTR was not expected to change at the plots that were not disturbed by the logging (the 15 year plot in Unit 3 and the control logging plot in Unit 4), so further measurements were not conducted. Measurements were taken after logging at the Unit 3 haul road and landing.

Penetrometer depth to refusal and soil moisture were measured along the same transects as the cover point data for each plot. All penetrometer measurements were taken at a soil moisture of less than 6%, which is typical of the dry, summer conditions in the area. To take a measurement, the cone penetrometer with a ½ inch diameter tip is pushed straight down into the soil until a maximum pressure of 350 pounds per square inch (2,413 kPa) is reached (Figures 18 and 19). At this pressure, the depth to refusal is read.

FIGURE 18. A CONE PENETROMETER DIAL, SHOWING PRESSURE APPLIED IN POUNDS PER SQUARE INCH.

FIGURE19. CONDUCTING CONE PENETROMETER MEASUREMENTS ALONG TRANSECTS.

NEXT STEPS

MONITOR MITIGATIONS

The development and identification of cost effective mitigation measures is crucial for water quality protection where unacceptable impacts are identified. We have begun mitigation implementation on some areas and have a number of additional mitigations defined. Monitoring of existing mitigation measures is the first step in this foundational development.

DEVELOP ADDITIONAL MITIGATION MEASURES FROM MONITORING DATA

Once initial monitoring of existing mitigation measures is completed, additional mitigation implementation will be completed. These measures will be based on data from mitigations and from input from technical advisory group members.

MONITOR OTHER TREATMENTS INSTALLED IN 2009

Additional treatments designed to treat road runoff, alter road drainage and answer other management questions, were installed in 2009. These treatments need to be monitored for effectiveness so that they can be developed into management tools and improved upon where indicated. Some of these tools may be critical management tools for roads and other types of disturbances.

INTEGRATE ALL TREATMENTS (PER 2010 WORKPLAN)

The 2010 work plan outlined the whole-watershed integration of all treatments. This integration will allow whole understanding of how each treatment links thought the watershed. While each treatment is monitoring separately, most are designed to integrate to one or more other treatments. For instance, there are a number of landing treatments that are designed to be linked with road treatments and would be monitoring for combined effectiveness.

IDENTIFY MONITORING TOOLS FOR HANDBOOK

Specific cost-effective monitoring tools need to be identified and described for the watershed and forestry handbooks. We will use existing tools and test some additional ones, such as the constant head permeameter and mini disc infiltrometers for their effectiveness in answering specific impact questions.

IDENTIFY TREATMENT AND MITIGATION MEASURES FOR HANDBOOK

The treatment and mitigation measures that have been and will be tested are to be developed into specific management tools. These tools are one of the three main pieces of both handbooks. This output of the monitoring work will help us reach our goal of cost-effective forest and watershed management.

SUMMARY-CONCLUSIONS

Logging, vegetation management and fuels reduction projects result in impacts to watersheds and ecosystems. We have little understanding of exactly how those activities impact those watersheds aside from generalized research and commonly accepted assumptions. The Waddle Ranch SEP project is designed to develop a model of watershed management that addresses our need to understand impacts and to use that understanding to more effectively manage those watersheds for sustainability, water quality protection and habitat. This report presents findings from the first year of monitoring and shows that impacts, even impacts from over 50 years ago, still affects watershed condition and function. We show that impact areas can slowly recover but that vegetation alone is not a sufficient indicator of recovery. We also show that new impacts can increase sediment yield by orders of magnitude. This information, linked with future development and monitoring of mitigation measures, can lead to more fully informed and effective watershed management; management that protects water quality while simultaneously providing for forest thinning and catastrophic fire potential reduction.

This SEP program and the monitoring presented in this report is unique in the Tahoe Sierra. These results, when incorporated into the SEP **Watershed Evaluation, Treatment and Monitoring Handbook** and the **Forestry Forest Fuels Treatment/Water Quality Protection Handbook** will assist a range of practitioners to confidently manage their watersheds in a manner that meets regulations and assured that water quality and other beneficial uses are fully protected.

APPENDIX D: EAST MARTIS CREEK WATER QUALITY AND DISCHARGE MONITORING

PHASE I SUMMARY REPORT

WADDLE RANCH/NORTHSTAR
SUPPLEMENTAL ENVIRONMENTAL PROJECT

PREPARED BY KEVIN DRAKE, GERALD ROCKWELL,
MICHAEL HOGAN AND MARK GRISMER

INTEGRATED ENVIRONMENTAL
RESTORATION SERVICES, INC.

APRIL 2011

INTEGRATED ENVIRONMENTAL
RESTORATION SERVICES, INC

COMMON GROUND • UNCOMMON SOLUTIONS

P.O. BOX 7559 • 2780 LAKE FOREST ROAD • TAHOE CITY, CA 96145
OFFICE: 530.581.IERS (4377) • FAX: 530.581.0359

OVERVIEW

IMPORTANCE OF EAST MARTIS CREEK MONITORING

This report describes a new working model of information-rich, cost-effective water quality monitoring and the data and interpretation derived from the application of that approach. The opportunity of continuing the monitoring program at East Martis Creek as part of the Waddle Ranch/Northstar SEP is to demonstrate a model for understanding and effectively managing watersheds, one that is readily transferable and in need throughout our region. East Martis Creek drains a relatively undeveloped watershed in the complex landscape of the Martis Valley. Understanding the responsiveness and loading patterns in the East Martis Creek watershed will offer important insights about development in adjacent watersheds and foundational information for efforts such as TMDL implementation and Martis Dam relicensing. The targeted monitoring approach described in this report is not complicated but it is uncommon, offering a robust and cost-effective compliment to the prevailing compliance-driven mean of monthly means approach.

BLINDED BY COMPLIANCE

Has 40 years of compliance-focused stream water quality monitoring increased our understanding of pollutant loading patterns and enabled us to make better watershed management decisions? The answer is not clear. It is well-established that daily sediment loads – particularly fine sediment particles (FSP<16µm) – are highly dependent on stream flow and runoff. At least 90% of the total annual sediment load in many Sierra streams is transported during the peak snowmelt period (2-4 weeks) and during a small number of isolated summer/fall thunderstorms. Yet, our approach to most compliance-oriented stream monitoring relies on routine weekly sampling, regardless of season or extreme weather events and associated changes in runoff and stream flow. Stream water quality data is further abstracted by averaging weekly "snapshots" over a month and ultimately over a year to produce an average annual concentration (mean of monthly means, or MoMM) for sediment and other pollutants. The MoMM is used to determine compliance with water quality standards but provides little information about how sediment and other pollutants move through our watersheds and how management actions might alter these patterns.

This is akin to a security guard routinely visiting a building every weekday at 10AM, not recognizing the fact that the past two burglaries occurred on weekend evenings. Despite this knowledge, the security guard is able to report that he has not observed unusual activity on his shift.

GO WITH THE FLOW: A TARGETED APPROACH

Integrated Environmental Restoration Services, Inc. (IERS) developed and implemented a **targeted, flow-based** in-stream water quality and discharge monitoring program on East Martis Creek as part of the Waddle Ranch/Northstar Watershed Improvement Project, a Supplemental Environmental Project (SEP) being implemented at Waddle Ranch. This project is intended to demonstrate a new model for targeted, cost-effective watershed monitoring that provides useful information on which to base watershed management decisions and actions.

ROUTINE VS TARGETED MONITORING APPROACHES

MoMM-type sampling can work well with point sources of pollution such as factory effluent streams that tend to be relatively consistent. However, for highly dynamic stream systems, where in-stream water quality is essentially defined by distributed, non-point sources of water and sediment, this approach does not accurately reflect rapidly changing stream and pollutant conditions. When grab samples are collected on a routine basis at a specified interval year-round, the data will poorly characterize sediment and nutrient concentrations during periods of highest concentration in streams draining small Sierra watersheds. In contrast, when the same number of samples are targeted around periods of high stream flow (e.g. peak spring snowmelt, isolated rain events), the resulting data can be used to accurately compute sediment and nutrient loading. By clustering the same number of samples around peak flow periods and, most importantly, on the <u>rising and falling limbs of daily diurnals during peak snowmelt and rain storms</u>, sediment-discharge rating curves can be produced and used to reliably predict

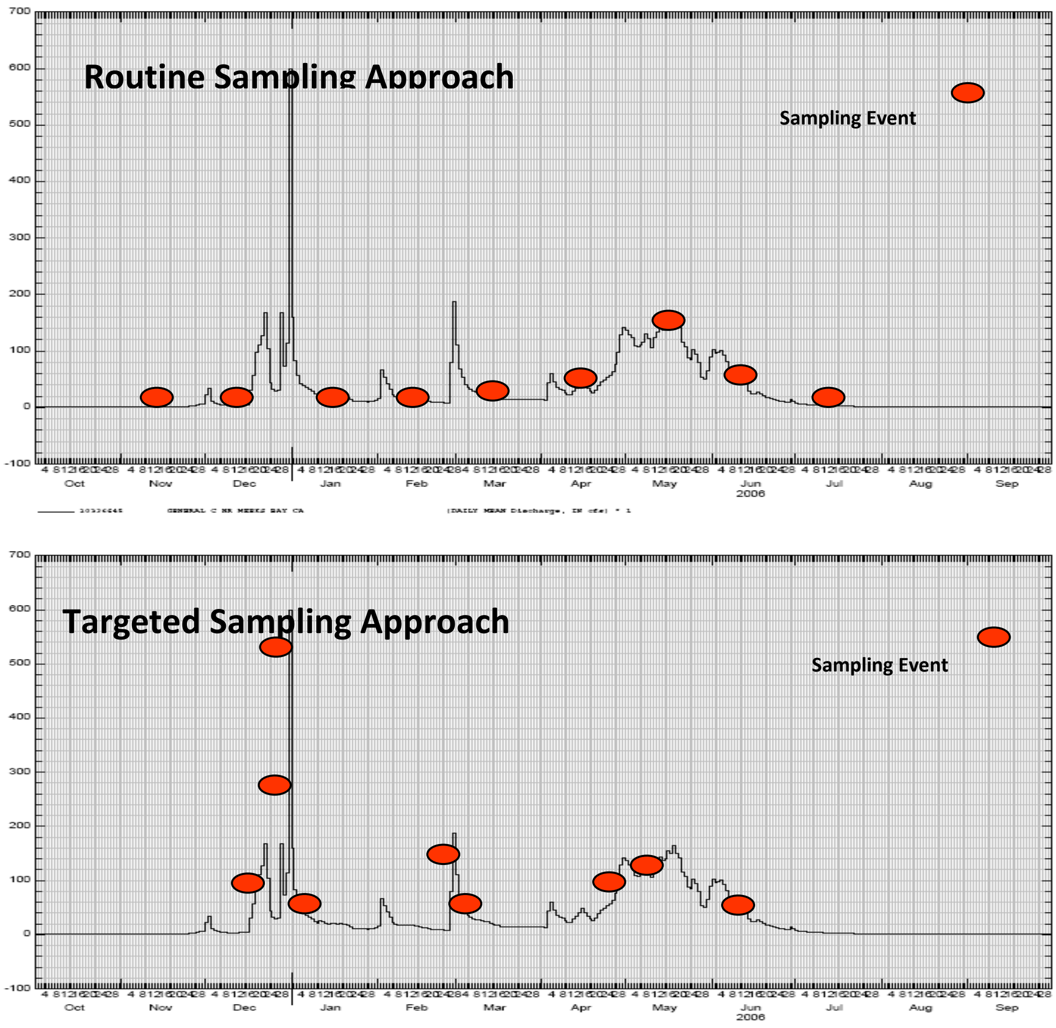


Figure 1. Example hydrographs illustrating two different sampling approaches. Routine sampling approaches (shown in top graph) typically miss spikes in stream flow and sediment concentration, limiting its usefulness for understanding sediment transport patterns in a given watershed. By clustering the same number of samples around peak flow periods (shown in bottom graph) and, most importantly, on the <u>rising and falling limbs of daily diurnals during peak snowmelt and rain storms</u>, sediment-discharge rating curves can be produced and used to reliably predict sediment and nutrient loads as a function of flow rate.

sediment and nutrient loads as a function of flow rate. Moreover, it appears that capturing the flows and loads during the daily rising limb of the hydrograph enables determination of a catchment sediment yield function that can be a signature of the catchments loading characteristics.

MONITORING GOALS AND OBJECTIVES

The goal of this monitoring program is to develop and demonstrate an information-rich and cost-effective approach for improving our understanding of sediment and nutrient loading patterns in the East Martis Creek watershed. Specific objectives to support this goal are:

1. To characterize sediment/ nutrient loading and discharge conditions in the East Martis Creek watershed.
2. To conduct and demonstrate targeted, flow-based grab sampling coupled with continuous flow measurement to define seasonal and event-based sediment/nutrient loading patterns.
3. To develop relationships necessary to develop high-confidence estimates of peak daily and annual loads for sediment and nutrients as a function of discharge.
4. To contribute to ongoing watershed assessment and modeling efforts focused on understanding linkages between upland erosion processes, sediment source control efforts and in-stream sediment loading.

TARGETED SAMPLING APPROACH FOR EAST MARTIS CREEK

In order to develop an accurate understanding of sediment and nutrient loading patterns in East Martis Creek, IERS developed and implemented a targeted, flow-based water quality sampling and discharge monitoring program. A monitoring station (EM50) was established in April 2008 on East Martis Creek near the west end of the Waddle Ranch property (see Waddle Ranch Watershed Assessment Map (Appendix A). A USGS monitoring station on Sagehen Creek was used to help estimate the timing of the peak snowmelt period for East Martis Creek. Grab sampling and discharge measurements were conducted during the snowmelt periods in 2008 and 2009 (see Figure 2). Grab samples were analyzed for TSS, FSP, NO3/NO2, TKN, TN, TP and turbidity. In 2008, discharge was measured using the drift method. In 2009, discharge was measured using a current meter. Sampling and discharge measurement was conducted at EM50 a total of 23 times during the 2008 and 2009 snowmelt periods. Once stream flow receded to base flow levels in mid-June 2009, sampling and discharge monitoring was decreased to monthly intervals. Weather conditions were monitored for storms during this base flow period. One significant rain event (~2.5 inches) occurred on October 13, 2009 and was monitored.

In late June 2009, once funding was in place for the SEP, a pressure transducer was purchased and installed at EM50 to measure continuous stage in East Martis Creek. Unfortunately, continuous stage measurement began after the peak snowmelt period in 2009. Continuous stage measurement and periodic grab sampling/discharge

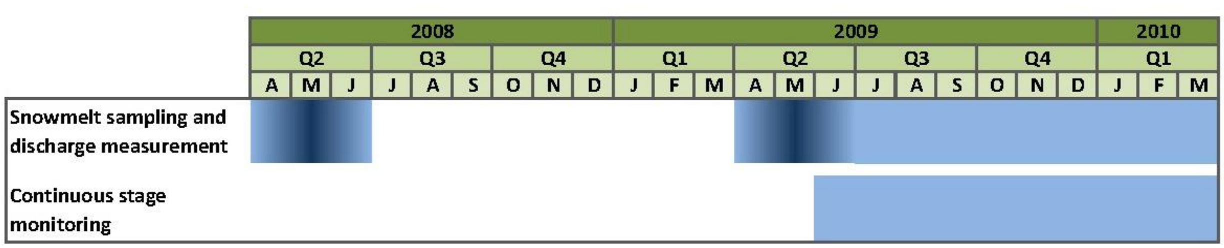


Figure 2. Graphical timeline of East Martis Creek monitoring activities.

measurement was continued until February 2010, at which point all sampling and monitoring was discontinued when the SEP was put on hold. Thus, continuous stage has not yet been measured during the snowmelt period on East Martis Creek.

KEY FINDINGS

OPPORTUNITIES – PAST AND PRESENT

- To our knowledge, this is the first and only set of stream data collected for East Martis Creek.
- We developed a robust, targeted monitoring plan that was not able to be implemented as planned due to a late project start date and premature end date.
- Our region needs a new method and model for water quality monitoring – one that is information-rich, cost-effective, locally demonstrated, and as responsive to weather as our watersheds themselves. Such an approach would dramatically improve our understanding of watershed processes and the effects of restoration and management actions. The SEP still offers that opportunity with East Martis Creek at Waddle Ranch.
- We missed the opportunity to monitor several large rain events in October 2010, which produced more than 22 inches of rain that month (measured at Martis Creek Lake). Summer/fall rain storms represent a large gap in our existing data set for East Martis Creek.
- With above-average snowpack and snow-water content (with more snow on the way), 2011 is likely to result in high-flow conditions that eluded us during the mild snowmelt periods in 2008-2010. The 2011 snowmelt period may provide a rare opportunity to measure the high-flow conditions needed to develop a robust data set and demonstrate the value of a targeted sampling approach.
- Continuing monitoring of East Martis Creek under the SEP is an opportunity to gain a better understanding of a relatively undisturbed sub-watershed within the complex Martis Watershed, which could provide important insights for moving forward with implementation of the Middle Truckee TMDL, Martis Dam relicensing, and other critical regional efforts.

2008-2009 RESULTS

- Mild temperatures produced relatively low flows during the 2008 and 2009 snowmelt periods (peak flow was ~ 8 cfs). Due to the lack of opportunity to take samples/measurements during medium to high flow conditions, we are unable to define reliable relationships between key variables such as sediment-discharge, TSS-turbidity, and turbidity-nutrients.
- The 2.5” rain storm on October 13, 2009 resulted in a spike in sediment and nutrient concentrations. However, with only one storm event sample, we are unable to determine if the data is a reliable characterization of fall rain storms. The spike may be the result of runoff from forest roads, sampling or lab error and additional sampling during such high flows are needed to support these results.
- We have incomplete and unreliable hydrographs for both 2008 and 2009 water years due to the absence of continuous stage data during snowmelt periods (a consequence of a delayed project start date,

premature end date). Complete hydrographs for a minimum of 1-2 snowmelt periods are needed to compute accurate daily or annual sediment loads.

- All of the plotted data indicate that the current data set is inadequate in the medium to high flow range. For example, a plot of turbidity vs TSS has an R^2 value of .71 and a slope of ~2.4, a somewhat larger than typical slope for this relationship (see Figure 4). By removing the October 13 sample from the data set, the R^2 value improves to .81 and the slope decreases to ~1.0, a slightly low value typical of low flows, but not sufficient for determining loading under higher flow conditions (see Figure 5). The other plots show similar improvement in R^2 values when the Oct. 13 sample is removed. This is encouraging and our confidence in these relationships would likely improve with another 1-2 seasons of snowmelt sampling.

- At low flows, nearly 100% of sediment particles are <2 microns, similar to other streams. However, for the October 13 storm event, the <20 micron fraction (~45%) is larger than what has been measured at Homewood. Additional sampling at high flows would help to further distinguish differences between other Martis Valley and Tahoe Basin watersheds (Figure 8).

RECOMMENDED NEXT STEPS

TARGETED SNOWMELT MONITORING FOR 1-2 YEARS: Install pressure transducer and turbidimeter at EM50, resume targeted grab sampling for TSS and particle size distribution, and collection of discharge measurements for 1-2 additional snowmelt periods. This would enable accurate characterization of sediment loading and discharge patterns and subsequent calculation of peak daily and annual sediment loads.

ESTABLISH BASELINE FOR EAST MARTIS CREEK: Continuation of targeted monitoring for 1-2 snowmelt periods will provide a baseline for this watershed that can be used to adequately assess its condition and restoration potential relative to other watersheds. Further, it will provide a much-needed baseline for understanding the impacts of any future restoration, forest management or development in the watershed.

SUPPORT TECHNOLOGY TRANSFER: Waddle Ranch demonstrates a new model of watershed management that includes targeted, flow-based water quality monitoring. Supporting the SEP **Watershed Evaluation, Treatment and Monitoring Handbook** will provide a platform for sharing this watershed management and monitoring approach with other watershed managers throughout the region.

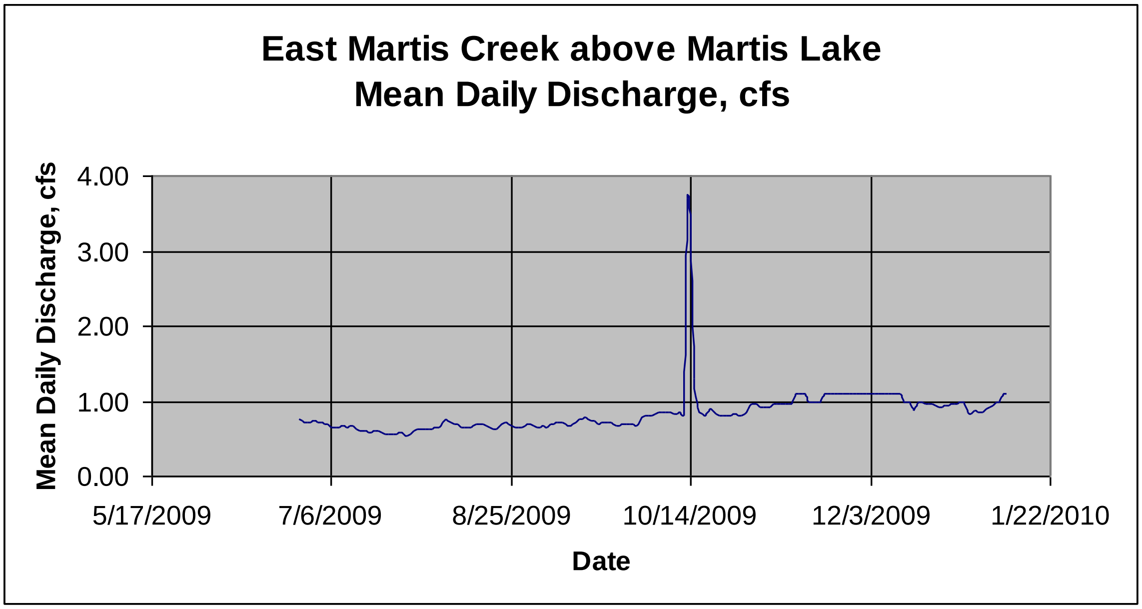


Figure 3. Mean daily discharge for East Martis Creek. Continuous stage measurement began in late June 2009, after the peak snowmelt period, and was discontinued prior to the 2010 snowmelt period.

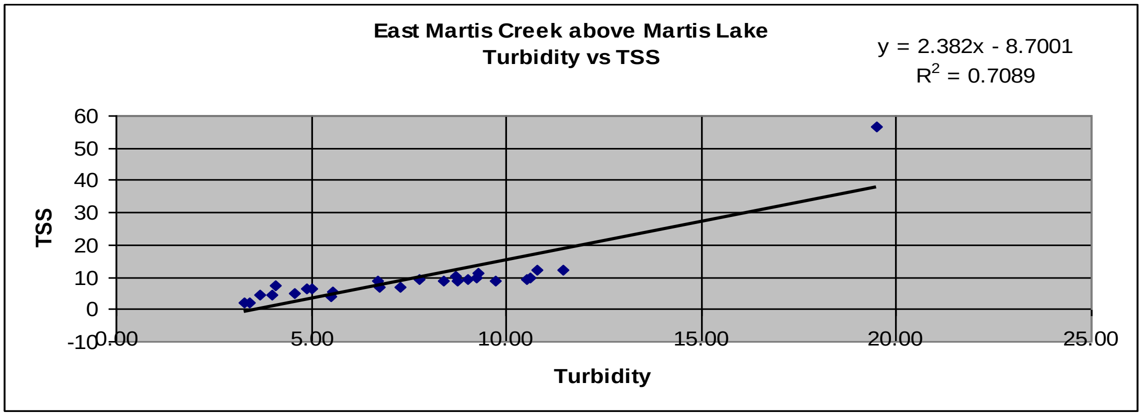


Figure 4. Turbidity-TSS relationship for East Martis Creek. This graph includes the single rain storm measurement from 10/13/09.

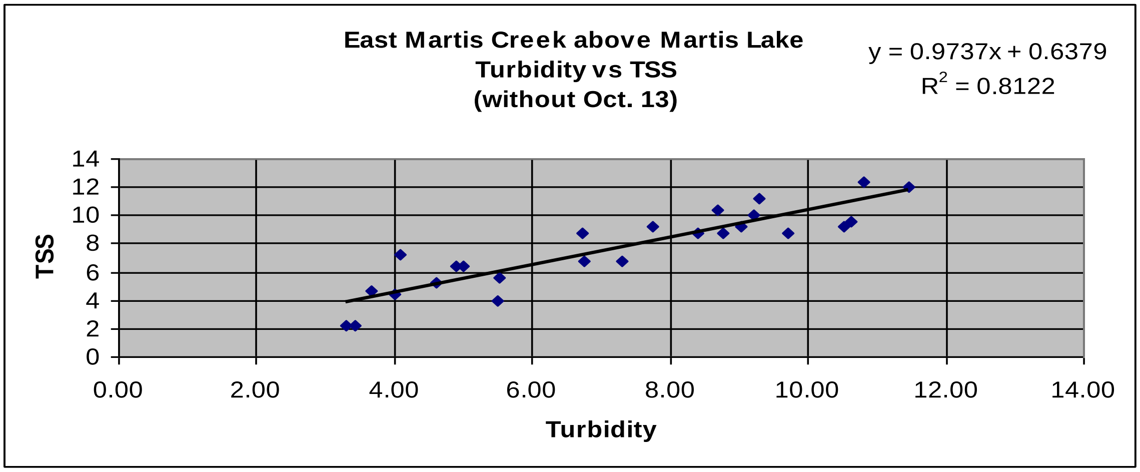


Figure 5. Turbidity-TSS relationship for East Martis Creek (without the 10/13/09 rain storm measurement). With the 10/13/09 data point removed, the R^2 from 0.71 to 0.81.

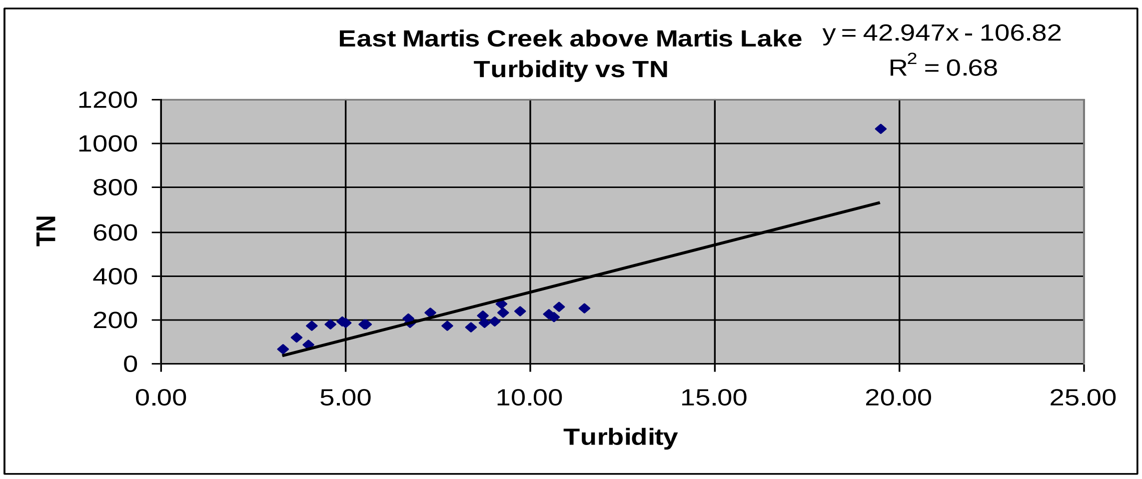


Figure 6. Turbidity-TN relationship for East Martis Creek. Confidence in this relationship is low due to the lack of measurements at medium and high flow.

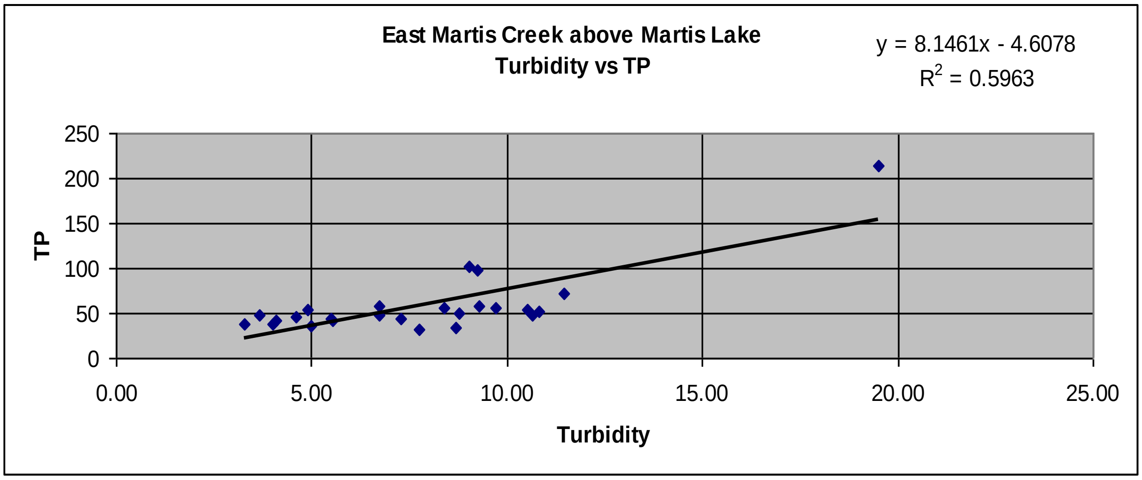


Figure 7. Turbidity-TP relationship for East Martis Creek. Confidence in this relationship is low due to the lack of measurements at medium and high flow.

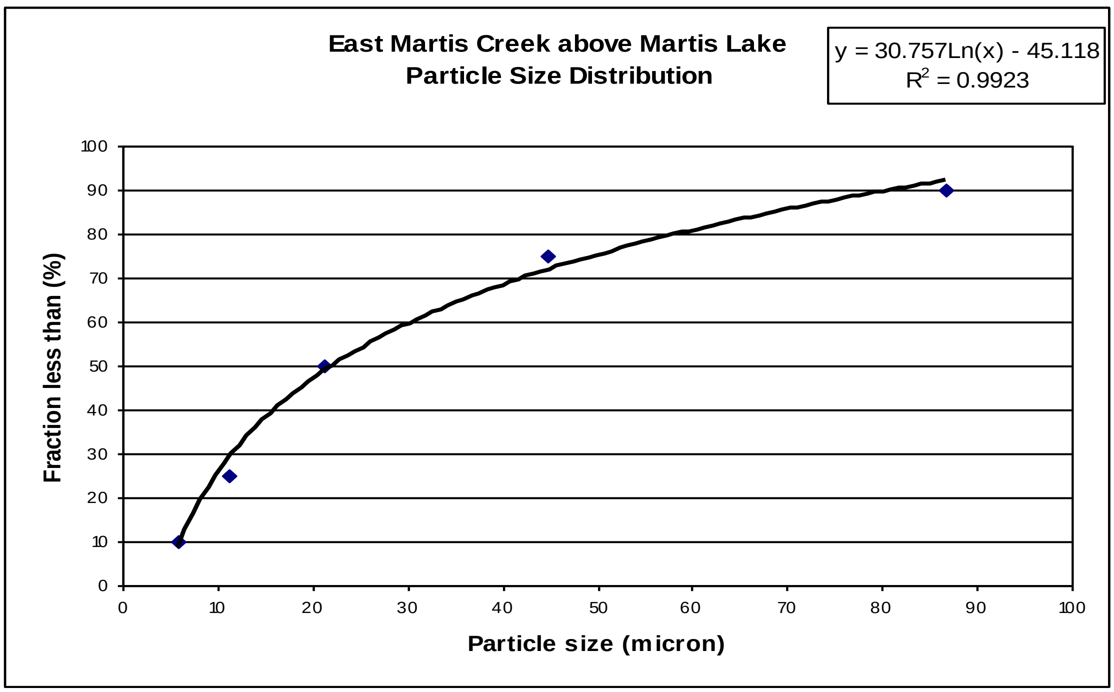


Figure 8. Suspended sediment particle-size distribution during high flow measurement on Oct. 13, 2009 at East Martis Cr.

WADDLE RANCH TEST PLOT SUMMARY

PURPOSE AND OVERVIEW OF TEST PLOTS

Testing assumptions is an essential part of the adaptive management process. The purpose of implementing test plots is to evaluate the site-specific performance and cost-effectiveness of various treatment approaches prior to large-scale implementation. Five treatment test plots were implemented at Waddle Ranch in 2009. All of these sites had been recently or historically impacted by road development and logging operations. Follow up (performance) monitoring at each of these test areas will provide a basis for selecting, implementing and testing other mitigation treatments at other priority erosion problem areas at Waddle Ranch. Further, it will provide much-needed data and a basis for developing treatment tools for mitigating the ongoing soil and water quality impacts of forest management and fuels reduction treatments throughout the region. Table 2 summarizes the test questions, intended outcomes and outputs, and management implications for each of these test plots. Detailed as-built reports for each treatment test site can be found in Appendix 5.

Table 1. Waddle Ranch test plot summary matrix.

Project	Test Questions	Outcomes	Outputs	Management Implications
Landing A	What are the functional differences between vegetated legacy landings and relatively undisturbed areas?	Increased understanding of infiltration and plant response differences between compacted landings and untreated areas	Data that describes function	increased understanding of potential impacts and mitigation needs/actions
	Can infiltration on a vegetated legacy landing be implemented such that vegetation is mostly retained but infiltration is returned to a near undisturbed condition?	Increased ability to effectively target restoration treatments on legacy landings	Data that describes differences between disturbed, undisturbed and mitigated/treated conditions	challenges our assumptions about watershed impacts
Beacon Road Meadow	Can infrequently used road beds be stabilized to reduce erosion under non-critical rainfall situations?	Expanded ability to stabilize infrequently used dirt roads	Cost, sediment and longevity data for road treatments	Develops the understanding of road runoff implications; allows targeted treatment linked to expected or measured benefits
	Can infiltration be reestablished to native conditions on a legacy landing that has been well colonized by native vegetation?	Increased understanding of techniques to reestablish hydrologic and soil function on legacy vegetated landing	Infiltration and sediment data on 6 treatment types for legacy landings	
	Can rust resistant sugar pine seedlings be used to reestablish white pines on treated legacy landings?	Understanding of ability of rust resistant sugar pine seedlings to withstand transplant and ultimately become established in rehabilitated soil	Survival and growth data for rust resistant sugar pine seedlings	

Project	Test Questions	Outcomes	Outputs	Management Implications
Unit 3 Landing C	Which technique, tilling vs. ripping, is more effective, less costly, to reestablish infiltration, plant growth?	Increased understanding of cost-effectiveness of ripping and tilling for soil function restoration	Infiltration and plant growth data for legacy landing treatments	Develops management tools for legacy impacts, cost-effectiveness data to support treatments; identifies new landing treatment tools
	Does seeding on a treated legacy landing increase veg cover and infiltration?	Increased understanding of seeding response for vegetation cover establishment on legacy landing	Vegetation cover data for seeded vs. unseeded area by species	
	Will surface mulch reduce erosion, accelerate veg establishment?	Increased understanding of cost-effectiveness of mulch only treatment as legacy landing mitigation	Infiltration and sediment data on mulch only treatment	
Unit 3 Haul Road	Can a 3" layer of wood chip mulch on a compacted road surface reduce mulch significantly?	Increased understanding of road protection treatments for post logging road surfaces	Sediment data for three road surface treatments compared to no treatment	Identifies a range of road treatments for infrequently used roads that need to be kept open but that continue to produce sediment
	Can tilling wood chips into the road surface, seeding and mulching reduce erosion, help establish vegetation and still allow some infrequent use?	Increased understanding of 'temporary' (2-25 yr window) dirt road stabilization methods as they relate to erosion, sediment delivery and water quality	Vegetation response data for those treatments	Managers assume that infrequently used roads must be kept 'open' and bare. This will allow us to determine whether that is the case and to what extend a road can be treated to maintain full access. This is a common situation throughout the west
	Can a 1" layer of asphalt grindings reduce erosion and dust on an infrequently used dirt road?			
Road Infiltration Basin	Can a specific rolling dip configuration withstand irregular traffic and what maintenance schedule is required to maintain effectiveness?	Increased understanding of a relatively new technology in terms of road surface maintenance	Assessment of road condition; length of upslope rilling; length if any, of downslope rilling	Identifies the level of function of rolling dips for diversion of water linked to infiltration LID-type installation
	Can water diverted from a dirt road be infiltrated and treated by a vegetated infiltration basin?	Increased understanding of water quality protection capacity of this rolling dip-in	Assessment of sediment capture in infiltration area	

RECOMMENDED NEXT STEPS

IDENTIFY LANDINGS USING AERIAL IMAGERY: GENERATE A HYDROLOGY MODEL THAT WILL ESTIMATE RESERVOIR CAPACITY OF TREATED LANDINGS ACROSS A LOGGED LANDSCAPE.

MONITOR EXISTING TREATMENT TEST AREAS: Conduct post-treatment performance monitoring at the five test sites implemented in 2009.

IDENTIFY ADDITIONAL MITIGATION TREATMENTS TO BE TESTED: Use results of monitoring 2009 treatments to identify other mitigation treatments to be tested (in collaboration with agency personnel and forestry practitioners)

IMPLEMENT TREATMENT TESTS AT ADDITIONAL SITES: Prioritize and select additional mitigation treatments to be implemented and monitored at Waddle Ranch.

DEVELOP MITIGATION TOOLS BASED ON MONITORING RESULTS: Use monitoring results from existing treatment test areas to develop draft mitigation treatment tools to address the soil and water quality impacts of forestry operations. Include these tools in the Forest Fuels Treatment/Water Quality Protection Handbook.

APPENDIX C: TEST PLOT AS-BUILT REPORTS

WADDLE RANCH LANDING A

AS-BUILT REPORT

Prepared By Lorenzo Worster and Michael Hogan

Integrated Environmental Restoration Services

For the Lahontan Regional Water Quality Control Board

March 24th, 2011

INTRODUCTION

This document describes details of implementation of a test site at Waddle Ranch that was installed in order to test the effectiveness of a specific legacy landing treatment. This test is part of a program that is designed to test and develop water quality protection tools and to assess them on the ground in real time. This program is designed to substantiate assumptions about forest management project performance and to improve that performance wherever possible.

PURPOSE OF TEST

Legacy landings retain compacted soil decades after the use of those landings. While vegetation tends to recolonize those areas, runoff and sediment yield can continue to be high, even on relatively flat areas. This condition leads to water quality degradation.

The purpose of the tests described in this document is to determine whether legacy landings that were left in a compacted state and have reestablished some vegetation cover can be treated to regain a higher degree of hydrologic and soil function.

Test questions include:

- What are the functional differences between vegetated legacy landings and relatively undisturbed areas?
- Can infiltration on a vegetated legacy landing be implemented such that vegetation is mostly retained but infiltration is returned to a near undisturbed condition?
- Can runoff, rilling and sedimentation differences be observed post treatment?

OUTCOME

- To determine which of three soil treatments re-create the highest level of soil function in a previously disturbed landing.
- To determine whether on-site chipped materials can be used effectively and inexpensively to restore hydrologic function to landings, thus protecting water quality.

OUTPUT

1. Data from plot monitoring
2. Tools from plot monitoring for landing mitigation

SITE LOCATION AND DESCRIPTION

Landing A is located on Sawmill Flat Road, 0.8 miles from the Highway 267 entrance gate and slightly beyond the beginning of the timber boundary. The site was a historic landing which had been abandoned following logging activities (date to be determined). Vegetation subsequently recolonized the site. Vegetation consisted primarily of shrubs (bitterbrush and Manzanita) and immature pine trees. Even though the landing had very little slope, there was a water bar running across the entire area perpendicular to Sawmill Flat Road.

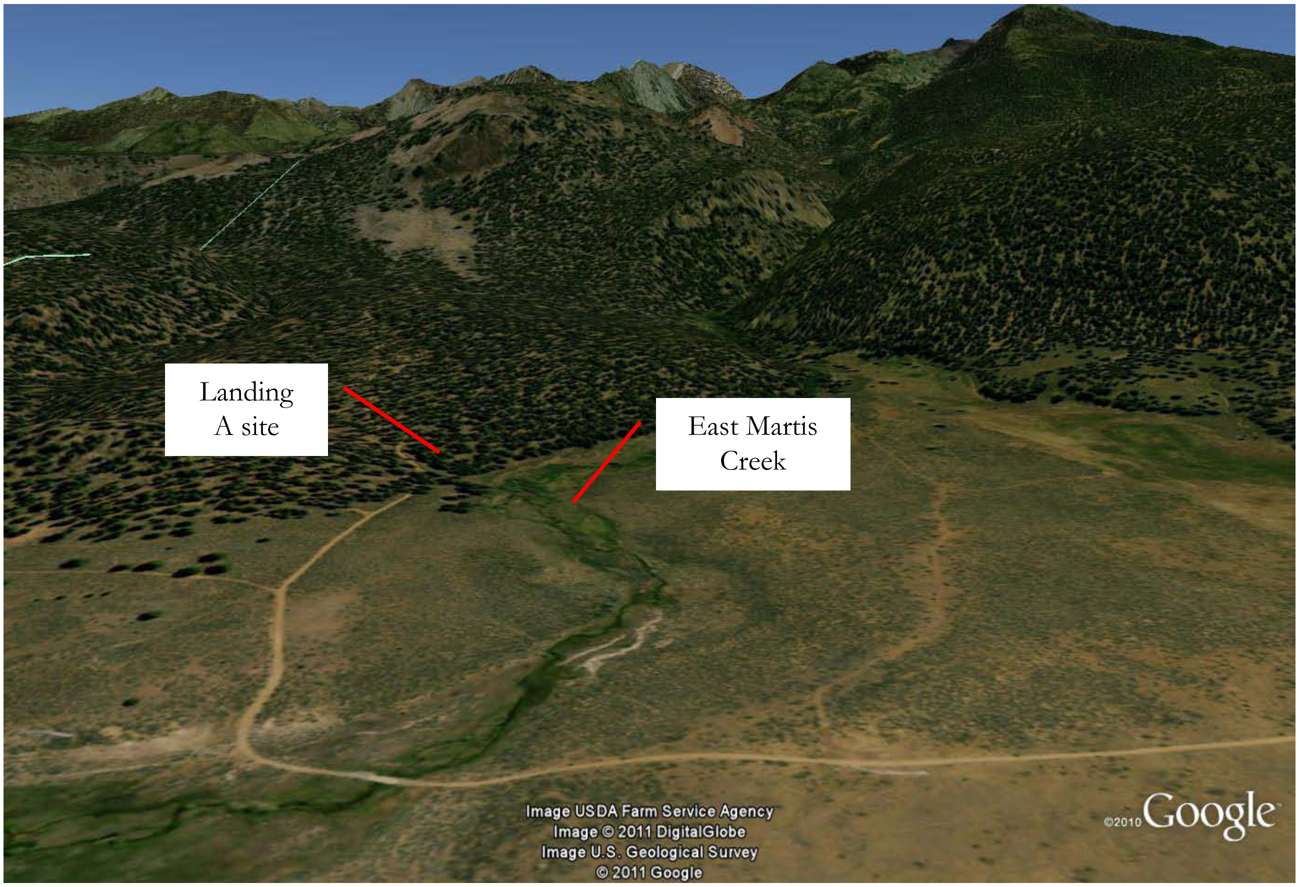


FIGURE 1: OBLIQUE VIEW OF LANDING A SITE RELATIVE TO MARTIS VALLEY AND EAST MARTIS CREEK

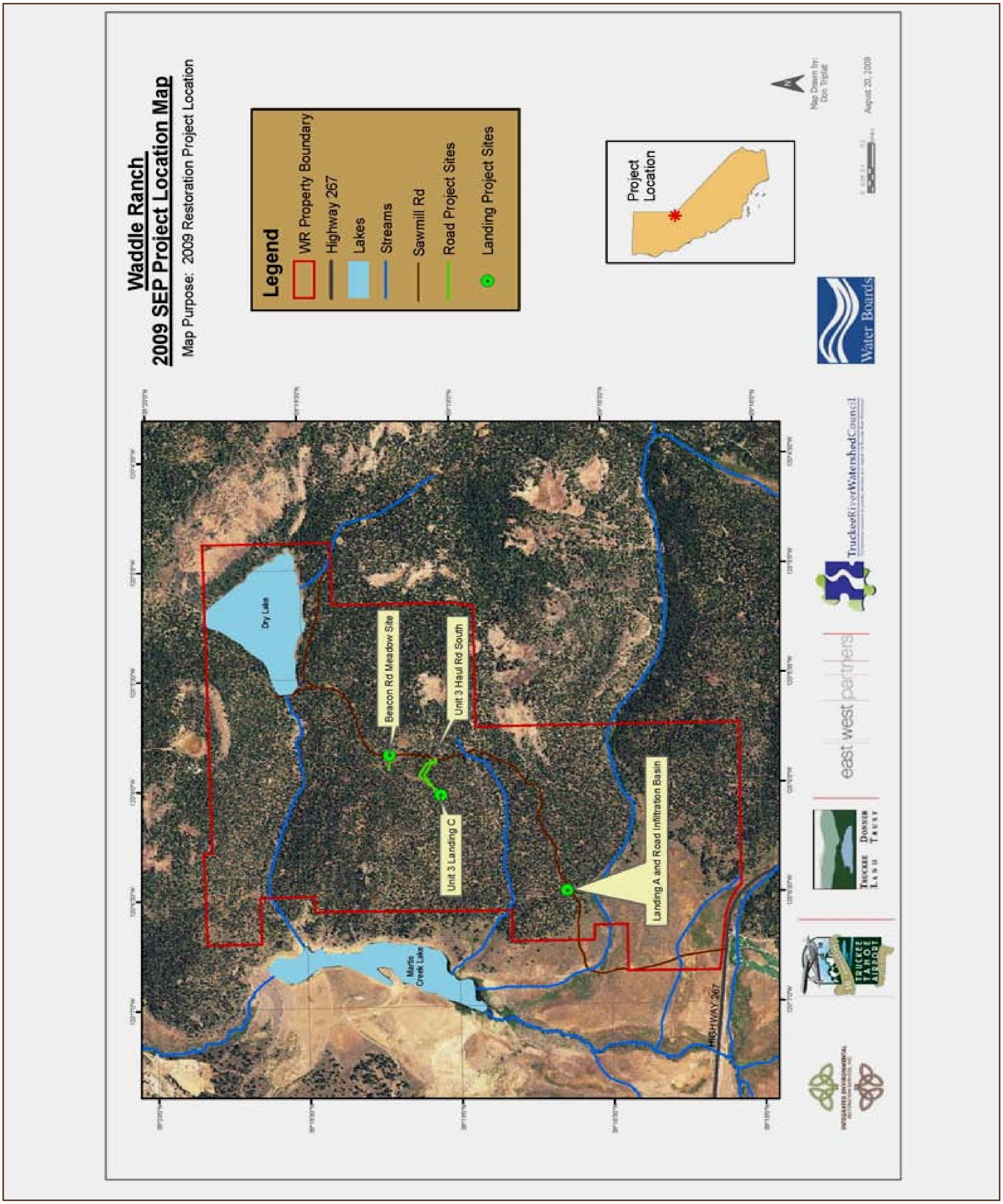


FIGURE 2: WADDLE RANCH AREA AND PLOT LOCATIONS

BASELINE CONDITIONS

The landing area is located within an existing stand of second or third growth timber, which has a canopy cover of approximately 30%. Soils are assumed to be relatively developed. Soil compaction measurements showed a depth to refusal of approximately 4". Soil cover consisted of a thin layer of mulch from surrounding tree needlecast and other residual forest materials (branches, cones, etc.). Total surface cover was close to 100%.

FIGURE 3. MODIFIED EXCAVATOR BUCKET AT FULL PENETRATION.

FIGURE 4. MODIFIED EXCAVATOR BUCKET RETRACTING FROM "TARGETED LOOSENING" WITHOUT TURNING SOIL.

FIGURE 5. KX 161 EXCAVATOR TARGETED LOOSENING.

FIGURE 6. SUGAR PINE SEEDLING.

FIGURE 7. PLOT 1 PRE-TREATMENT (PP2).

FIGURE 8. PLOT 1 POST-TREATMENT (PP2).

TREATMENT DATES

September 24, 2009 – September 30, 2009

TREATMENT DESCRIPTION

The landing was separated into three plots leading away from the road to the north. Each plot is 7.5m wide by 18m long and 135m². The first 2 plots were treated while the third plot was left untreated for comparison.

The landing was separated into three distinct test plots (see figure 9.). Plot 1 is the northernmost plot. This area was amended with just over 2" of locally sourced woodchips. A modified excavator bucket with two tines was used to loosen soil. This method is called "targeted loosening", a method developed to loosen soil while maintaining the existing vegetative growth and root systems. Areas in and around vegetation were loosened to between 7" and 8" deep. While loosening the soil, targeted loosening also incorporates amendments into the soil providing nutrients for future plant growth and addition infiltration capacity to the soil. Next, 2000lbs/acre of Biosol organic fertilizer was spread and raked followed by 125lbs pure live seed/acre native seed mix. Finally the area was mulched with pine needles from the North Lake Tahoe area.

Plot 2 was treated using the same method except the soil was amended with just over 2" of aged tub grindings.

Plot 3 was left untreated to be used as a comparison or control. In late October, all 3 plots were planted with 15 sugar pine seedlings each, totaling 45 seedlings in all.

FIGURE 9

TABLE 1. TREATMENT MATRIX

Treatments		Plot 1	Plot 2	Plot 3
Amendment	**Type**	Green Woodchips (<50% needles)	Tub Grindings	None
	Depth	2.2”	2.1”	
Soil Loosening	**Type**	Targeted Loosening	Targeted Loosening	None
	Depth	7.6”	7.24”	
Fertilizer	**Type**	Biosol	Biosol	None
	Rate	2000lbs/acre	2000lbs/acre	
Seed	**Mix**	Shrub, Forb & Grass mix	Shrub, Forb & Grass mix	None
	Rate	125lbs PLS/acre	125lbs PLS/acre	
Mulch	**Type**	Pine Needle	Pine Needle	None
	Depth	2.5”	2.5”	
Plants	**Type**	Sugar Pine Seedlings	Sugar Pine Seedlings	Sugar Pine Seedlings
	Qty	15”	15”	15”
Dimensions (W X L =A)		7.5m x 18m = 135m^2	7.5m x 18m = 135m^2	7.5m x 18m = 135m^2
Dimensions (W X L =A)		25ft x 60ft = 1500ft^2	25ft x 60ft = 1500ft^2	25ft x 60ft = 1500ft^2

MATERIALS

The materials used on this project were all from local sources (Table 2).

- Woodchips were sourced onsite from a regional timber harvest and fuels reduction program.
- Biosol Organic Fertilizer (6-1-3) was sourced from Pacific Coast Seed.
- Native seed mix was sourced from Comstock Seed and consisted of a Tahoe specific mix of grass, shrub, and forb seed (Table 3).
- Pine needles were collected from North Lake Tahoe.
- Sugar pine seedlings were sourced from the Sugar Pine Foundation.

TABLE 2. MATERIALS SOURCE AND QUANTITY LIST.

Materials	Type	Source	Quantity
Amendment	Aged Tub Grindings	Truckee Eastern Regional Landfill	10 yds^3
Amendment	Green Wood Chips	Local forestry operation	10 yds^3
Fertilizer	6-1-3 Biosol	Pacific Coast Seed	92 lbs
Seed	IERS Upland Mix	Comstock Seed	6 lbs
Mulch	Pine Needles	Meeks Bay Fire Collection	8 yds^3
Seedlings	Sugar Pine	Sugar Pine Foundation	45

TABLE 3. IERS UPLAND SHRUB, FORB, GRASS MIX.

Scientific Name	Common Name	Pure Live Seed (%)	Rate (lbs/acre)
Elymus elymoides	Squirreltail or bottlebrush	28.33	35.42
Elymus glaucus	Blue wildrye	33.33	41.67
Bromus carinatus	Mountain brome	27.50	34.38
Purshia tridentata	Antelope bitterbrush	6.67	8.33
Ribes cereum	Wax currant	0.42	0.52
Eriogonum umbellatum	Sulphur flower buckwheat	2.08	2.60
Arctostaphylos patula	Geenleaf manzanita	1.67	2.08

PERSONNEL

Don Triplat, IERS Project Manager; Lorenzo Worster, IERS Foreman; Kate Gross, IERS Restoration Technician; Brad Lariviere, IERS Restoration Technician; Peter Ceccon, IERS Restoration Technician/Equipment Operator.

INCIDENTAL NOTES

These tests are located adjacent to road runoff/diversion plots and are related in that this area has been a source of runoff onto the main Waddle Ranch access road (Sawmill Flat Road). Part of the reason behind restoring this area is to remove a potential source of runoff onto the road, thus creating a systematic approach to water quality improvement.

NEXT STEPS

1. Monitor 3 plots to determine treatment differences for plant and seed response
2. Assess soil density in 2011 for residual or long lasting treatment effects
3. Measure soil nutrients to determine soil capital, suggesting site sustainability
4. Develop tools from plot data output

WADDLE RANCH

ROAD INFILTRATION BASIN

AS-BUILT REPORT

Prepared By Michael Hogan and Lorenzo Worster

Integrated Environmental Restoration Services

For the Lahontan Regional Water Quality Control Board

March 24th, 2011

INTRODUCTION

Dirt road runoff is a common and insidious problem in logging areas. Roads can capture runoff and move sediment for long distances when adequate controls are not in place. Further, commonly used BMP's are seldom tested for effectiveness. Regulatory requirements also do not tend to incentivize innovation. This report describes installation of an innovative, LID or 'low impact development-type of treatment. Waddle Ranch, like many timber lands in the West, is criss crossed with roads. Waddle Ranch road management practices have been relatively non-existent, consisting mostly of regarding roads when they either become impassible or when logging is about to occur.

The test area described in this report is developed as part of an overall program to install and test road treatments that protect the roads and water quality and provide the new Waddle Ranch managers, the Truckee Tahoe Airport District, with management tools that they can use to meet their management goals of low maintenance and high water quality protection roads throughout the Waddle Ranch.

PURPOSE OF TEST

The purpose of this test is to determine the level of effectiveness of a combination rolling dip with outlet infiltration area. This configuration can be used throughout the property and on other properties as well. This test will allow us to gather data that would support use of this application.

Test questions include:

- Can a specific rolling dip configuration withstand irregular traffic and what maintenance schedule is required to maintain effectiveness?
- Can diversion water from a dirt road be infiltrated and treated by a vegetated infiltration basin?

OUTCOME

Increased understanding of a relatively new technology in terms of road surface maintenance

Increased understanding of water quality protection capacity of this rolling dip-infiltration area combination

OUTPUT

1. Assessment of road condition
    a. Length of upslope rilling
    b. Length if any, of downslope rilling
2. Assessment of sediment capture in infiltration area

3. Infiltration rate as determined by water truck input (depends on future monitoring)

SITE LOCATION AND DESCRIPTION

Waddle Ranch is located between Northstar-at-Tahoe and the Truckee Tahoe Airport. This test plot is located approximately 0.8 miles from the main entrance gate just off of Highway 267.

This rolling dip-infiltration swale area was installed where road runoff has been repeatedly observed. Runoff tends to run a long distance down the road and has access to East Martis Creek from a number of off-shoots from this road. The road has been variously rutted and then re-graded over the past few years. Each time the road is re-graded, it creates a new supply of sediment to be transported to the creek.

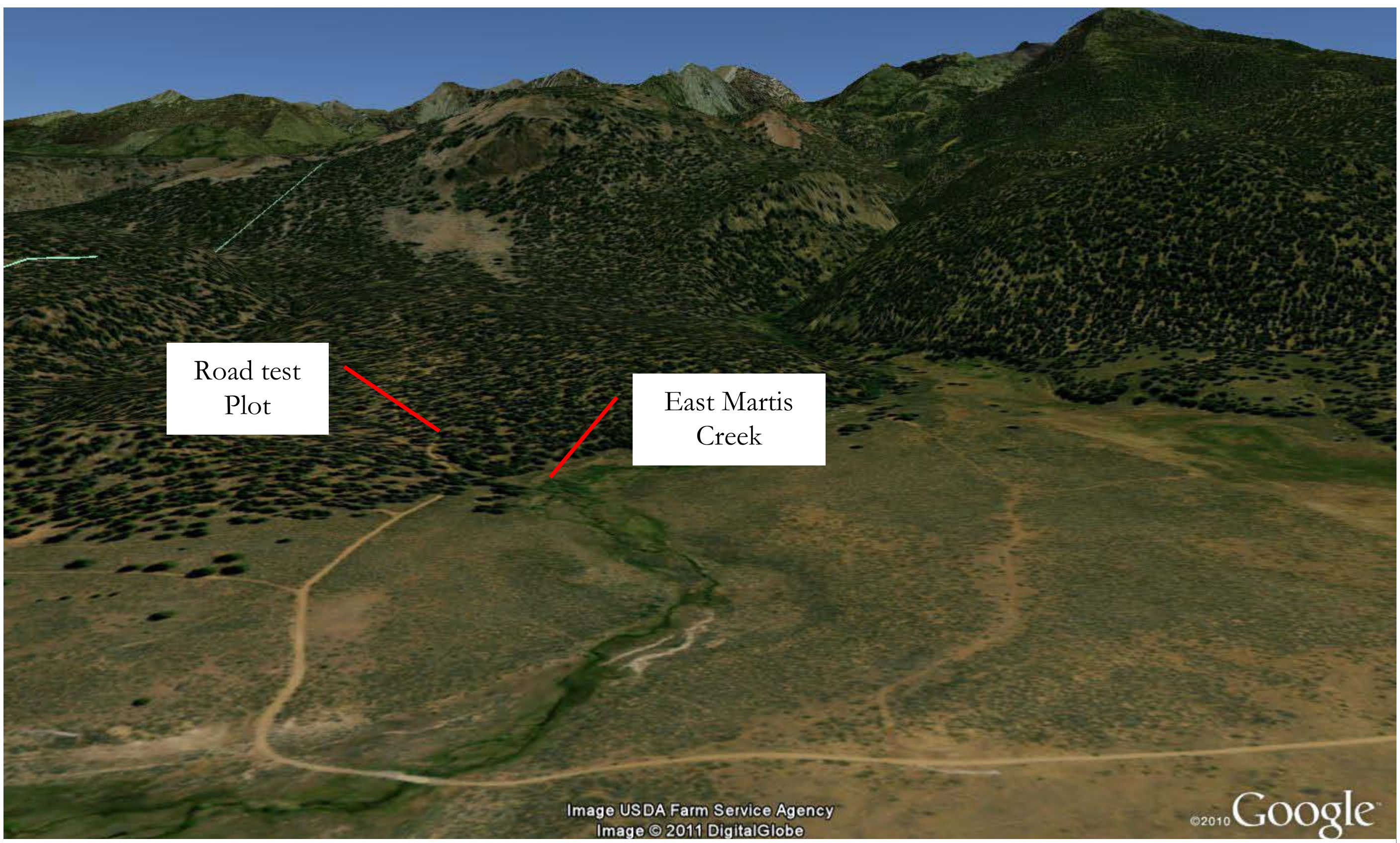


FIGURE 1: SITE LOCATION AND PROXIMITY TO EAST MARTIS CREEK

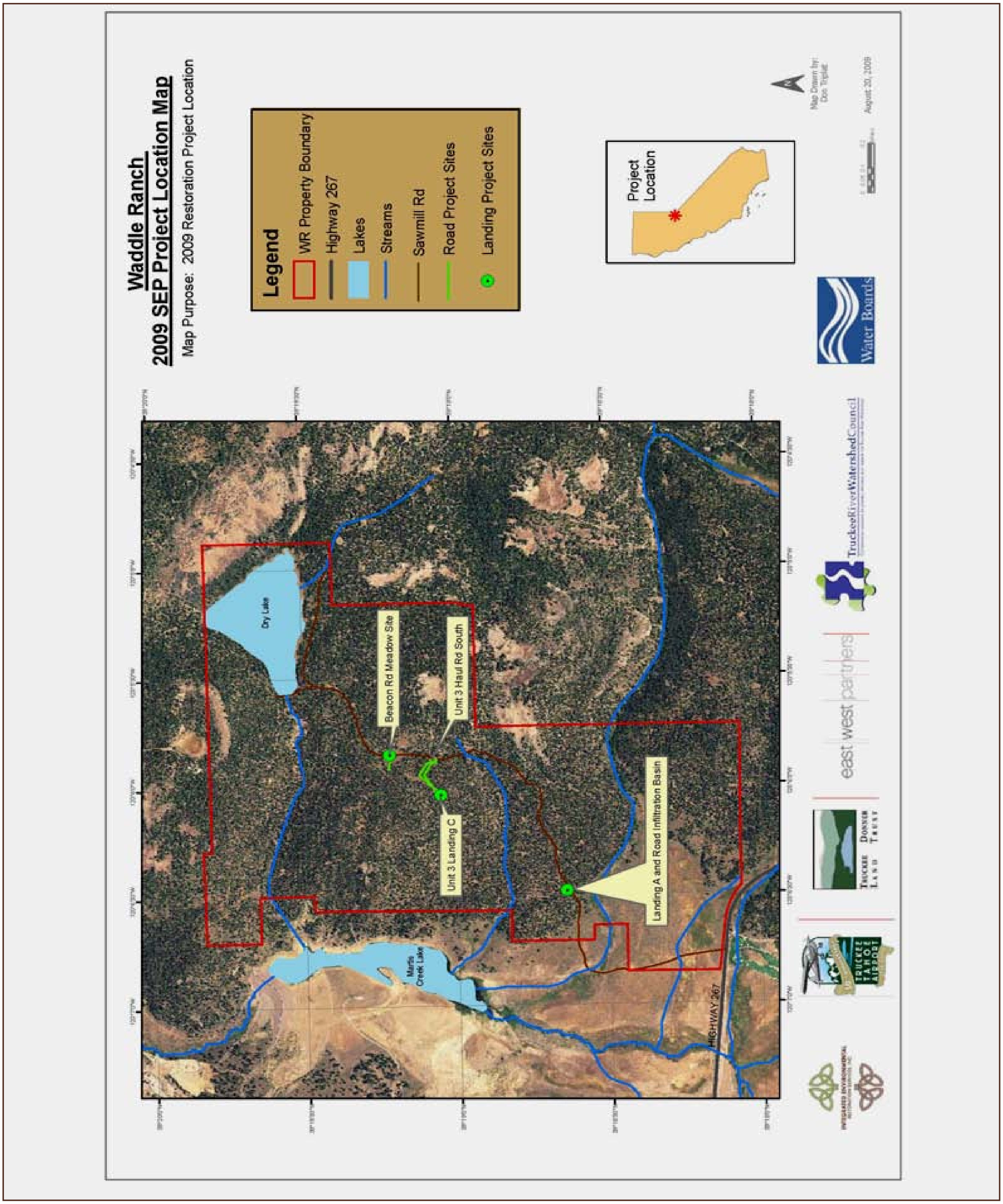


FIGURE 2: LOCATION MAP

BASELINE CONDITIONS

Baseline conditions consist of a long, highly compacted, entrenched road bed that is main vehicle access into Waddle Ranch. Years of erosion have lowered the road bed below the surrounding grade and thus captures water. Just prior to plot creation, the road had been graded. Prior to grading, the road exhibited rilling for long distances. The water bar infiltration test plot was installed at the intersection of an old road spur. That spur leads to East Martis Creek, which is within approximately 200 yards downslope to the south.

Figure 3. Rolling dip site on Sawmill Flat Road pre-construction (PPA). The basin site is on the right.

Figure 4. Track packing rolling dip. Basin is on the left (PPC).

Figure 5. Removing topsoil and shaping basin.

Figure 6. Looking across post construction (PPB).

Figure 7. Pre-construction (PPD).

Figure 8. Site post construction (PPB).

TREATMENT DATES

September 24, 2009 – September 30, 2009

TREATMENT DESCRIPTION

Two distinct treatments were implemented at the infiltration site. First, a rolling dip was created on the road to direct water into the basin. Next, the infiltration basin, which is 8 ft wide, 20 ft long and 1 ft deep, was constructed. The basin included a rock dissipation pad at the entrance to dissipate force from road runoff.

TABLE 1. TREATMENT MATRIX

Materials		Infiltration Basin
Amendment	Type	Green woodchips (<50% pine needles)
	Depth	10”
Soil Loosening	Type	Mini Ex Bucket Full Till
	Depth	17.54”
Fertilizer	Type	Biosol 6-1-3
	Rate	2,000 lbs/acre
Seed	Mix	IERS Upland mix
	Rate	125 lbs/acre PLS
Mulch	Type	Pine Needles
	Depth	2.5”
Dimensions in ft^2		20’ x 8’ = 160ft^2
Dimensions in m^2		4.5m x 9m = 40.5m^2

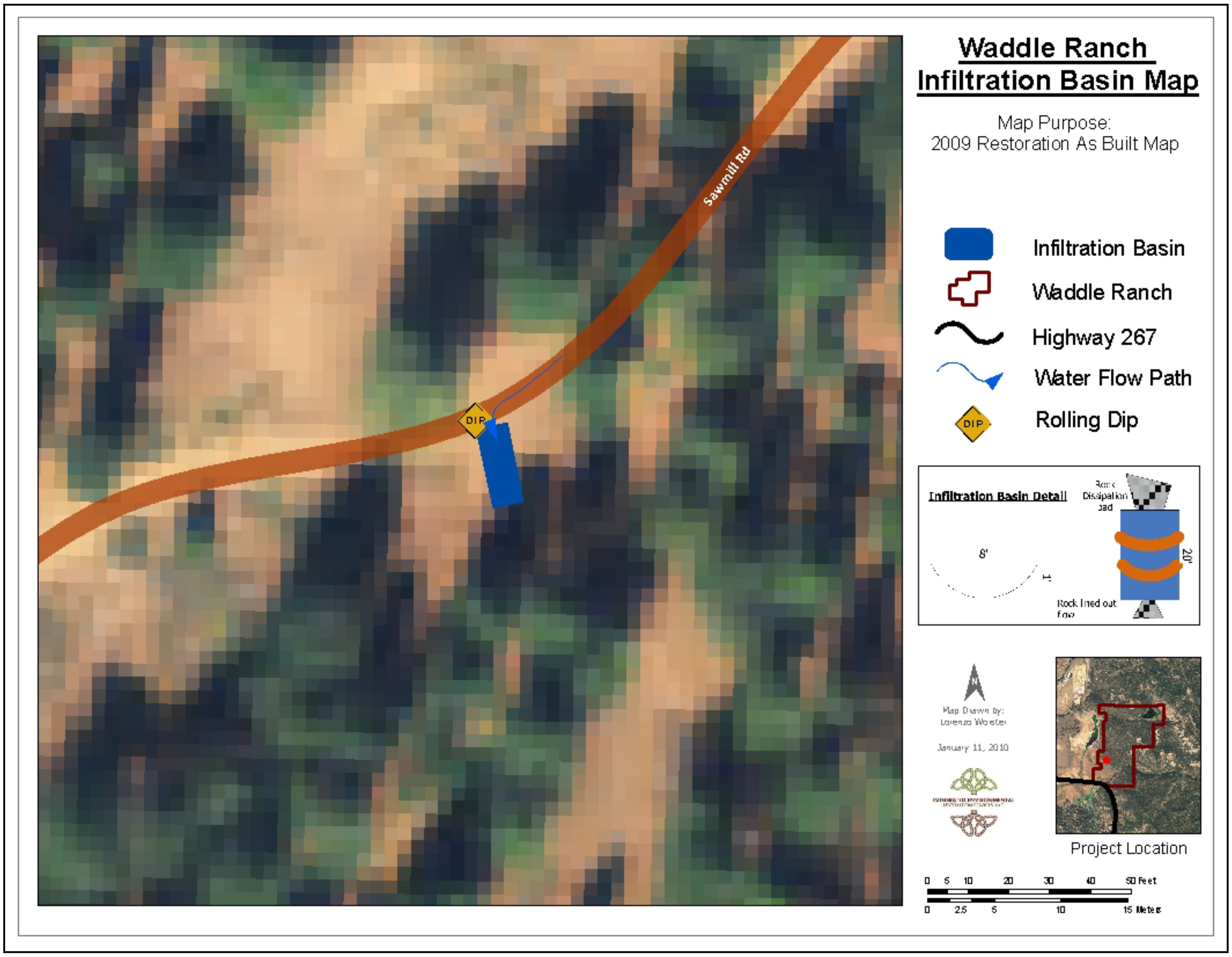


FIGURE 7: TEST PLOT LOCATION AND LAYOUT

MATERIALS

The materials used on this project were (Table 2).

- Woodchips were sourced onsite from a regional timber harvest and fuels reduction program.
- Biosol Organic Fertilizer (6-1-3) was sourced from Pacific Coast Seed.
- Native seed mix was sourced from Comstock Seed and consisted of a Tahoe specific mix of grass, shrub, and forb seed (Table 2).
- Pine needles were collected from North Lake Tahoe.

TABLE 2. MATERIALS SOURCE AND QUANTITY LIST.

Materials	Type	Source	Quantity
Amendment	Green Wood Chips	Local forestry operation	5 yds^3
Fertilizer	6-1-3 Biosol	Pacific Coast Seed	7 lbs
Seed	IERS Upland Mix	Comstock Seed	.5 lbs
Mulch	Pine Needles	Meeks Bay Fire Collection Program	2 yds^3

TABLE 3. IERS UPLAND SHRUB, FORB, GRASS MIX.

Scientific Name	Common Name	Pure Live Seed (%)	Rate (lbs/acre)
Elymus elymoides	Squirreltail or bottlebrush	28.33	35.42
Elymus glaucus	Blue wildrye	33.33	41.67
Bromus carinatus	Mountain brome	27.50	34.38
Purshia tridentata	Antelope bitterbrush	6.67	8.33
Ribes cereum	Wax currant	0.42	0.52
Eriogonum umbellatum	Sulphur flower buckwheat	2.08	2.60
Arctostaphylos patula	Geenleaf manzanita	1.67	2.08

PERSONNEL

Don Triplat, IERS Project Manager; Lorenzo Worster, IERS Foreman; Kate Gross, IERS Restoration Technician; Brad Lariviere, IERS Restoration Technician; Peter Ceccon, IERS Restoration Technician/Equipment Operator.

INCIDENTAL NOTES

This test area attempts to address a very common issue on dirt roads throughout the Sierra. That is, long road runs with no runoff exits engineered into the road.

WADDLE RANCH BEACON ROAD MEADOW TEST AREA AS-BUILT REPORT

Prepared By Michael Hogan

Integrated Environmental Restoration Services

For the Lahontan Regional Water Quality Control Board

March 24th, 2011

INTRODUCTION

Legacy landings are an insidious element of the western mountain landscape. Landings are thought by some to be of little impact to watersheds. Landings are also left in a compacted state following logging since many landings may be used in the future. Direct observation at Waddle Ranch has shown that these compacted landings capture water and, due to the low infiltration rate, shunt that water onto nearby roads. Once on the roads, the water creates a great amount of erosion over long distances.

PURPOSE OF TEST

To return a large legacy impact site to a higher level of hydrologic and soil function, thus limiting runoff onto the road system. A number of different tests were implemented in this area due to the large and diverse nature of the site. Test questions include:

- Can infrequently used road beds be stabilized to reduce erosion under non-critical rainfall situations?
- Can infiltration be reestablished to native conditions on a legacy landing that has been well colonized by native vegetation?
- Can infiltration be reestablished to native or undisturbed levels on a legacy landing that has been well colonized by native vegetation?

Road bed stabilization and infiltration restoration

Tilling of 'weedy' native species as amendment (low cost approach)

Identify effectiveness of low cost treatments using locally available materials

To determine whether rust-resistant sugar pine seedlings can be used to recolonize the site with this species of white pines.

OUTCOME

- Increased understanding tools that can be used to restore large legacy areas
- Increased understanding of cost effectiveness of these low and moderate cost tools
- Development of treatments for roads that are used only occasionally
- Increased understanding of rust resistant sugar pine seedling response

OUTPUT

1. Assessment and data on various low cost treatments
2. Identification of low cost tools to remove compaction, increase plant growth and infiltration on large legacy landings
3. Assessment of decrease of runoff from these treatments

4. Survival data from sugar pine seedlings

SITE LOCATION AND DESCRIPTION

The Beacon Road "Meadow" is an area that has previously been used as a landing and staging area for past logging operations and has an access road running through part of the site. It is located at the junction of Sawmill Flat Road and Beacon Road, 1.8 miles from the Waddle Ranch Highway 267 entrance. The site includes part of Beacon Road and is adjacent to the Founders Rock which is a landmark rock and plaque that was installed to honor participants in the acquisition of Waddle Ranch for conservation and public enjoyment. The landing was highly compacted but covered with a moderate amount of native vegetation consisting primarily of shrubs and some young pine trees. There was also a short cut haul road that developed through the middle of the landing that large logging trucks used to turn left onto Sawmill Flat Road.

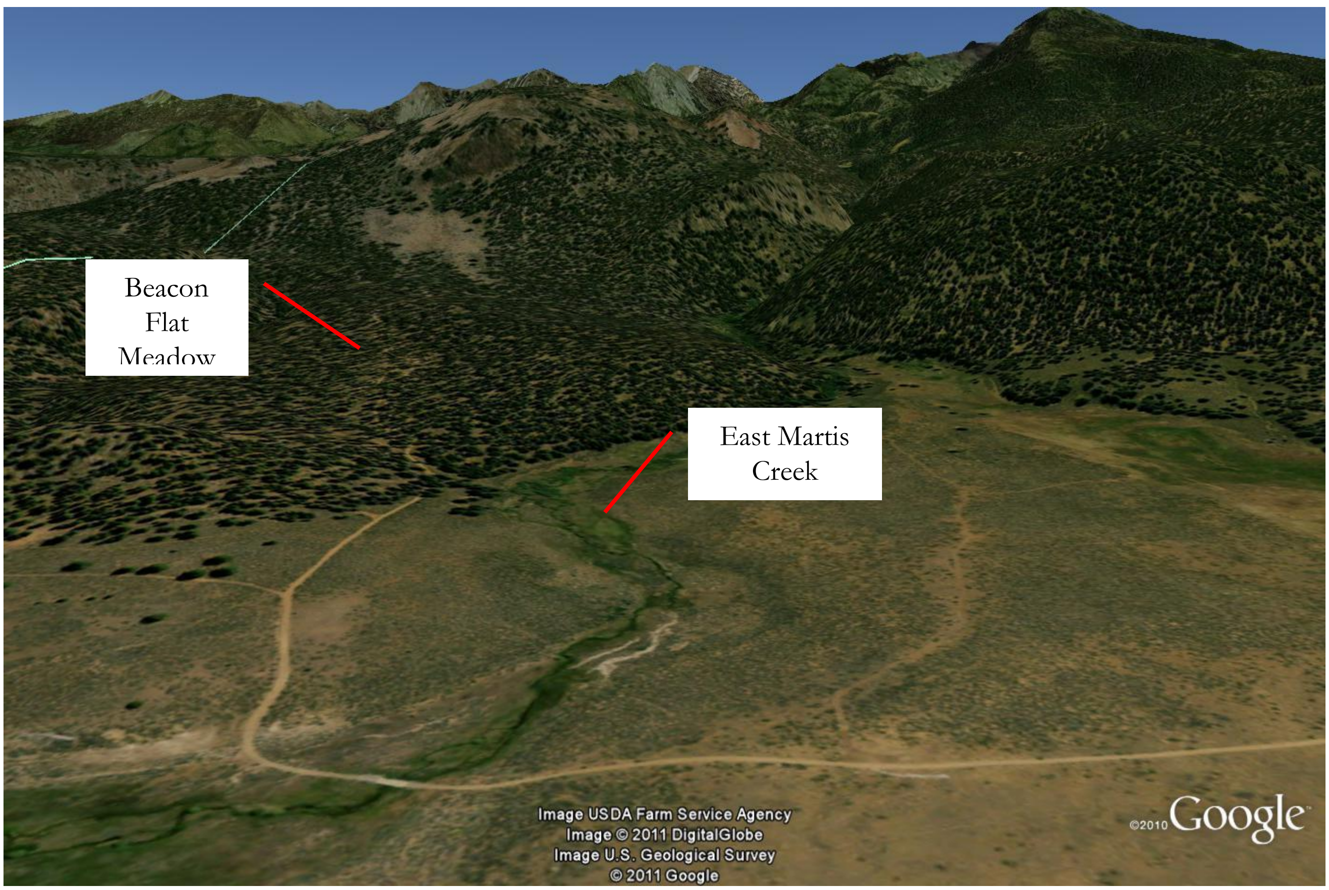


FIGURE 1: APPROXIMATE LOCATION OF BEACON FLAT MEADOW

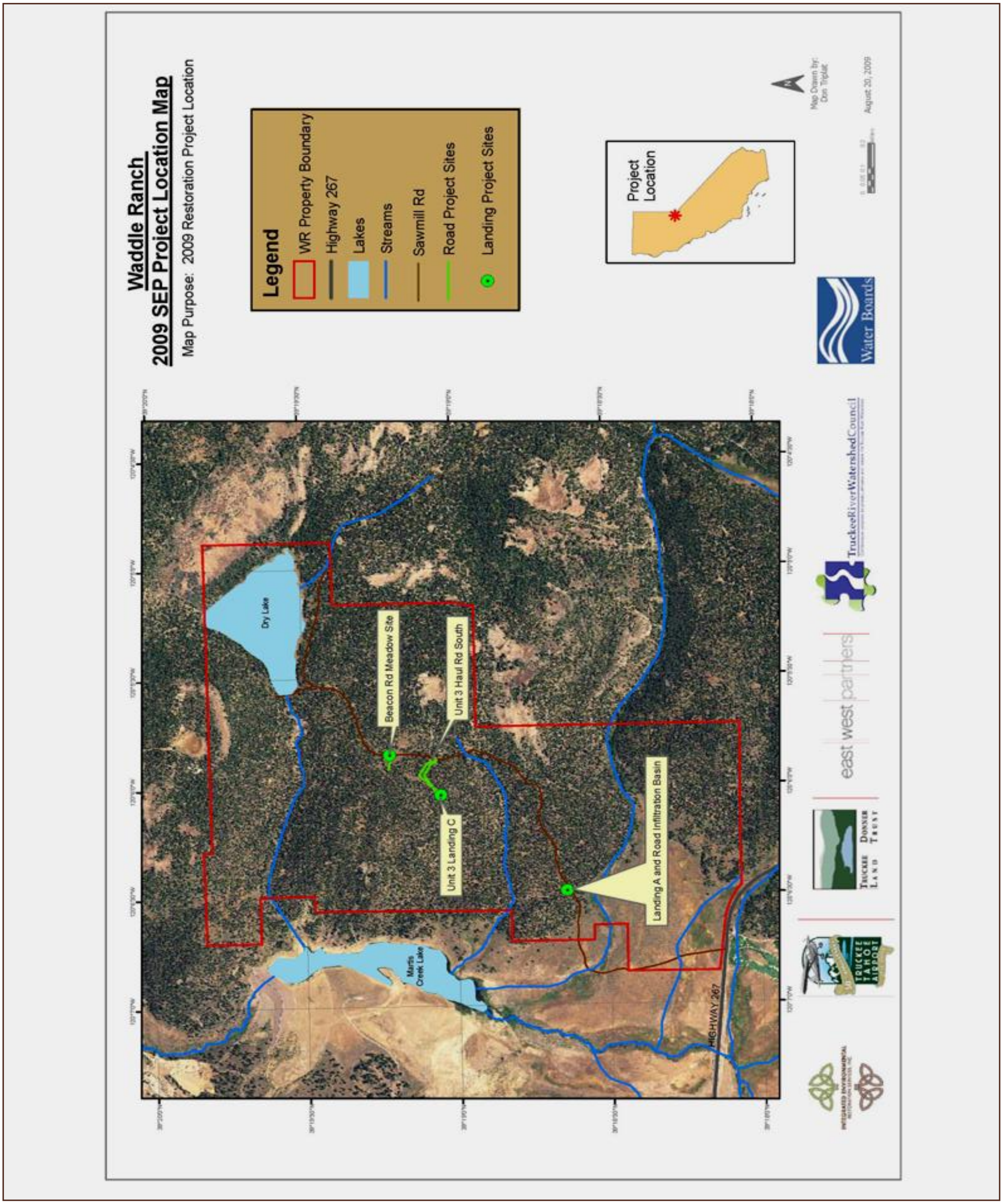


FIGURE 2: LOCATION MAP

BASELINE CONDITIONS

Baseline conditions consisted of a large meadow-like area that was moderately to highly compacted that had been colonized by a range of native grass, forb, shrub and tree species. An actively used road that accesses the landing beacon for the Truckee Tahoe Airport bisects the site. Rilling was apparent through the site.

TREATMENT DATES

September 25, 2009 – October 2, 2009

Figure 3. Ripping with the modified excavator bucket on plot 1.

Figure 4. Amendments spread on test plots. Note the horse manure on plot 6.

Figure 5. The site pre-treatment (PPC).

Figure 6. Plot 1 post-treatment (PPC).

Figure 7. Planted sugar pine seedling.

TREATMENT DESCRIPTION

TABLE 1: TREATMENT MATRIX

Treatments		Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8
Amendment	**Type**	Green Wood Chips (<50% Needles)	Existing Sage incorporated	None	None	Sagebrush, Green Wood Chips (<50% Needles)	Green Wood Chips (<50% Needles)/ Composted Horse Manure	Green Wood Chips (<50% Needles)	Sage Brush, Green Wood Chips (<50% Needles)
	Depth	2.61″	-	-	-	2″	2.88″/2.02″	3.24″	1.98″
Soil Loosening	**Type**	KX161 Mod. Bucket rip	KX161 Full bucket	None	KX161 Mod. Bucket rip	KX161 Full bucket	KX161 Full bucket	KX161 Full bucket and modified bucket	KX161 Full bucket
	Depth	9.2″	13.52″	-	12″	13.12″	14.6″	12.4″	13.1″
Fertilizer	**Type**	None	Biosol 6-1-3	None	None	Biosol 6-1-3	Biosol 6-1-3	Biosol 6-1-3	Biosol 6-1-3
	Rate	-	2000lbs/acre	-	-	-	2000lbs/acre	2000lbs/acre	2000lbs/acre
Seed	**Mix**	None	Shrub/Forb/Grass mix	None	None	None	Shrub/Forb/Grass mix	Shrub/Forb/Grass mix	Shrub/Forb/Grass mix
	Rate	-	125lbs/acre PLS	-	-	-	125lbs/acre PLS	125lbs/acre PLS	125lbs/acre PLS
Mulch	**Type**	Green Wood Chips (<50% Needles)	Green Wood Chips (<50% Needles)	None	None	Green Wood Chips (<50% Needles)	Green Wood Chips (<50% Needles)	Green Wood Chips (<50% Needles)	Green Wood Chips (<50% Needles)
	Depth	0.5″	1.5″	-	-	1.1″	1.7″	2.1″	2.3″
Plants	**Type**	None	Sugar Pine Seedlings	None	None	Sugar Pine Seedlings	Sugar Pine Seedlings	Sugar Pine Seedlings	Sugar Pine Seedlings
	Qty	-	5	-	-	5	10	10	10
Dimensions in ft^2		15 x 200 = 3000ft^2	21 x 36 = 756ft^2	3 x 6 = 18ft^2	3 x 6 = 18ft^2	3 x 6 = 18ft^2	15 x 38 = 570ft^2	22 x 36 = 792ft^2	25 x 60 = 1500ft^2
Dimensions in m^2		4.5 x 61 = 274.5m^2	9 x 6 = 54m^2	1 x 2 = 2m^2	1 x 2 = 2m^2	1 x 2 = 2m^2	4.5 x 11.5 = 51.75m^2	6.5 x 11 = 71.5m^2	7.5 x 18 = 135m^2

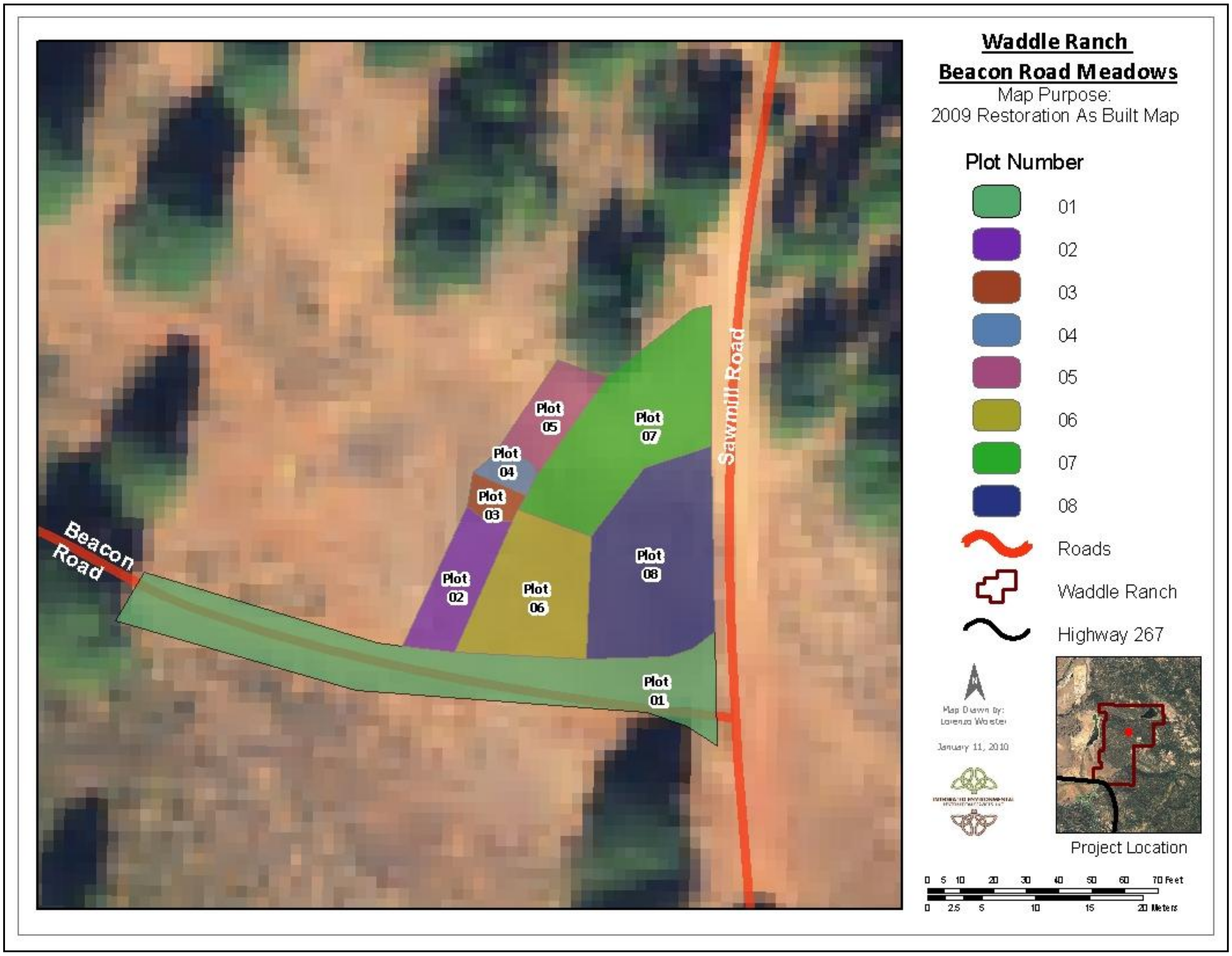


FIGURE 8: TEST PLOT LOCATION AND LAYOUT

TREATMENT DESCRIPTION

The area was separated into 8 plots (**Error! Reference source not found.**). The first test plot was set up on Beacon Road where woodchips were spread, tilled in, and the road surface re-compacted in order to allow for future vehicle access.

Test plots 2 and 5 existing sage brush, which is an easy growing, aggressive species, indicative of compacted, low nutrient soil, was incorporated as an amendment. In plot 5 woodchips were spread also spread and the sagebrush and chips were tilled in together. Both plots were amended with Biosol fertilizer, seed was added and was raked lightly into the soil. Finally the areas were covered with woodchip mulch.

Plot 3 and 4 contained an existing stand of native *Carex sp.* plants. Plot 3 was untreated to be used as a control for comparison. Plot 4 was treated by targeted loosening with a modified bucket on the KX161 mini excavator in order to disturb the existing plants as little as possible.

Woodchips were spread on plots 6, 7 and 8 and tilled into the soil using a standard bucket. The area on plot 7 adjacent to Sawmill Flat Road was so compacted that a modified bucket was used to loosen the soil in addition to the standard bucket. Aged horse manure was tilled into plot 6 and the exiting sage brush was tilled into plot 8. In all three plots, Biosol and seed were raked in. The areas were then covered with woodchip mulch.

MATERIALS

The materials used on this project were (Table).

- Woodchips were sourced onsite from a regional timber harvest and fuels reduction program.
- Composted horse manure from Northstar-at-Tahoe.
- Biosol Organic Fertilizer (6-1-3) was sourced from Pacific Coast Seed.
- Native seed mix was sourced from Comstock Seed and consisted of a Tahoe specific mix of grass, shrub, and forb seed (Table).
- Sugar pine seedlings were sourced from the Sugar Pine Foundation.

TABLE 2. MATERIALS SOURCE AND QUANTITY LIST.

Materials	Type	Source	Quantity
Amendment	Green wood chips	On site forestry chipping	64 yds
Amendment	Aged horse manure	Northstar Stables	15 yds
Fertilizer	Biosol 6-1-3	Pacific Coast Seed	184 lbs
Seed	Upland Seed Mix	Comstock Seed	11.5 lbs
Mulch	Green wood chips	On site forestry chipping	Include in Amend.
Wattles	Pine needle	IERS Wattle Factory	3 - 25'
Plantings	Sugar Pine Seedings	Sugar Pine Foundation	40

TABLE 3. IERS UPLAND SHRUB, FORB, GRASS MIX.

Scientific Name	Common Name	Pure Live Seed (%)	Rate (lbs/acre)
Elymus elymoides	Squirreltail or bottlebrush	28.33	35.42
Elymus glaucus	Blue wildrye	33.33	41.67
Bromus carinatus	Mountain brome	27.50	34.38
Purshia tridentata	Antelope bitterbrush	6.67	8.33
Ribes cereum	Wax currant	0.42	0.52
Eriogonum umbellatum	Sulphur flower buckwheat	2.08	2.60
Arctostaphylos patula	Geenleaf manzanita	1.67	2.08

PERSONNEL

Don Triplat, IERS Project Manager; Lorenzo Worster, IERS Foreman; Kate Gross, IERS Restoration Technician; Brad Lariviere, IERS Restoration Technician; Peter Ceccon, IERS Restoration Technician/Equipment Operator.

INCIDENTAL NOTES

This native-appearing meadow-like area is considered pristine by some. However, assessment indicated that it is clearly impacted. These test should help us understand how to re-create higher levels of functional conditions.
We tried to block off some areas to preclude non-essential vehicle traffic.

NEXT STEPS

1. Assess all test areas
2. Assess runoff onto main road
3. Develop tools based on results of data

WADDLE RANCH UNIT 3 LANDING C

AS-BUILT REPORT

Prepared By Michael Hogan and Lorenzo Worster

Integrated Environmental Restoration Services

For The Lahontan Regional Water Quality Control Board

March 24th, 2011

INTRODUCTION

This report describes test plots that were installed on Waddle Ranch Unit 3, Landing C. Typically, landings are not restored or treated or if they are, they tend to be ripped and left until needed again. These landings may be contributing accelerated runoff and sediment into the watershed. If this is the case, some landings may need mitigation treatment to increase infiltration and accelerate plant response. These plots are designed to test some cost effective methods to address this issue.

The plots were installed in 2009 with the intention that they would be monitored in subsequent seasons for effectiveness. No monitoring was conducted in 2010. This test is part of a program that is designed to test and develop water quality protection tools and to assess them on the ground in real time. This program is designed to substantiate assumptions about forest management project performance and to improve that performance wherever possible. Results of these tests are designed to be incorporated into a Forestry handbook as potential treatment tools.

PURPOSE OF TEST

This installation consists of 6 plots. All plots are designed to help understand how soil and hydrologic function in highly compacted landings following use. The plots are designed to determine which mitigation treatments are most cost effective. Specifically, we are testing 3 things:

TABLE 1: TESTS AND PURPOSE

Test	Question
Tilling vs. ripping	Which is less costly, more effective?
Seeding vs. no seeding	Does seeding increase veg cover and infiltration?
Mulch only	Will surface mulch reduce erosion, accelerate veg establishment?

Since tilling is thought to be less costly, we are comparing that to full tilling, which mixes the soil more thoroughly.

Seeding is often thought to be the most effective method of reestablishing vegetation on disturbed sites. We are testing seed application vs. no seed application in order to determine whether spontaneous regeneration may be a reasonable approach to vegetation re-establishment.

The mulch only test is done to determine what level of sediment reduction and plant growth results from application of surface mulch. This is the least expensive of the applications and may offer a reasonably effective alternative treatment.

OUTCOME

- A greater understanding of the installation cost and sediment and vegetation response to tilling, ripping, seeding and mulching treatments on landings.
- The ability to specify landing mitigation treatments based on actual field data.

OUTPUT

1. Data derived information related to specific management practices, as listed above.
2. Infiltration data for each treatment type
3. Vegetation response data for each treatment type
4. Each of the above converted into tools for inclusion into a Forest Vegetation Management Handbook.

SITE LOCATION AND DESCRIPTION

Waddle Ranch is located in the Martis Valley between Northstar-at-Tahoe and the Truckee-Tahoe Airport. Most of the Waddle Ranch property abuts the Airport property to the south.

The landing C site is located approximately 1.7 miles from the Highway 267 entrance gate. At 1.7 miles, turn left on the Unit 3 haul road (see site map, Figure 1).. The site is on the right in the large landing at the end of the road.

The test plots are constructed on a landing that was used for processing and hauling during logging and forest thinning activities. This landing has been in use since at least the 1994 logging period and was reused during the summer of 2009. The landing had very little slope, was highly compacted and was covered with a layer of woodchips produced during the 2009 activities.

Part of the landing was separated into 6 test plots. Each plot is 20ft wide by 30ft long and 1200ft^2 (see Figure 7).

PROXIMITY TO DRAINAGE AND EAST MARTIS CREEK

Landing C is approximately 1.1 road miles from East Martis Creek. It may link to the Creek through road drainage and other ski road that are relatively overgrown but that still provide some level of connectivity to the Creek.

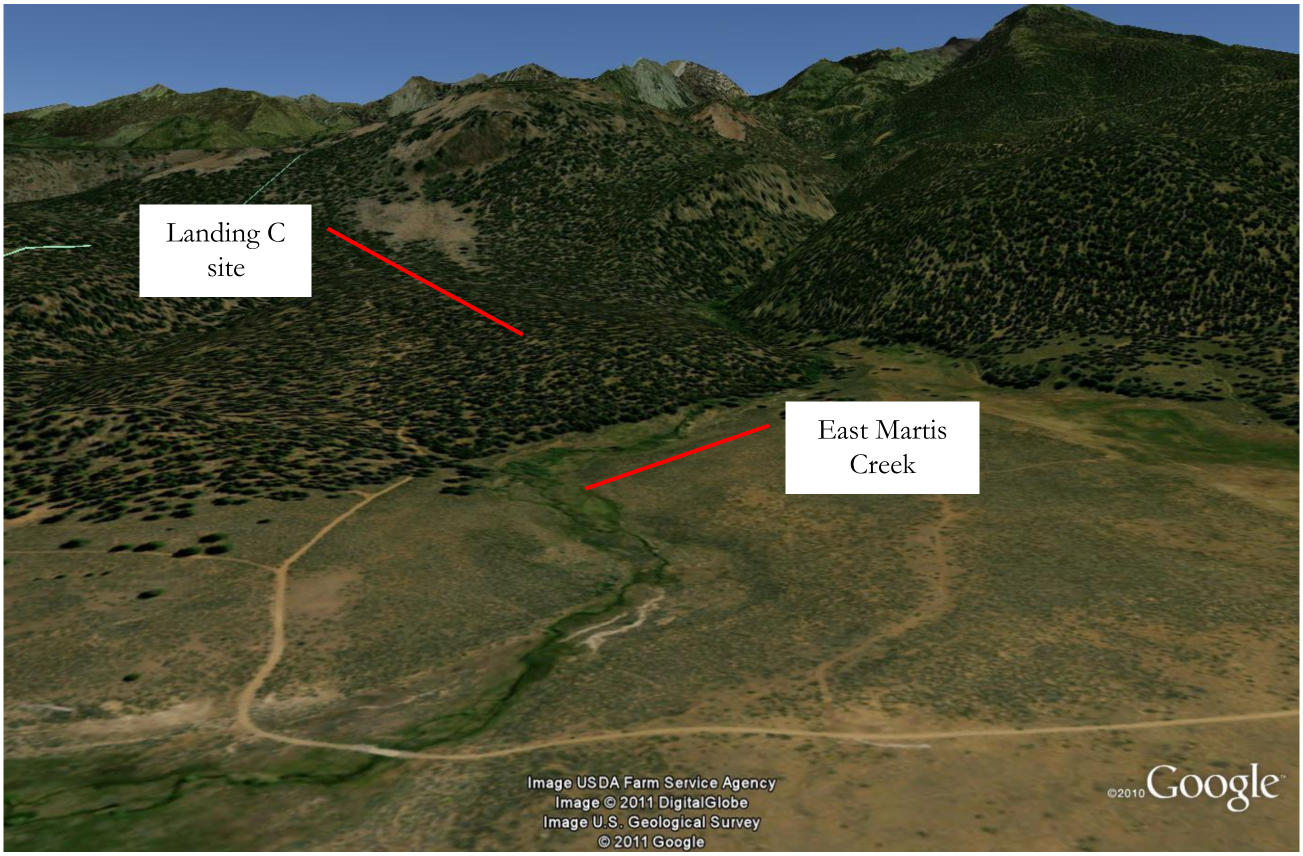


FIGURE 1: GENERAL LOCATION OF LANDING C SHOWING PROXIMITY TO EAST MARTIS CREEK.

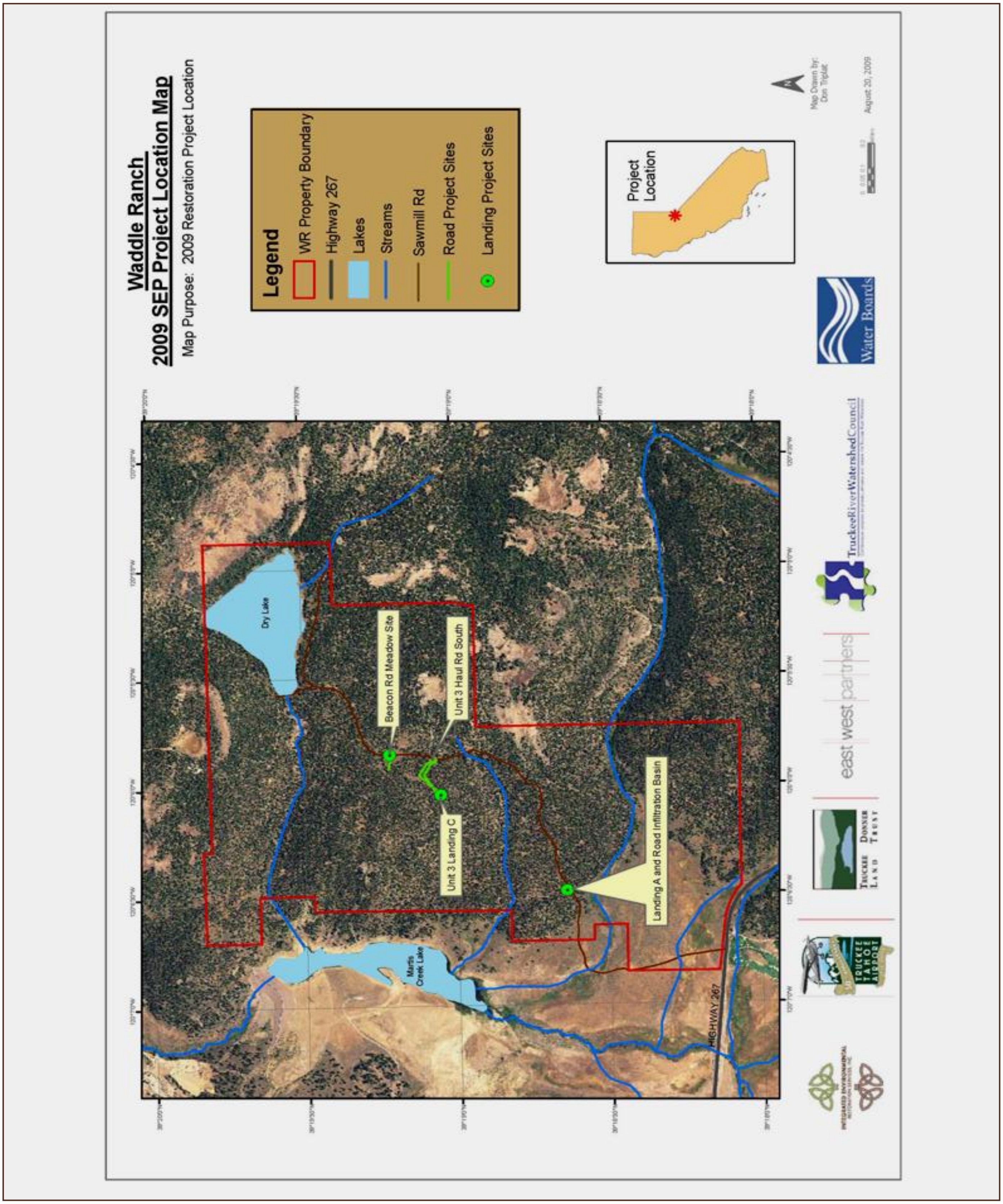


FIGURE 2: GENERAL SITE AND PLOT LOCATION MAP

BASELINE CONDITIONS

Baseline conditions consisted of a highly compacted landing. Average penetrometer Depths to refusal were approximately 2 inches.

Figure 3. Ripping with a modified excavator bucket.

Figure 4. Stock piled chips at Landing C.

Figure 5. Landing C pre-treatment.

Figure 6. Landing C post treatment.

TREATMENT DATES

September 29, 2009 – October 2, 2009

TREATMENT DESCRIPTION

The landing was separated into 6 test plots (**Error! Reference source not found.**). Wood chip amendment was spread over plots 1-5 to a depth of approximately 5". Plot 1E was scraped clean of any amendment.

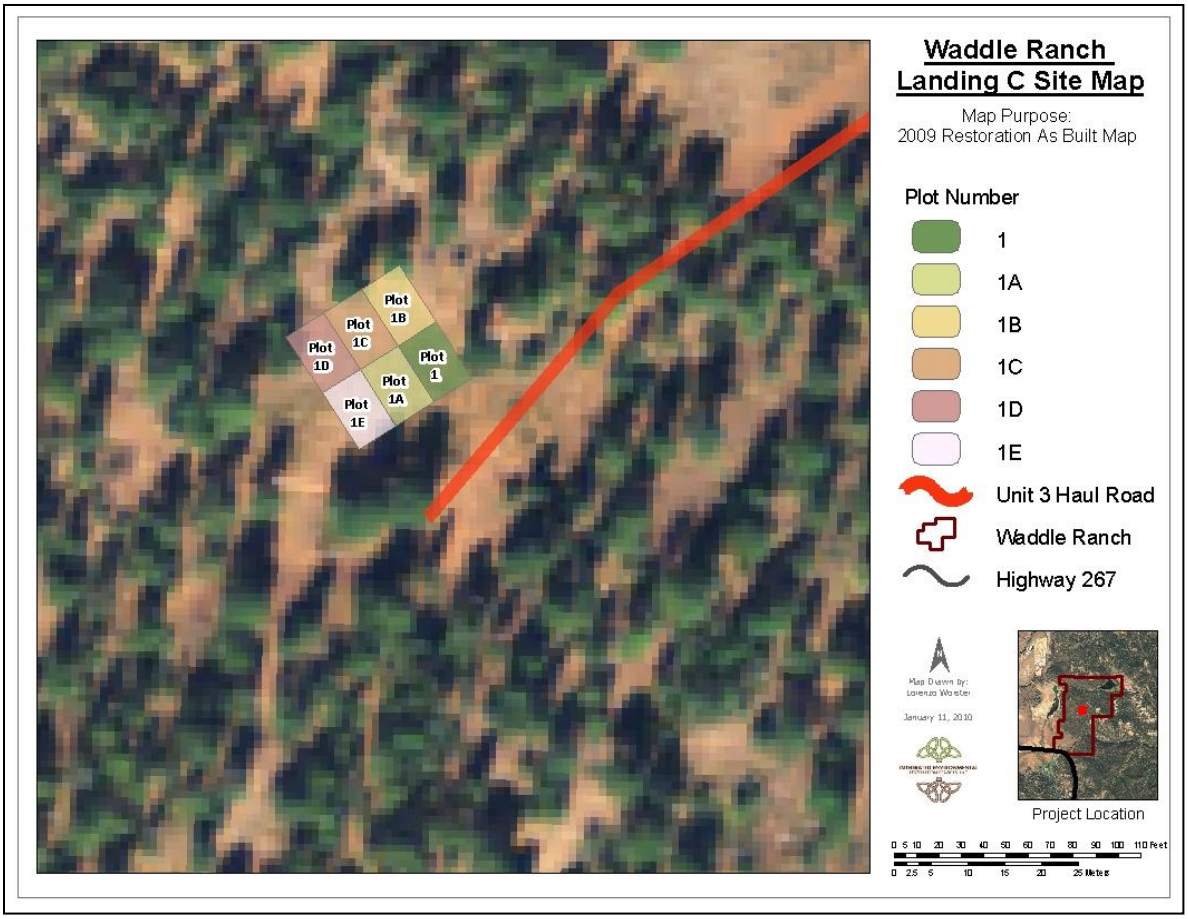


FIGURE 7: PLOT LOCATION AND LAYOUT

Plot 1 and 1A were tilled with a standard 36" excavator bucket to at least 12". Biosol was spread and raked into each plot. Seed was then spread and raked on plot 1 and both plots were covered with a woodchip mulch. This is our standard full treatment.

As a comparison, plots 1B and 1C were treated by ripping using a modified excavator bucket to at least 12". Biosol was spread and raked into each plot. Seed was then spread and raked into the surface. Some woodchip amendment was left on the surface as mulch. The mulch was raked to insure coverage at the same time the seed was raked into the soil.

Plots 1D and 1E were not tilled. 1E was spread with woodchips as a mulch. Plot 1E was scraped to the mineral soil to provide as a control (untreated) plot.

TABLE 2. TREATMENT MATRIX

Treatments		Plot 1	Plot 1A	Plot 1B	Plot 1C	Plot 1D	Plot 1E (Control)
Amendment	**Type**	Green Wood Chips (<50% Needles)	Green Wood Chips (<50% Needles)	Green Wood Chips (<50% Needles)	Green Wood Chips (<50% Needles)	None	None
	Depth	4.8"	4.84"	5.16"	4.86"		
Soil Loosening	**Type**	KX161 Full bucket	KX161 Full bucket	KX161 Mod. Bucket rip	KX161 Mod. Bucket rip	None	None
	Depth	14"	11.75"	12.25"	12.1"		
Fertilizer	**Type**	Biosol 6-1-3	Biosol 6-1-3	Biosol 6-1-3	Biosol 6-1-3	None	None
	Rate	2000lbs/acre	2000lbs/acre	2000lbs/acre	2000lbs/acre		
Seed	**Mix**	Shrub/Forb/Grass mix	None	Shrub/Forb/Grass mix	None	None	None
	Rate	125lbs/acre PLS	-	125lbs/acre PLS	-		
Mulch	**Type**	Green Wood Chips (<50% Needles)	Green Wood Chips (<50% Needles)	Green Wood Chips (<50% Needles)	Green Wood Chips (<50% Needles)	Green Wood Chips (<50% Needles)	None
	Depth	2.2"	2.3"	3.2"	1.7"	5.5"	
Dimensions in ft^2		60 x 20 = 1200ft^2	60 x 20 = 1200ft^2	60 x 20 = 1200ft^2	60 x 20 = 1200ft^2	60 x 20 = 1200ft^2	60 x 20 = 1200ft^2
Dimensions in m^2		9 x 6 = 54	9 x 6 = 54	9 x 6 = 54	9 x 6 = 54	9 x 6 = 54	9 x 6 = 54

MATERIALS

The materials used on this project were all from local sources and included:

- Woodchips were sourced onsite from a regional timber harvest.
- Biosol Organic Fertilizer (6-1-3) was sourced from Pacific Coast Seed.
- Native seed mix was sourced from Comstock Seed and consisted of a local species mix of grass, shrub, and forb seed (**Error! Reference source not found.**).

TABLE 3. MATERIALS SOURCE AND QUANTITY LIST.

Materials	Type	Source
Amendment	Green Wood Chips	Local forestry operation
Fertilizer	6-1-3 Biosol	Pacific Coast Seed
Seed	IERS Upland Mix	Comstock Seed
Mulch	Green Wood Chips	Local forestry operation

TABLE 4. IERS UPLAND SHRUB, FORB, GRASS MIX.

Scientific Name	Common Name	Pure Live Seed (%)	Rate (lbs/acre)
Elymus elymoides	Squirreltail or bottlebrush	28.33	35.42
Elymus glaucus	Blue wildrye	33.33	41.67
Bromus carinatus	Mountain brome	27.50	34.38
Purshia tridentata	Antelope bitterbrush	6.67	8.33
Ribes cereum	Wax currant	0.42	0.52
Eriogonum umbellatum	Sulphur flower buckwheat	2.08	2.60
Arctostaphylos patula	Geenleaf manzanita	1.67	2.08

PERSONNEL

Don Triplat, IERS Project Manager; Lorenzo Worster, IERS Foreman; Kate Gross, IERS Restoration Technician; Brad Lariviere, IERS Restoration Technician; Peter Ceccon, IERS Restoration Technician/Equipment Operator

NEXT STEPS

1. Monitor plots during the 2011 season for total cover, infiltration rate and soil nutrients

WADDLE RANCH UNIT 3 HAUL ROAD

AS-BUILT REPORT

Prepared By Michael Hogan and Lorenzo Worster

Integrated Environmental Restoration Services

For the Lahontan Regional Water Quality Control Board

March 24th, 2011

INTRODUCTION

This report describes post logging treatments that were done to a haul road at the Waddle Ranch. Haul roads are often associated with a large increase in sediment delivery to the watershed. Those haul roads are typically not restored after use since they may be used in subsequent logging operations and may also provide infrequent access for maintenance, fire and other needs. Thus, the ability to reduce sediment from these roads will help protect watershed water quality and can also reduce maintenance costs that are incurred on roads that are actively eroding. This test project was set up to determine whether there are some cost effective methods that can be used to stabilize roads following logging and that can reduce sediment delivery and protect water quality.

PURPOSE OF TEST

These test plots were installed in order to compare 3 treatments and a no-treatment control on a logging road that was used heavily during the 2009 logging operations at Waddle Ranch. The purpose of the tests is to determine to what level each treatment can reduce sediment. We compared a 3" layer of mulch on the compacted surface, tilling of wood chips into the soil, seeded and then mulched (to determine whether vegetation can be reestablished) and asphalt grindings applied to the surface as a 'mulch/surface protectant' .

Test questions:

On an infrequently used dirt road…

- Can a 3" layer of wood chip mulch on a compacted road surface reduce mulch significantly?
- Can tilling wood chips into the road surface, seeding and mulching reduce erosion, help establish vegetation and still allow some infrequent use?
- Can a 1" layer of asphalt grindings reduce erosion and dust on an infrequently used dirt road?

OUTCOME

- Increased understanding of road protection treatments for post logging road surfaces
- Increased understanding of 'temporary' (2-25 yr window) dirt road stabilization methods as they relate to erosion, sediment delivery and water quality.

OUTPUT

1. Sediment data for 3 road surface treatments compared to no treatment
2. Vegetation response data for those treatments

SITE LOCATION AND DESCRIPTION

Unit 3 haul road is located on Sawmill Flat Road about .25 miles short of Beacon Meadow when approaching from Martis Valley. The site was used for hauling timber as recent as the summer of 2009. The road has a low slope angle and was highly compacted.

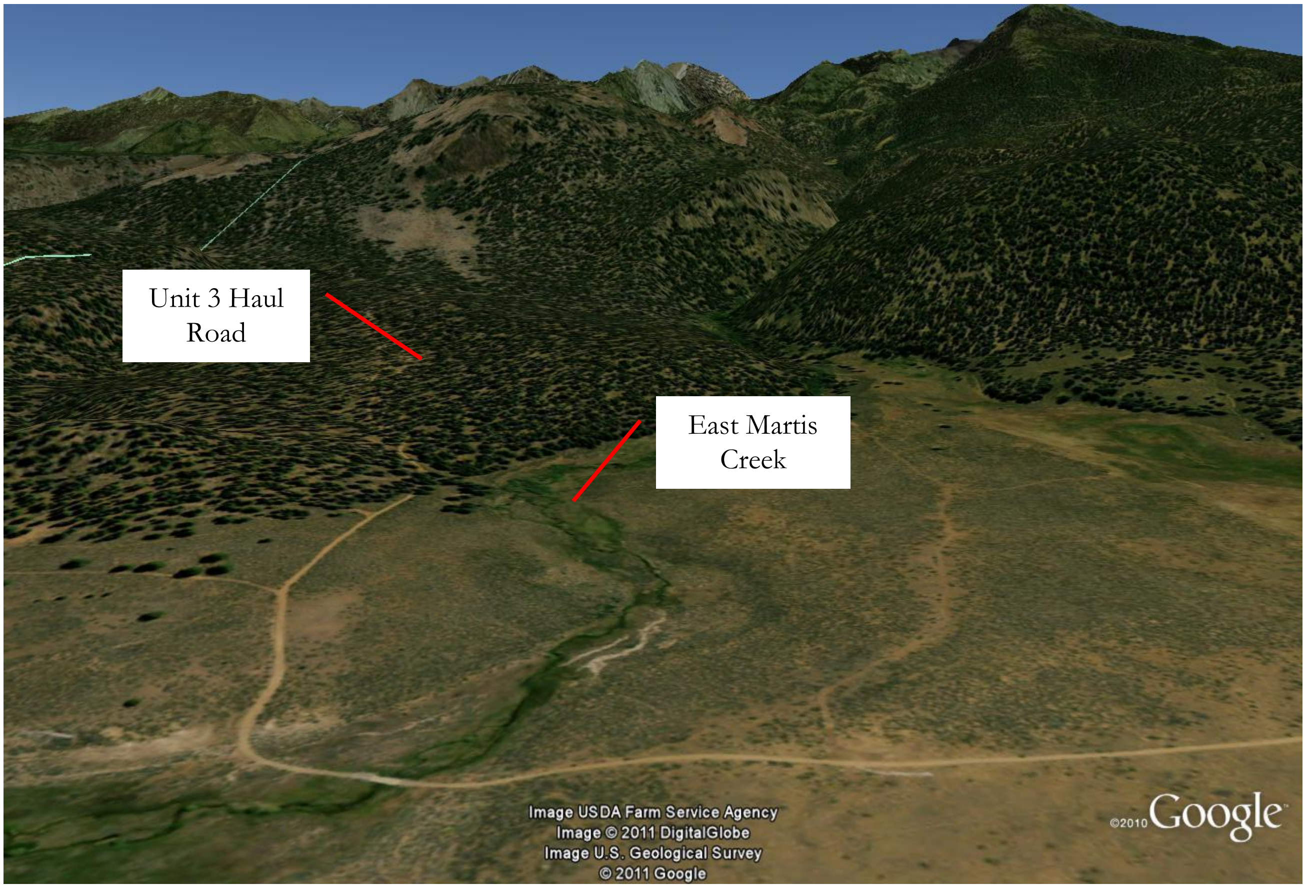


FIGURE 1: GOOGLE EARTH IMAGE SHOWING UNIT 3 HAUL ROAD AND PROXIMITY TO EAST MARTIS CREEK

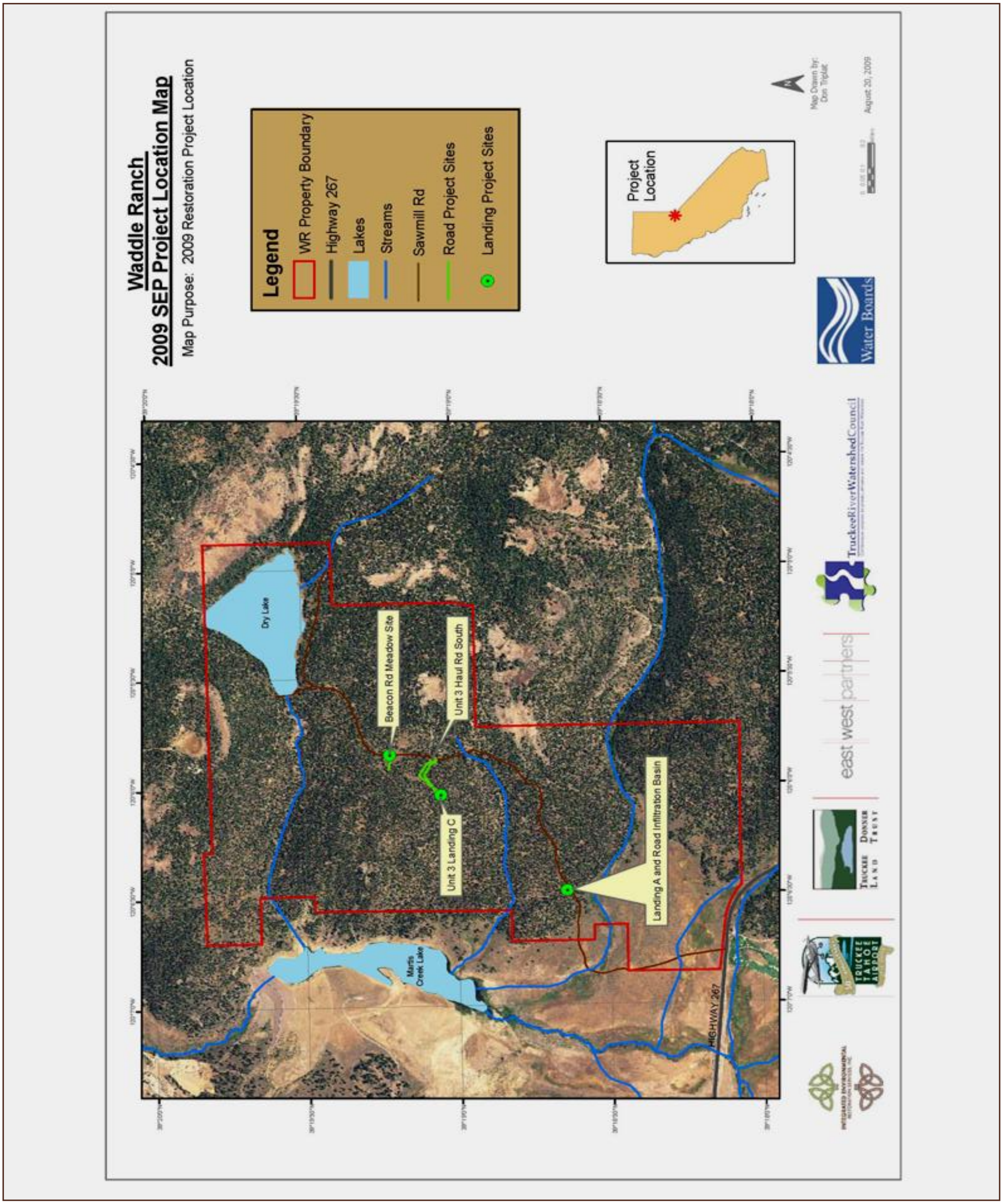


FIGURE 2: LOCATION MAP

BASELINE CONDITIONS

The site consisted of a recently used haul road that was highly compacted below 1". The top 1" of road surface was loosened due to truck and tractor traffic and prior to mulch application was prone to wind and water erosion.

TREATMENT DATES

September 30, 2009 – October 2, 2009

TREATMENT DESCRIPTION

The road segment was separated into 4 test plots. Plots 2A (surface mulch only) and 2B (tilled, amended, seeded, mulched) are approximately 100' in length and 12' wide covering 1200ft^2. Plot 2C (control) is 52' long and 12' wide covering 624ft^2. Plot 2 D)(asphalt grindings) measured 25' by 12' for a total of 300ft^2.

Figure 3. An example of ripping with a modified excavator bucket.

Figure 4. Stock piled chips at Landing C.

Figure 5. Plot 2B

Figure 6. Compacted asphalt grindings on plot 2E

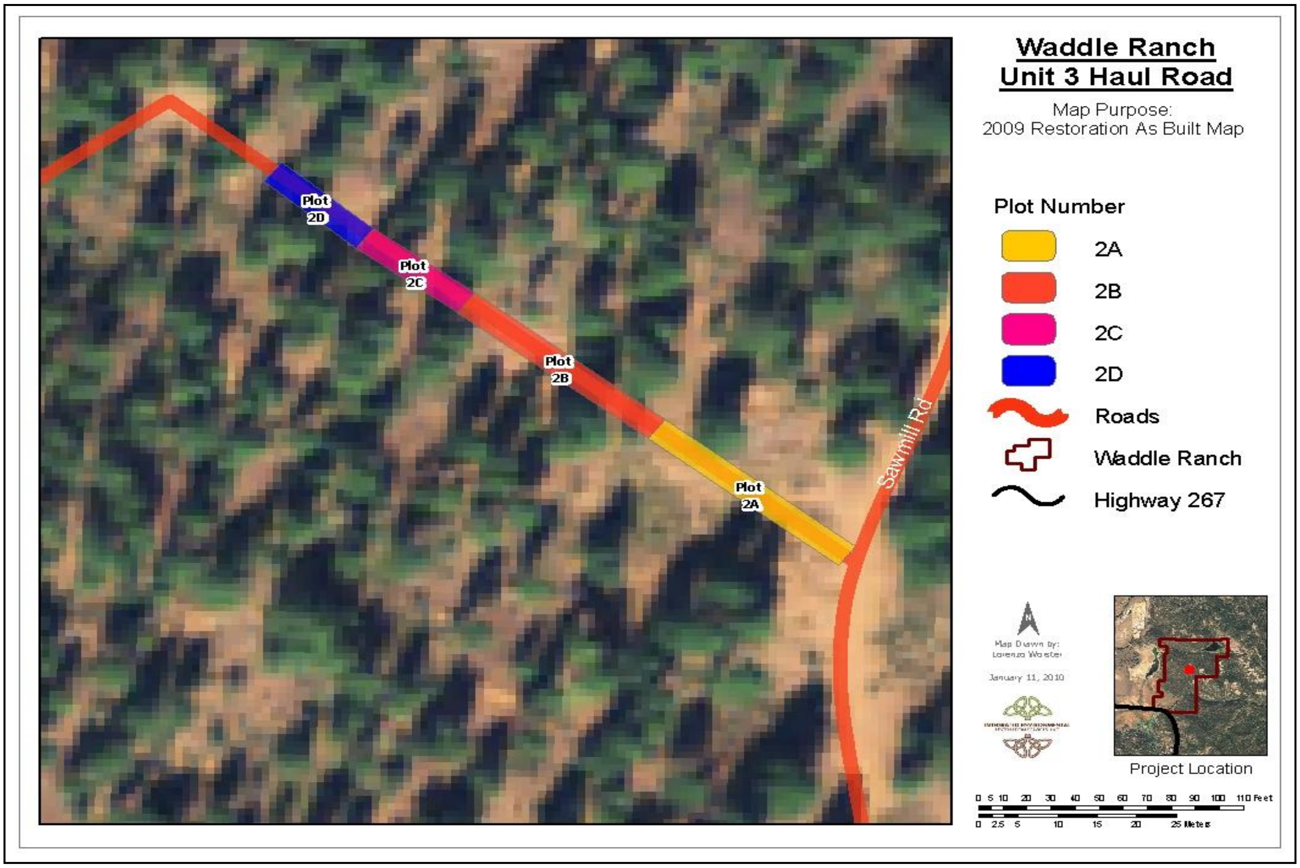


FIGURE 7: PLOT LOCATION AND LAYOUT

TABLE 1. TREATMENT MATRIX

Treatments		Plot 2A	Plot 2B	Plot 2C	Plot 2D
Amendment	**Type**	None	Green Wood Chips (<50% Needles)	None	None
	Depth	-	3.8″	-	-
Soil Loosening	**Type**	None	KX161 Full bucket	None	None
	Depth	-	11.5″	-	-
Fertilizer	**Type**	None	Biosol 6-1-3	None	None
	Rate	-	2000lbs/acre	-	-
Seed	**Mix**	None	Shrub/Forb/Grass mix	None	None
	Rate	-	125lbs/acre PLS	-	-
Mulch	**Type**	Green Wood Chips (<50% Needles)	Green Wood Chips (<50% Needles)	None	Compacted Asphalt Grindings
	Depth	3″	1.4″	-	1.7″
Dimensions in ft^2		100 x 12 = 1200ft^2	100 x 12 = 1200ft^2	52 x 12 = 624ft^2	25 x 12 = 300ft^2
Dimensions in m2		30 x 4.5 = 137.25m^2	30 x 4.5 = 137.25m^2	16 x 4.5 = 72m^2	8 x 4.5 = 36m^2

MATERIALS

The materials used on this project included:

- Woodchips were sourced onsite from a regional timber harvest and fuels reduction program.
- Biosol Organic Fertilizer (6-1-3) was sourced from Pacific Coast Seed.
- Native seed mix was sourced from Comstock Seed and consisted of a Tahoe specific mix of grass, shrub, and forb seed (**Error! Reference source not found.**).
- Asphalt grindings were bought from Al Pombo Inc.

TABLE 2. MATERIALS SOURCE AND QUANTITY LIST.

Materials	Type	Source	QTY
Amendment	Green Wood Chips	Local forestry operation	37yds^3
Fertilizer	6-1-3 Biosol	Pacific Coast Seed	55lbs
Seed	IERS Upland Mix	Comstock Seed	3.5lbs
Mulch 1	Green Wood Chips	Local forestry operation	In amendment qty
Mulch 2	Asphalt Grindings	Al Pombo Inc.	3yds^3

TABLE 3. IERS UPLAND SHRUB, FORB, GRASS MIX., EQUIVALENT PER ACRE AMOUNT

Scientific Name	Common Name	Pure Live Seed (%)	Rate (lbs/acre)
Elymus elymoides	Squirreltail or bottlebrush	28.33	35.42
Elymus glaucus	Blue wildrye	33.33	41.67
Bromus carinatus	Mountain brome	27.50	34.38
Purshia tridentata	Antelope bitterbrush	6.67	8.33
Ribes cereum	Wax currant	0.42	0.52
Eriogonum umbellatum	Sulphur flower buckwheat	2.08	2.60
Arctostaphylos patula	Geenleaf manzanita	1.67	2.08

PERSONNEL

Don Triplat, IERS Project Manager; Lorenzo Worster, IERS Foreman; Kate Gross, IERS Restoration Technician; Brad Lariviere, IERS Restoration Technician; Peter Ceccon, IERS Restoration Technician/Equipment Operator.

INCIDENTAL NOTES

Road may receive some incidental traffic during 2010 but according to Airport staff, will not be reused for several seasons.

NEXT STEPS

1. Monitor road surfaces for runoff, rainfall, infiltration
2. Monitor road test areas for vegetation response, especially plot 2B