Appendix H. Pond Evaluation, Road Crossing Evaluation, and Zim Zim Creek Evaluation

WEST YOST ASSOCIATES 25 YEARS 1990–2015

REGISTERED PROFESSIONAL ENGINEER DOUGLAS T. MOORE No. 58122 Exp. 6-30-16 CIVIL STATE OF CALIFORNIA

TECHNICAL MEMORANDUM

DATE: October 9, 2015 Project No.: 579-10-15-02
SENT VIA: EMAIL

TO: Matt Wacker, H.T. Harvey & Associates

FROM: Doug Moore, R.C.E. #C058122

REVIEWED BY: Mary Young, R.C.E. #39713

SUBJECT: Knoxville Wildlife Areas Land Management Plan Pond Evaluation

INTRODUCTION

The Knoxville Wildlife Area (KWA) Land Management Plan Pond Evaluation is summarized in this Technical Memorandum. In accordance with the H. T. Harvey & Associates' Team scope and in collaboration with the California Department of Fish and Wildlife (CDFW), 5 ponds in the KWA were selected for evaluation. These ponds were selected because they are representative of the majority of ponds within the Knoxville Wildlife Area. The purpose of the pond evaluation is to identify sources of impairment (e.g., sedimentation, erosion) and develop restoration recommendations to address impairments and improve the hydrologic and ecological functions of the ponds. Therefore, the below observations and recommendations were developed via collaboration between West Yost's engineers and H. T. Harvey & Associates ecologists. This evaluation does not include an assessment of environmental clearance requirements for the recommended actions.

The following ponds are evaluated:

- Pond P10 (Windmill)
- Pond P24 (Corral)
- Pond P49 (Wilson Barn)
- Pond P62 (Air Strip)
- Pond P68 (Bathtub)

The pond locations are shown on Figure 1. Site visits to the ponds were conducted on April 21, 2015 by Doug Moore (West Yost Associates' engineer). Additionally, H. T. Harvey & Associates' ecologists Hillary White, Rebecca Nuffer, and Renata Di Battista visited ponds 62 and 68 on April 23 and May 6, 2015, respectively. During the site visits, a pond data sheet was completed and the pond and surrounding area were photographed.

Each pond evaluation below includes the following sections:

- Problem Statement – The problems statements were provided by CDFW staff.
- Photographs – Photographs of certain elements of the ponds are provided.
- Aquatic Vegetation – The observed aquatic vegetation are noted.
- Erosion – Erosion problems are summarized.
- General Observations – General Observations are summarized.
- Recommended Improvements – The recommended improvements are discussed.
- Improvement Cost Estimates – The cost of the recommended improvements are estimated. Costs are based on RSMeans Heavy Construction Cost Data for 2015 and the work being performed by a private contractor. All cost estimates are preliminary and need to be refined through more detailed predesign and design of the improvements for each pond site. If CDFW staff perform the work using CDFW-owned equipment, the costs could be reduced.

POND P10 (WINDMILL)

The Pond P10 evaluation is presented below.

Problem Statement

CDFW identified the following as the problems for this pond:

- Design a livestock water delivery system while maintaining or improving wildlife habitat values; and
- Increase the hydroperiod (length of time the pond retains water through the spring and summer).

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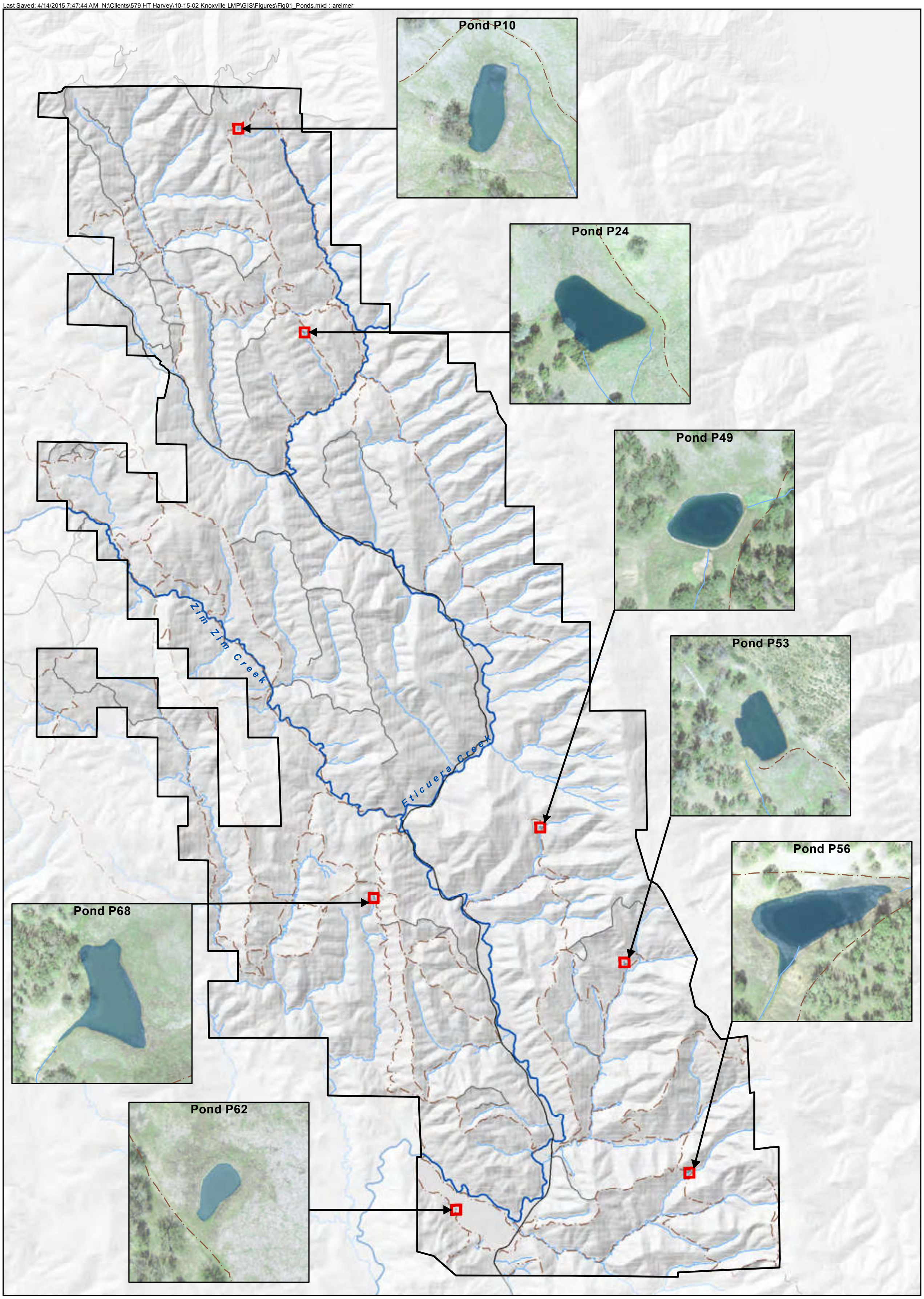

Symbology

Pond of Interest

Other Knoxville Wildlife Area Pond

Zim Zim and Eticuera Creeks

Other Waterway

Paved Road

Possible Route

Overland Route

Trail

Knoxville Wildlife Area

N

0 2,000 4,000

Scale in Feet

Inset Maps: 1 inch = 200 feet

WEST YOST ASSOCIATES

Figure 1

Knoxville Wildlife Area
Ponds of Interest

Knoxville Wildlife Area

Photographs

Photographs of the pond and surrounding area are provided below:

Pond P10 viewed from the north.

Pond P10 viewed from the south.

Erosion of the hillside above Pond P10 generates
sediment that contributes to filling of the pond.

The dam embankment is eroding below the twin pipe outlet.

The channel at the toe of the dam is eroding.

Aquatic Vegetation

The following aquatic vegetation was observed at this pond:

- Cattails (*Typha* sp.) – only at the north end of the pond;
- Tules (*Schoenoplectus* sp.) – only at the north end of the pond;
- Spikerush (*Eleocharis macrostachya*) – around the perimeter of the pond; and
- Buttercup (*Ranunculus aquatilis*) - around the perimeter of the pond.

Erosion

Erosion is occurring on the hillside above the north end of the pond. This erosion may be depositing sediment in the north end of the pond, reducing the water depth such that the cattails and tules have grown at the north end.

There is a small amount of erosion on the dry side of the pond dam. There is also erosion just below the release pipes.

General Observations

The release pipes are rusted, but visually appear to be in reasonable condition.

Wildlife Habitat Values

The pond currently provides moderately suitable habitat for western pond turtle (*Actinemys marmorata*) and California red-legged frog (*Rana draytonii*). The emergent vegetation (i.e., tules and cattails) at the north end of the pond provides limited cover for western pond turtles and California red-legged frogs. There are no natural basking features or underwater refugia (e.g., rocks, logs) for western pond turtles. The uplands surrounding the pond currently support vegetation at a suitable height to facilitate nesting by western pond turtles.

Recommended Improvements

To prevent continued erosion, the small areas of erosion above the pond should be revegetated. The revegetation would include: 1) grading to fill the ruts and channels with topsoil and/or 2-inch to 6-inch rock, depending upon further design; 2) manual broadcast seeding of topsoil with the seed mix presented in Table 1; and 3) installation of a biodegradable, long-term erosion control blanket made of coconut fiber or other degradable fibers.

Table 1. Recommended Broadcast Seed Mix for Repair of Small Erosion Areas[(a)]

Species	Pure Live Seed, lbs/ac
Arroyo lupine (*Lupinus succulentus*)	3
Blue wildrye (*Elymus glaucus*)	12
California melic (*Melica californica*)	5
One-sided bluegrass (*Poa secunda* ssp. *secunda*)	8
Purple needle grass (*Stipa pulchra*)	5
Small fescue (*Festuca microstachys*)	5
Tomcat clover (*Trifolium willdenovii*)	2
Yarrow (*Achillea millefolium*)	1

(a) The seeds should be obtained from a commercial seed producer specializing in California native plants and should originate from seed sources within the Coast Range regions of Yolo, Napa, or Lake Counties.

Approximately 2 cubic yards of rock scour protection should be placed below the dam discharge pipes to prevent continued erosion of the discharge channel.

To increase the hydroperiod two improvements could be implemented: 1) Native drought tolerant trees (species to be determined during detailed design) could be planted along the western pond bank to partially shade the pond; and 2) Increase the pond area and hydroperiod by reconstructing the southern segment of the pond dam to capture the intermittent flows from the drainage at the south edge of the pond. Additionally, accumulated sediment could be removed from the pond bottom, increasing the depth by 2 to 3 feet. The estimated volume of earthwork for the extension of the dam is about 1,200 cubic yards (CY). Dirt from the southern end of the dam could potentially be reused for the dam extension. The estimated volume of sediment to be removed is about 500 CY. The removed sediment from the pond could also potentially be used for the dam relocation. The suitability of the local soils/sediment for use in the dam would have to be verified through a geotechnical evaluation. The bare ground after the earthwork should be revegetated with the seed mix in Table 1.

A stock watering tank and trough could be installed on the relatively flat ground southeast of the pond. The watering trough system would include a trough, a water storage tank, a small pump powered by solar panels, and piping from the pond to the trough. Fencing would also be installed around the pond to prevent livestock access to the pond.

Recommended Wildlife Habitat Enhancements

If sediment is excavated from the pond bottom to increase hydroperiod, excess sediment could be placed at the north end of the pond to expand the existing small patch of emergent vegetation. Soil should be placed to facilitate summer water depths of 1-2 feet along the margin of the north end of the pond. Shallow water levels will facilitate recruitment and growth of emergent vegetation that provides cover for western pond turtles. It is also recommended that rocks, stumps, logs, or other natural debris be placed in and around the pond to provide natural basking features and underwater refugia for western pond turtles. Such features would also provide underwater escape cover for California red-legged frogs. As described above, planting trees along the western margin of the pond is recommended as a way to increase hydroperiod; however, planting should be limited to a small portion of the margin of the pond to ensure that the majority of the pond receives adequate sun exposure for western pond turtles and California red-legged frogs.

Improvement Cost Estimates

Approximate construction costs for the improvements described above are provided in Table 2.

Table 2. Preliminary Cost Estimate for the Pond P10 Improvements (Windmill)

Item	Unit	Unit Cost	Quantity	Cost, dollars
Improve Site Access	Labor Hours	150	24	3,600
Revegetate Erosion Area	Acres	10,000	0.02	200
On-Site Earthwork	CY	40	1,200	48,000
Revegetate Earthwork Area	Acres	10,000	0.25	2,500
Rock Scour Protection (less than 8 CY)	LS	2,000	1	2,000
Tree Installation and 3 Years Watering/Weeding	Each	200	4	800
Fencing	Feet	10	700	7,000
Stock Watering Trough System	Each	10,000	1	10,000
Dewatering	Lump Sum	5,000	1	5,000
Mobilization and Demobilization (20%)	Lump Sum	15,820	1	15,820
Miscelaneous (at 25 Percent)	Lump Sum	19,775	1	19,775
			Total (rounded up)	$115,000

POND P24 (CORRAL)

The Pond P24 evaluation is presented below.

Problem Statement

CDFW identified the following as the problem for this pond:

- Improve dam stability.

Photographs

Photographs of the pond and surrounding area are provided below.

Pond P24 dam viewed from the east.

Pond P24 viewed from the southeast.

Pond P24 dam from the west.

Erosion of Dam Spillway just below the Dam Crest at Pond P24.

Aquatic Vegetation

The following aquatic vegetation was observed at this pond:

- Spikerush (*Eleocharis macrostachya*) – around the perimeter of the pond; and
- Buttercup (*Ranunculus aquatilis*) – around the perimeter of the pond.

Erosion

There is a small area of erosion on the dam spillway just below the dam crest.

General Observations

There are animal burrows in the dam embankment.

Wildlife Habitat Values

The pond currently provides limited habitat for western pond turtle and California red-legged frog. The pond supports only a small amount of spikerush but lacks more substantial emergent vegetation like tules and cattails that provide cover for western pond turtles and California red-legged frogs. Emergent vegetation is also important to California red-legged frogs during the breeding season because they attach their egg masses to this substrate. Additionally, there are no natural basking features or underwater refugia (e.g., rocks, logs) for western pond turtles in or around the pond. The uplands surrounding the pond support vegetation at a suitable height to facilitate nesting by western pond turtles. The dam embankment supports animal burrows that may provide upland refugia for California red-legged frogs.

Recommended Improvements

The animal burrows should be filled with dirt. Also, about 2 CY of rock erosion protection should be placed in the spillway erosion area.

Recommended Wildlife Habitat Enhancements

Plugs of native emergent vegetation (e.g., tules, cattails) could be planted in shallow ponded areas (with summer water depths of 1-3 feet) along the margin of the pond to provide cover for western pond turtles and California red-legged frogs and habitat for native birds. This recommendation assumes that the summer ponding depth throughout the majority of the pond is greater than 4 feet to ensure that planted tall emergent vegetation does not colonize the majority of the pond. Natural basking features and underwater refugia (e.g., rocks, logs) could be placed in and along pond margins.

Improvement Cost Estimates

Approximate construction costs for the improvements described above are provided in Table 3.

Table 3. Preliminary Cost Estimate for the Pond 24 Improvements (Corral)				
Item	Unit	Unit Cost	Quantity	Cost, dollars
Improve Site Access	Labor Hours	150	32	4,800
Rock Scour Protection (less than 8 CY)	LS	2,000	1	2,000
Mobilization and Demobilization (20%)	Lump Sum	1,360	1	1,360
Miscellaneous (at 25 Percent)	Lump Sum	1,700	1	1,700
			Total (rounded up)	$10,000

POND P49 (WILSON BARN)

The Pond P49 evaluation is presented below.

Problem Statement

CDFW identified the following as the problems for this pond:

- Increase the hydroperiod; and
- Improve the reservoir reliability (dam stability).

Photographs

Photographs of the pond and surrounding area are provided below:

Pond viewed from the northeast.

West bank of the Dam Breach viewed from the east.

East bank of the Dam Breach viewed from the west.

Dam Breach viewed from the North.

Aquatic Vegetation

The following aquatic vegetation was observed at this pond:

- Spikerush (*Eleocharis macrostachya*) – around the perimeter of the pond; and
- Buttercup (*Ranunculus aquatilis*) - around the perimeter of the pond.

Erosion

A segment of the dam has been eroded to the point that the dam cannot retain its full water volume. This erosion is so deep that flow from the dam occurs through this erosion problem area rather than down the intended spillway. With continued erosion, the dam will cease to retain any water.

A small area of erosion was occurring above the east end of the pond.

The spillway downstream of the dam has eroded, and the hillside above the spillway has also eroded.

General Observations

No additional observations or issues were noted during the site visit.

Wildlife Habitat Values

The pond currently provides moderate habitat for western pond turtle and California red-legged frog. The pond supports spikerush along its margins which provides some cover for California red-legged frog, as well as a substrate on which to attach egg masses. The pond lacks tall emergent vegetation like tules and cattails that provide cover for western pond turtles and California red-legged frogs. Additionally, there are no natural basking features or underwater refugia (e.g., rocks, logs) for western pond turtles in or around the pond. The vegetation in the surrounding uplands is generally thick and tall and composed of nonnative species such as ripgut brome (*Bromus diandrus*) and Italian thistle (*Carduus pycnocephalus*).

Recommended Improvements

The eroded dam segment needs to be reconstructed with about 1,000 CY of imported dirt. This work will also require cutting back and replacing segments of the existing dam (800 CY) to achieve a stable slope to place the imported fill against.

The small area of erosion above the east end of the pond should be revegetated via broadcast seeding and biodegradable erosion control fabric to prevent continued erosion. Table 1 provides the recommended seed mix.

About 4 cubic yards of rock scour protection should be placed in the dam spillway.

Recommended Wildlife Habitat Enhancements

Plugs of native emergent vegetation (e.g., tules, cattails) could be planted in shallow ponded areas (summer water depth of 1-3 feet) along the margin of the pond to provide cover for western pond turtles and California red-legged frog and habitat for native birds. This recommendation assumes that the summer ponding depth throughout the majority of the pond is greater than 4 feet to ensure that planted tall emergent vegetation does not colonize the majority of the pond. Natural basking features and underwater refugia (e.g., rocks, logs) could be placed in and along pond margins. The adjacent uplands could be grazed to help reduce vegetation height and facilitate upland nesting by western pond turtles.

Improvement Cost Estimates

Approximate construction costs for the improvements described above are provided in Table 4.

Table 4. Preliminary Cost Estimate for the Pond P49 Improvements (Wilson Barn)				
Item	Unit	Unit Cost	Quantity	Cost, dollars
Improve Site Access	Labor Hours	150	16	2,400
Revegetate Erosion Area East of Dam	Acres	10,000	0.01	100
Import Fill	CY	60	1,000	60,000
On-Site Earthwork	CY	40	1,800	72,000
Revegetate Dam Construction Area	Acres	10,000	0.25	2,500
Rock Scour Protection (less than 8 CY)	LS	2,000	1	2,000
Mobilization and Demobilization (20%)	Lump Sum	27,800	1	27,800
Miscellaneous (at 25 Percent)	Lump Sum	34,750	1	34,750
Geotechnical Engineering (at 25 Percent)	Lump Sum	34,750	1	34,750
			Total (rounded up)	$237,000

POND P62 (AIRSTRIP)

The Pond P62 evaluation is presented below.

Problem Statement

CDFW identified the following as the problems for this pond:

- Increase the pond storage volume/holding capacity; and
- Increase the hydroperiod.

Photographs

Photographs of the pond and surrounding area are provided below.

Pond P62 viewed from the south.

Pond P62 Water supply drainage showing the breach
in the pond levee that allows supply water to bypass the pond.

Pond P62 Water supply channel coming from the
hillside to south and west.

Pond P62 Water supply channel going to the pond. The breach
in the pond levee that allows supply water to bypass the pond is visible.

Aquatic Vegetation

The following aquatic vegetation was observed at this pond:

- Algae

Erosion

There is a small area of erosion on the north bank of the pond.

General Observations

The pond was constructed on relatively flat ground by digging a hole and using the excavated dirt to construct the pond levees. It appears that the intended water supply for the pond is the drainage from the hillside to the southwest of the pond. The drainage was originally directed into the pond by a short segment of levee that conveys the flow into the pond. At some time in the past, the end of the levee segment that was intended to direct the flow into the pond has eroded away, although the old erosion area is now vegetated and is not currently eroding. Consequently, most of the flow from the drainage probably bypasses the pond and continues to flow to the north. There is no release from the pond, so there is no significant flow through the pond. This condition is probably why this pond is stagnant.

Wildlife Habitat Values

The pond currently provides limited habitat for western pond turtle and California red-legged frog. The pond is stagnant and lacks emergent vegetation that provides cover for western pond turtles and California red-legged frogs, however, algal blooms can provide cover for these species in the absence of emergent vegetation. Additionally, there are no natural basking features or underwater refugia (e.g., rocks, logs) for western pond turtles in or around the pond. The vegetation in the surrounding uplands is thick and tall and composed of nonnative species such as ripgut brome, Italian thistle, and yellow star-thistle (*Centaurea solstitialis*).

Recommended Improvements

The recommended improvements for this site include:

The eroded levee segment should be reconstructed to direct flow into the pond. Additionally, to prevent erosion of the levee segment in the future, a release structure should be constructed to prevent flow over the pond levee and the associated erosion of the levee. The release structure should be constructed at the opposite end of the pond from the inlet to allow flow through the pond. The release structure would be a relatively simple structure such as a standpipe in the pond (a precast manhole) and a release pipe through the levee (alternatively a concrete spillway could be used). A swale would need to be constructed to convey the released flow around the north end of end of the pond and back into its current channel.

The pond could be enlarged and deepened. The excavated dirt could potentially be used for the new pond levee. Also, the enlargement could be designed to provide the dirt needed for the reconstruction of the Pond P49 (Wilson Barn) dam. Making the pond deeper would increase the hydroperiod of the pond. This earthwork would generate about 3,400 CY of dirt, but only about 800 CY would be needed for the Pond P62 work. There would be about 2,600 CY of remaining dirt. About 1,000 CY of the remaining dirt could be used for the Pond P49 dam repair and about 1,600 CY would be available for other uses. Alternatively the enlargement of Pond P49 could be shallower or smaller to result in a balance of the excavated dirt and the required dirt. However, a geotechnical evaluation would be required to determine the suitability of the excavated material for dam/levee construction.

All disturbed, upland soils would be revegetated for erosion control by manually broadcasting a native seed mix (Table 1). Biodegradable erosion control fabric may be necessary in graded areas where flow is concentrated.

Recommended Wildlife Habitat Enhancements

If sediment is excavated from the pond to increase hydroperiod, excess sediment could be placed at one end of the pond or along pond margins to create shallow summer water depths of 1-3 feet. Shallow water depths would facilitate recruitment and growth of emergent vegetation that provides habitat for native species. Plugs of native, tall emergent vegetation (e.g., tules, cattails) could be planted in these areas along pond margins to provide cover for western pond turtles and California red-legged frogs, a substrate on which to attach California red-legged frog egg masses, and habitat for native birds. This assumes that the majority of the pond is deeper than 4 feet in the summer, to preclude colonization by tall emergent vegetation and thereby retain a balance of open water and vegetated wetland. Natural basking features and underwater refugia (e.g., rocks, logs) for western pond turtle could be placed in and along pond margins. The adjacent uplands could be mowed or grazed to reduce vegetation height and facilitate upland nesting by western pond turtles. If mowing is used to manage vegetation, the height of mowing blades should be set no less than six inches from the ground. Herbicides or other methods of weed control (e.g., prescribed burning) could be used to control yellow star-thistle in the surrounding uplands

Improvement Cost Estimates

Approximate construction costs for the improvements described above are provided in Table 5. For this cost estimate, the pond enlargement was assumed to approximately double the pond size.

Table 5. Preliminary Cost Estimate for the Pond P62 Improvements (Air Strip)

Item	Unit	Unit Cost	Quantity	Cost, dollars
Improve Site Access	Labor Hours	150	8	1,200
Pond Excavation and Levee Earthwork	CY	20	2,700	54,000
Pond Standpipe	Lump Sum	5,000	1	5,000
Revegetate Dam Construction Area	Acres	10,000	0.50	5,000
Mobilization and Demobilization (20%)	Lump Sum	13,040	1	13,040
Miscellaneous (at 25 Percent)	Lump Sum	16,300	1	16,300
			Total (rounded up)	$95,000

POND P68 (BATHTUB)

The Pond P68 evaluation is presented below.

Problem Statement

CDFW identified the following as the problems for this pond:

- Potential for Dam failure; and
- Identify best practices for pond maintenance.

Photographs

Photographs of the pond and surrounding area are provided below.

Pond P68 viewed from the northeast.

Pond P68 has erosion of the spillway embankment.

Pond P68 has severe erosion of the spillway looking upstream.

Pond P68 has severe erosion of the spillway looking downstream.

Aquatic Vegetation

The following aquatic vegetation was observed at this pond:

- Cattails (*Typha sp.*) – only at the north end of the pond;
- Tules (*Schoenoplectus sp.*) – only at the north end of the pond;
- Spikerush (*Eleocharis macrostachya*) – around the perimeter of the pond; and
- Buttercup (*Ranunculus aquatilis*) - around the perimeter of the pond.

Erosion

The spillway is eroding, with a headcut migrating upstream toward the dam. The headcut appears to have reached bedrock, but will likely continue to slowly migrate toward the dam. The hillside above the spillway has also eroded. There is also a small area of bank sloughing of the spillway embankment.

General Observations

Several bullfrogs (*Lithobates catesbeianus*) were heard at this pond.

Wildlife Habitat Values

The pond currently provides suitable habitat for western pond turtle; however, bullfrogs were detected in the pond, which decreases habitat suitability for California red-legged frogs by elevating competition and predation risks. The pond supports some emergent vegetation that provides cover for western pond turtles and California red-legged frogs, a substrate on which to attach California red-legged frog egg masses, and habitat for native birds. Mats of floating emergent vegetation provide a basking substrate for western pond turtles, however, there are no other natural basking features or underwater refugia (e.g., rocks, logs) in or around the pond. The pond supports a small amount of invasive, Eurasian watermilfoil (*Myriophyllum spicatum*) that out competes native vegetation and decreases habitat suitability for aquatic species. The vegetation in the surrounding uplands is thick and tall and composed of nonnative species such as Italian thistle, yellow star-thistle, and common naturalized grasses.

Recommended Improvements

The head cut at the spillway may already be stabilized by bedrock. The position of the headcut should be monitored annually, and if it is still progressing, then it should be stabilized. To stabilize the spillway head cut, about 200 CY of rock should be placed in the spillway channel to prevent or slow the head cutting of the spillway. The sloughing of the spillway embankment should be revegetated.

Recommended Wildlife Habitat Enhancements

Bullfrogs should be managed or eradicated by draining the pond for approximately two to three weeks in September prior to the first rain fall. Fencing could be installed around the pond to prevent the emigration of adult bullfrogs during draw down. Bullfrogs observed during draw down should be removed using a combination of netting and gigging methods. Draining the pond should disrupt the two-year development cycle of bullfrogs and should substantially reduce or eliminate successful reproduction by bullfrogs. Treatment of Eurasian watermilfoil could be conducted simultaneously with draw down. Natural basking features and underwater refugia (e.g., rocks, logs) for western pond turtle could be placed in and along pond margins. Additionally, the adjacent uplands could be grazed to help reduce vegetation height and facilitate upland nesting by western pond turtles. Herbicides or other methods of weed control (e.g., prescribed burning) could be used to control yellow star-thistle in the surrounding uplands.

Improvement Cost Estimates

Approximate construction costs for the improvements described above are provided in Table 6.

Table 6. Preliminary Cost Estimate for the Pond P68 Improvements (Bath Tub)

Item	Unit	Unit Cost	Quantity	Cost, dollars
Improve Site Access	Labor Hours	150	24	3,600
Revegetate Sloughing of the Dam Spillway	Acres	10,000	0.01	100
Rock Scour Protection	CY	200	200	40,000
Mobilization and Demobilization (20%)	Lump Sum	8,740	1	8,740
Miscelaneous (at 25 Percent)	Lump Sum	10,925	1	10,925
			Total (rounded up)	$64,000

WEST YOST ASSOCIATES 25 YEARS 1990–2015

REGISTERED PROFESSIONAL ENGINEER DOUGLAS T. MOORE No. 58122 Exp. 6-30-16 CIVIL STATE OF CALIFORNIA

TECHNICAL MEMORANDUM

DATE:	October 7, 2015	Project No.: 579-10-15-02 SENT VIA: EMAIL
TO:	Matt Wacker, H.T. Harvey & Associates	
FROM:	Doug Moore, R.C.E. #C058122	
REVIEWED BY:	Mary Young, R.C.E. #39713	
SUBJECT:	Knoxville Wildlife Areas Land Management Plan Road Crossing Evaluation	

INTRODUCTION

The Knoxville Wildlife Area (KWA) Land Management Plan Road Crossing Evaluation is summarized in this Technical Memorandum. Eticuera Creek is the main drainage within the KWA and roughly parallels the alignment of Berryessa-Knoxville Road. From Zim-Zim Creek downstream to Todd Ranch, Berryessa-Knoxville Road crosses Eticuera Creek at six locations. These low water crossings are shown on Figure 1.

Each road crossing evaluation includes the following sections:

- General Comments and Recommendations
- Photographs

Many of the low flow crossing depth markers are broken or missing. These markers serve two purposes, including delineating the edges of the crossing and indicating the depth of water. Lack of functional markers represents a safety hazard, and it is recommended that new markers be installed on all of the low water crossings.

None of the recommendations provided below are urgent or critical (other than the installation of depth markers discussed above). Annual monitoring of the road crossings could be performed and the recommended maintenance be performed if the conditions worsen in the future. In the discussion below, the use of right and left always assumes the viewer is looking downstream.

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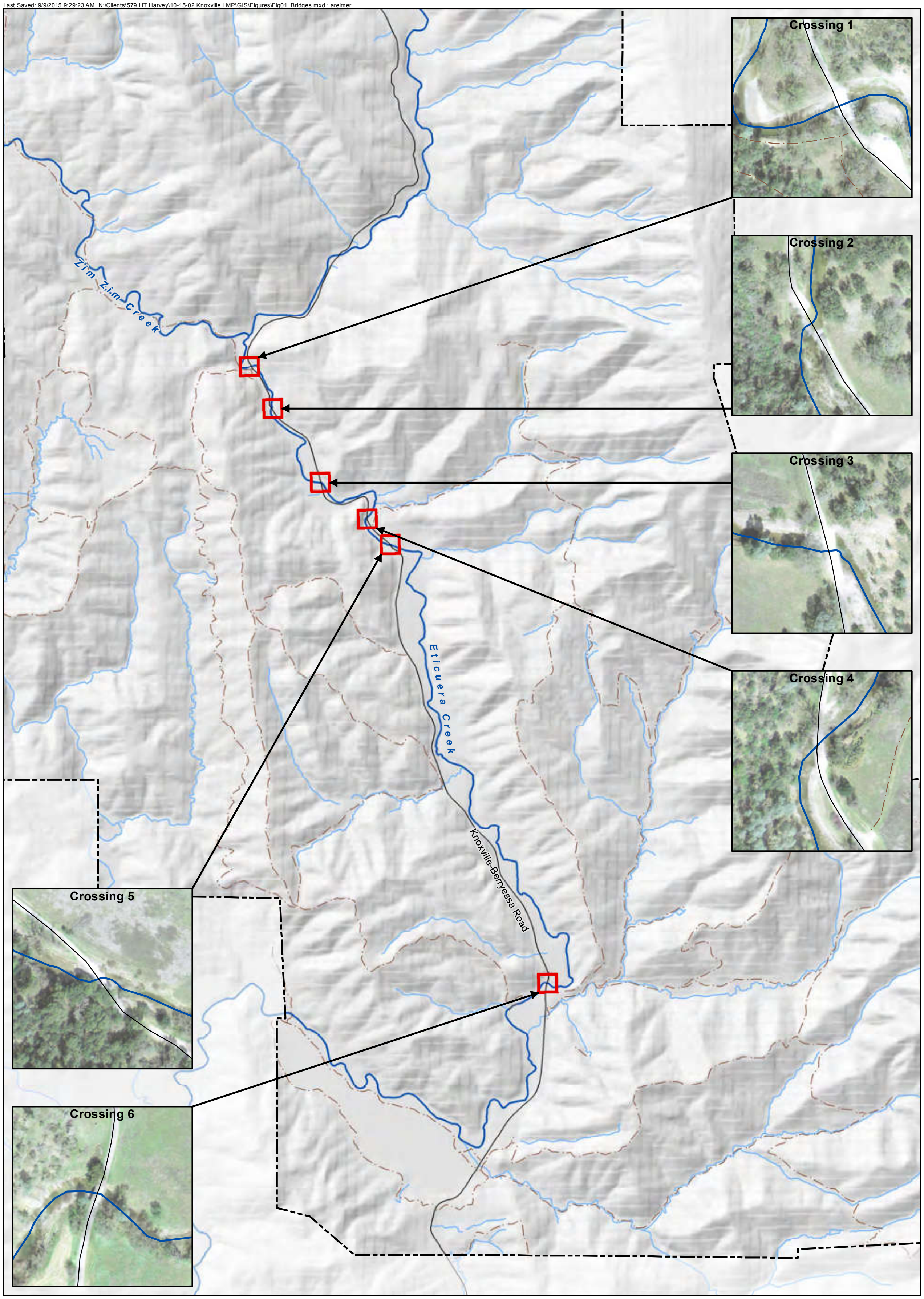


Symbology

- Paved Road
- Trail
- Zim Zim and Eticuera Creeks
- Other Creeks
- Knoxville Wildlife Area Boundary

N

0 1,000 2,000

Scale in Feet

Inset Maps: 1 inch = 200 feet

WEST YOST ASSOCIATES

Figure 1

Eticuera Creek Crossings

Knoxville Wildlife Area

CROSSING 1

General Comments and Recommendations

This low water crossing consists of a concrete overflow structure (about 70 feet long by 30 feet wide) with twin 42-inch Reinforced Concrete Pipe (RCP) culverts. The structure is in good general condition with only minor cracks and wear. There is minor cracking in the upstream end of the right (looking downstream) culvert. The culverts have no accumulation of sediment or debris and are flowing freely.

At the upstream side of the crossing, there is no pool and the structure is not undermined.

The downstream side of the crossing has previously been protected with large rock and gunite to prevent undermining of the structure. Despite these previous attempts to protect the structure from undermining, segments of the gunite are again undermined. The downstream side should be protected with well graded rock scour protection as described below:

- Slopes down from the crossing top to the creek bed at about 2 horizontal to 1 vertical.
- Is keyed into the creek bed at least 4 feet deep.
- Extends downstream of the rock slope toe by at least 8 feet (essentially a rock apron) and the downstream end of the apron is keyed into the bed at least 4 feet.
- The well graded rock would have a range of sizes so that the smaller rocks can fill the gaps between the larger rocks.
- After the rock is in place, the remaining voids near the edges of the creek and above the normal water level should be filled with top soil and planted with native grasses. The grass seeds should be obtained from a commercial seed producer specializing in CA native plants and should originate from seed sources within the Coast Range regions of Yolo, Napa, or Lake Counties. A seed mix is provided in the Table 1.

Table 1. Recommended Seed Mix

Species	Pure Live Seed lbs/ac
Arroyo lupine (Lupinus succulentus)	3
Blue wildrye (Elymus glaucus)	6
California melic (Melica californica)	3
Purple needle grass (Stipa pulchra)	5
Small fescue (Festuca microstachys)	3
Tomcat clover (Trifolium willdenovii)	1.5
Yarrow (Achillea millefolium)	0.5

The seeds should be obtained from a commercial seed producer specializing in California native plants and should originate from seed sources within the Coast Range regions of Yolo, Napa, or Lake Counties.

- Locally native willow stakes such as sandbar willow (*Salix exigua*), red willow (*S. laevigata*), and arroyo willow (*S. lasiolepis*) should be planted in the rock voids at the edges of the creek to help direct high overflows into the center of the crossing. Willows should not be planted in the voids in the center of crossings to prevent blocking the flow over the low water crossing, which would tend to force the flow to the banks and other unprotected areas of the creek channel.
- The rock and willows should not block the outlets of the culverts.
- Use of more gunite is not recommended because it is not flexible and does not adjust to changes in the creek bed.
- Rock sizing and extent of the rock placement should be evaluated in a stream scour study for each crossing.

Just downstream of the crossing, the left bank of the creek and hillside is eroding. Native willow poles, willow wattles or willow blankets could be used to help reduce the water velocity and direct high flows away from the toe of the bank and thereby stabilize the bank. Specific appropriate and affordable bank stabilization methods should be identified through a future, more detailed geomorphology evaluation of the creek at this crossing.

Photographs

Upstream side of Crossing 1 is not undermined and has no pool.

Downstream side of Crossing 1 has previously been protected with rock and gunite; however, the gunite is undermined and should be replaced with rock scour protection.

CROSSING 2

General Comments and Recommendations

This crossing consists of a concrete overflow structure (about 90 feet long by 25 feet wide) with twin 36-inch RCP culverts. The structure is in good general condition with only minor cracks and wear. The inside of the culverts could not be inspected because the water is flowing over the structure.

At the upstream side of the crossing, there is a pool, but the structure does not appear to be undermined. The upstream ends of the left and right culverts appear to be about ½ and ¾ plugged with sediment, but since water is flowing over the structure, at some point, the culverts are probably nearly completely plugged with sediment. The sediment should be cleaned from the culverts.

Just upstream of the crossing, the left bank of the creek is eroding. Native willows could be planted (combined with grading to layback the bank to a more stable angle where needed) to help direct high flows away from the bank and stabilize the bank. Boulder weirs could also be used to direct the flow to the center of the creek and away from the bank. Additionally, logs, willow wattles, and/or willow blankets, could be applied to the graded banks to prevent future erosion. Specific appropriate and affordable bank stabilization methods should be identified through a future geomorphology evaluation of the creek at this crossing.

At the downstream side of the crossing, the structure has been protected with gunite, but the gunite is undermined. The gunite should be replaced with rock scour protection, native grasses, and native willows, as described for Crossing 1.

Photographs

Water is ponded above Crossing 2 and the upstream ends of the culverts are submerged. The left bank upstream of the crossing is eroding and should be protected with native willows as described above.

The gunite on the downstream side of Crossing 2 is undermined and should be replace with rock scour protection as described for Crossing 1.

CROSSING 3

General Comments and Recommendations

This low flow crossing consists of a concrete overflow structure (about 120 feet long by 20 feet wide) with twin 36-inch RCP culverts. The structure is in good general condition with only minor cracks and wear. The culverts have no accumulation of sediment or debris and are flowing freely.

The upstream ends of the culverts are broken and rebar is exposed. However, the insides of the culverts are in good condition. There is no pool at the upstream side of the culverts, and the structure is not undermined.

At the downstream side of the crossing, the structure has been protected with gunite, but the gunite is undermined. The downstream side should be protected with rock scour protection, native grasses, and native willows, as described for Crossing 1.

Just downstream of the crossing, the left bank of the creek is eroding. As described for crossing 2, native willows and other methods could be used to help direct high flows away from the bank and stabilize the bank.

Photographs

The upstream ends of the Crossing 3 RCP culverts are broken and rebar is exposed.

Downstream side of Crossing 3 has previously been protected with rock and gunite; however, the gunite is undermined and should be replaced with rock scour protection.

CROSSING 4

General Comments and Recommendations

This low flow crossing consists of a concrete overflow structure (about 80 feet long by 20 feet wide) with five 24-inch RCP culverts with flared end sections; however, the left culvert is made of corrugated metal at the upstream end and RCP at the downstream end. The structure is in good general condition with minor cracks and wear, and one larger crack at the left end. The inside of the culverts could not be inspected because the culverts were too small and dark. The left and right most culverts are completely plugged with sediment and rocks. The second culvert from the right is partially plugged. The other culverts are free of sediment and debris and flowing freely. The sediment and rocks should be cleaned from the culverts. Also, the larger rocks or obstructions in the creek bed at the downstream ends of the culverts should be removed.

At the upstream side of the crossing there is a pool, which appears to have caused deposition of fine sediment and sand. The upstream side of the structure does not appear to be undermined.

Just upstream of the crossing, the left bank of the creek is eroding, which has caused a large tree to fall into the creek channel. As described above for Crossing 2, willows and other methods could be used to help direct high flows away from the left bank and stabilize the bank.

The downstream side of the crossing does not have a pool, and the creek bed consists of sand and rock. The downstream side of the crossing is not undermined.

Photographs

The upstream side of Crossing 4 has a pool with fine sediment and sand.

The creek bed at the downstream side of Crossing 4 consists of sand and rock.

CROSSING 5

General Comments and Recommendations

This low flow crossing consists of a concrete overflow structure (about 100 feet long by 20 feet wide) with five 2 feet by 2 feet square concrete culverts. The structure is in moderate general condition with significant cracks and wear. The inside of the culverts could not be inspected because the culverts were too small and dark. The two left culverts are nearly or completely plugged with sediment and rock. The second culvert from the right end is also completely plugged. The other two culverts are open and flowing freely. The sediment and rocks should be cleaned from the culverts.

There is no pool on the upstream side of the crossing. There is no undermining of the structure on the upstream side. The creek bed consists of sand and rock. Just upstream of the crossing, the right bank of the creek is eroding. As described above for Crossing 2, willows and other methods could be used to help direct high flows away from the left bank and stabilize the bank.

The downstream side of the crossing does not have a pool. There is a concrete apron (about 12 feet long) that appears to have protected the structure from undermining. The downstream creek bed consists of sand and rock.

Photographs

The right creek bank on the upstream side of Crossing 5 is eroding and should be protected with willows and/or other methods as described above.

The downstream side of Crossing 5 has a concrete apron that appears to have protected the crossing from undermining.

CROSSING 6

Crossing 6 is discussed below.

General Comments and Recommendations

Crossing 6 is a bridge that was constructed in 1920. The left abutment is slightly undermined. There is a weir (perhaps a structure leftover from a previous bridge) that runs between the bridge abutments. The weir limits the passage of fish, especially during low flow conditions. The equivalent weir on the downstream side of the bridge is broken and mostly missing. One or two notches should be cut into the upstream weir to improve fish passage.

Photographs

The bridge on Berryessa-Knoxville Road was constructed in 1920.

The weir between the bridge abutments restricts fish passage, and one or two notches should be cut in the weir.

WEST YOST ASSOCIATES 25 YEARS 1990–2015

REGISTERED PROFESSIONAL ENGINEER DOUGLAS T. MOORE No. 58122 Exp. 6-30-16 CIVIL STATE OF CALIFORNIA

TECHNICAL MEMORANDUM

DATE: October 12, 2015

Project No.: 579-10-15-02
SENT VIA: EMAIL

TO: Matt Wacker, H.T. Harvey & Associates

FROM: Daria Isupov

REVIEWED BY: Doug Moore, R.C.E. #C058122

SUBJECT: Knoxville Wildlife Area Land Management - Zim Zim Creek Evaluation

INTRODUCTION

The Knoxville Wildlife Area (KWA) Land Management Plan Zim Zim Creek Evaluation is summarized in this Technical Memorandum. Zim Zim Creek is an ephemeral stream that flows approximately 3.6 miles from Zim Zim falls into Eticuera Creek through a narrow canyon. Historic land uses, road crossings, erosion, and other factors have caused erosion, down cutting, and other alterations to the stream that have impaired hydrologic, geomorphic, and ecological functions of the creek. A rapid field assessment of this reach was conducted to characterize current hydrologic/fluvial geomorphic conditions, identify sources of impairment, and identify restoration opportunities. Results of this field assessment are discussed in the following sections:

- Evaluation Summary (below) – This summary includes methodology, observations, Conclusions, and Recommendations from the field evaluation of Zim Zim Creek.
- Photographs (below) - Photographs of representative conditions along Zim Zim Creek.
- Attachment 1– Zim Zim Creek Bank Stability maps: this map series shows field-delineated sections of the left and right creek banks by stability class.
- Attachment 2 – Tables 1-3: bank stability delineations by right bank and left bank as shown in Attachment 1 and observations of creek crossings.

EVALUATION SUMMARY

This summary includes methodology, observations, Conclusions, and Recommendations from the field evaluation of Zim Zim Creek.

Methods

On April 29, 2015, Matt Smeltzer of Geomorph Design and Daria Isupov of West Yost Associates walked Zim Zim Creek from Eticuera Creek upstream to a point that the dense vegetation and the narrow canyon prevented further access. A total of 17,500 feet, or 3.3 miles, of the Creek were evaluated. Along the accessible reach, vegetation conditions and bank stability were field-delineated and field-mapped into stability classes. These classes are described below and are color-coded in the map set located in Attachment 1.

> **Class A** – Not eroding, generally not susceptible to erosion with the channel in its current alignment due primarily to inside bend channel position or location within overall straight, stable channel reaches, sometimes dominated by channel spanning bedrock outcrops. Generally suitable locations for establishing new riparian vegetation.
>
> **Class B** – Eroding, having relatively steep banks, and showing completely or partially exposed bank material not covered by vegetation, but deemed self-stabilizing or eroding at relatively slow rate as mitigated by any of several physical factors including presence of exposed bedrock outcrop on the bank, partial vegetation cover, inside bend or straight channel position, attached gravel bars, etc. Generally not of management concern as a sediment source.
>
> **Class B*** – Relatively rapidly eroding, having steep to very steep to near vertical banks lacking riparian vegetation cover, almost exclusively occurring at outside bend channel positions with erosion dominated by undermining during high velocity flows impinging on the bank during floods, including land sliding, slumping, and other related bank failures. Highest sediment producing sites that should be considered for repairs, erosion protection, stabilization, vegetation establishment, etc. depending on management objectives, feasibility, and cost.

Mr. Smeltzer and Ms. Isupov also field-inspected and field-mapped roadway crossings and roadways narrowed by ongoing bank erosion, evaluated watershed-scale geologic controls on valley slope, hydraulic conveyance, and channel form, headcuts (i.e., typically less than 2 vertical feet) and profile steps (i.e., generally greater than 2 vertical feet), characterized patterns in nearshore and in-channel vegetation establishment, characterized recent and historical channel change processes, evaluated bank stratigraphy patterns and geologic units exposed, identified potential vegetation establishment sites, and identified potential priority bank repair sites.

Observations

- Banks typically have bedrock exposed at the toe of the bank and rising 1-3 feet above the creek bed. There is typically a 2-4-feet-thick layer of older very coarse small boulder and large cobble dominated alluvium exposed in the bank above bedrock. The thickness of fine-grained older floodplain deposits overlying the older alluvium and capping the bank profile is usually 2-6 feet.
- Presence of bedrock and older alluvium at the toe of the banks generally mitigates the rate of bank erosion, but recent long-term bank erosion indicated in places by exposed oak tree roots can be as much as 4-6 horizontal feet at outside bend channel positions, even where cut in bedrock at the toe. The typical bedrock is highly fractured dark grey

sandstone and siltstone that appears to erode relatively rapidly for adopting curved (fluvial) exposures caused by channel meandering.

- Older coarse alluvium produces boulder size materials similar to “self-launching rip-rap” which has a self-stabilizing effect on some bank segments.
- Increasingly moving upstream through Zim Zim Creek, the bed materials are dominated in riffles by large cobbles and small to medium sized boulders. Boulder bars appear to be formed by a combination of lag medium size boulders (i.e., creek headcutting through older coarse alluvium leaving the largest immobile materials in place). The large immobile material show long-term smoothing and carving where exposed. The smaller boulders and large cobble materials which were transported during historical high flood flows came to rest at the riffles; these materials show less smoothing.
- There are multiple head cuts less than 2 vertical feet (typically 0.5-0.75 vertical feet) that have advanced into the boulder bars described above, indicating the typical depth and head cut processes within the older alluvium unit. Elsewhere, head cuts in more resistant exposed bedrock units (conglomerate, brown massive sandstone) are typically greater than 2 vertical feet (i.e., “profile steps”).
- Mapped in Attachment 1, there are two long, typically straight and shallow, plane-bedded channel type reaches underlain by shallow channel-spanning conglomerate and brown sandstone with low banks. These reaches also have thin veneers of alluvium on the bed dominated by sedges (*Carex spp)*.
- Contemporary channel change is dominated by chute-cutoff processes that occur when outside bend bank erosion progresses so far as to create a wide inside bend gravel bar. Two recent or active chute-cutoffs are mapped.
- The most complex channel bed forms occur immediately upstream from outside bend bedrock outcrop where “jammed” (i.e., forced) boulder bar riffles establish with multiple low-flow channels and active main channel switching occurs during high flows.
- Mature oak trees occur near the top of bank but recruitment of young oak trees appears limited along the top of bank and at distance from the top of bank. Tree throw of mature oaks by progressive bank erosion appears to cause channel segments lacking mature canopy-forming vegetation.

Nearshore and in-channel vegetation is limited but increases markedly moving upstream along Zim Creek and becomes very dense and nearly continuously dense near the upstream end of the mapping.

CONCLUSIONS

- In general, sediment supply to the mapped portion of Zim Zim Creek is dominated by bank toe erosion undercutting, high steep eroding bank formation, and associated land sliding into the channel where the channel cuts into the canyon walls at either side of the narrow valley floor. It appears that there is a greater total length of banks cut in the left canyon wall compared to the right canyon wall, which may be explained by tectonic influencing forcing a down-to-the-east channel migration tendency.
- In general, significant sediment supply reduction is not feasible because the large majority of sediment is supplied by very large natural canyon wall cutting and associated land sliding. In places, channel bends cut in the canyon wall can be abandoned by forcing artificial or premature "chute-cutoffs" by blocking outer channels in favor of focused flow over the inside end of inside bend gravel bars. Recommended priority locations include Left-Bank sections: B*4, B*5, B*7, B*14, B*16, B*22, B*23. Other areas that would benefit from cut-off also include Left-Bank sections B*1, B*2, B*3, B*10, B*21. No Right-Bank sections are recommended because proposed cut offs would require grading of the canyon wall.

RECOMMENDATIONS

- In general, the B* sites with the greatest thicknesses of fine-grained bank materials capping the bank profile, that are also closest to the channel bed elevation, are the sites which may yield the greatest sediment source reduction if repaired. Potential repair techniques include:
  - Removal of the over steepened fine grained material caps and recontouring the fine grained material to 2(H):1(V) slopes and fastening perimeter-keyed biodegradable erosion control fabric onto the finished slope.
  - Installation of engineered log-jams or loose placement of large woody debris onto the bank to deflect high flow erosion pressure attacking the lower and upper bank areas.
- Establishing vegetation is recommended where coarse alluvium is thick and dominates the lower and mid-bank profile and is exposed on the bed. Vegetation establishment would typically include using hand-deployed gas-powered 4" to 6" auger hole drilling and embedding 3-4-inch diameter live willow poles.
- Establishing willow thickets (by hand-deployed auger drilling) is recommended at locations where there are surfaces relatively close to the channel bed and summer low-flow water surface elevation which may not be underlain by thick layers of very coarse older alluvium.

  - Recommended sites for establishing willow thickets include Left Bank B*2, B*3 (below the road), B*8, B16/B*22 transition, and Right Bank A9/B*6 transition, A18, A19, A22, and A/23/B*17 transition. The installation method (gas-powered or hand-augured) will need to be determined in the field.

- Prioritization for erosion reduction work should include practical site access considerations, specifically distance to Berryessa-Knoxville Road and site proximity to unpaved road that runs semi-parallel to Zim Zim Creek. Below are several priority sites based on ease of access and other considerations (if applicable):
  - Left Bank segments B*2 and B*3 are near Berryessa-Knoxville Road and are located immediately below the unpaved access road. Establishing willow thickets in these segments would stabilize creek bed erosion and prevent road collapse.
  - Right Bank segments A9 and B*6 are also highly recommended sections for establishing willow thickets. These segments are located in a relatively flat area with minimal vegetation and are located along the unpaved site access road.
  - Left Bank B*14 is located along an outside bend that cuts into the steep, actively eroding canyon wall. Historical chute cutoffs are apparent in this bend and it is worth considering forcing an artificial or premature chute cutoff where historical cutoffs are located. This site is not immediately adjacent to the site access road but there is adequate space for staging equipment and vehicles. Care should be taken to minimize disturbance of vegetation.

PHOTOGRAPHS

Zim Zim Creek just upstream of the Eticuera Creek confluence. This stretch is designated Class A.

Class B stretch of Zim Zim Creek.

Note head of floodplain bar has steep eroding edge at inside bend channel position. Well vegetated.

Class B* stretch of Creek. Note 50 feet high near vertical bank with active erosion. Increase in fine sediment observed immediately downstream.

Bouldery old alluvium layer exposed in bank toe on Class A stretch; loosened rock self-stabilizes and protects the bank toe.

Class B* stretch of Creek with 10-20 feet high sub-vertical bank and abandoned channel stream on outside of bend.

Steep bank with active sediment accumulation at base.

Sub-vertical bank with active sediment accumulation at base.

Left bank rockfall upstream causes right bank erosion

(left bank-attached gravel bar deposition results in channel migration to right bank).

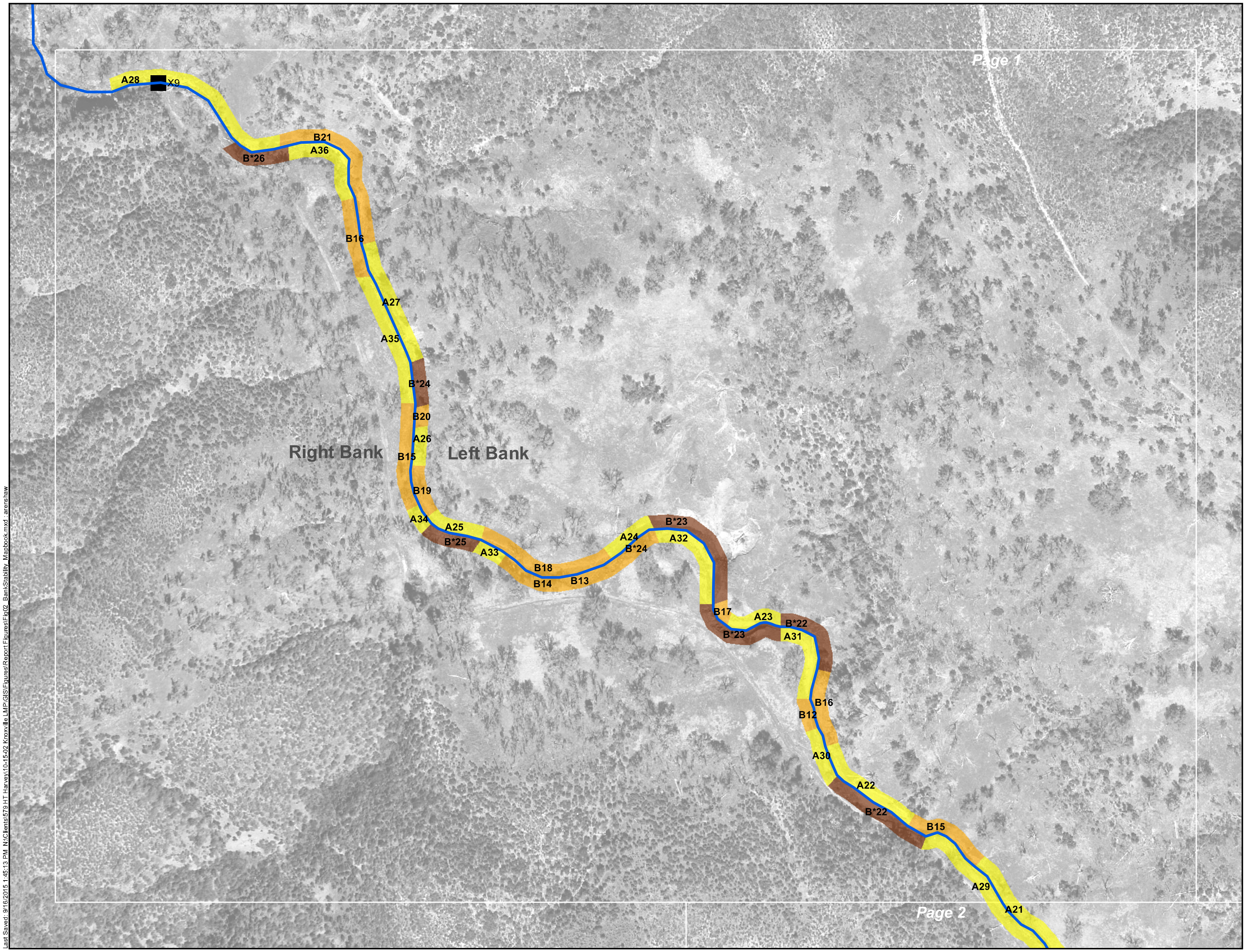
Canyon wall bedrock (sandstone) with recent rockfall results in high sediment supply.

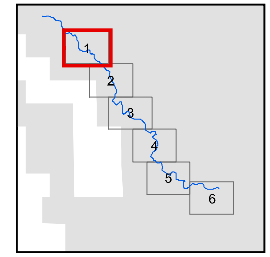
Cemented conglomerate and coarse alluvium bedrock-dominated stretches of Creek.

Narrow canyon and dense instream vegetation limits access to Creek.

ATTACHMENT 1

Map Set





N

0 100 200

Scale in Feet

Symbology

Zim Zim Creek

Creek Crossing Location

Knoxville Wildlife Area

Creek Bank Soil Stability Classification

A

B

B*

Notes:
1. Aerial photography was collected in 2011 for Napa County.
2. Bank stability classification widths are not drawn to scale.

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Figure 2-1

Zim Zim Creek
Bank Stability Maps
Page 1

Knoxville Wildlife Area

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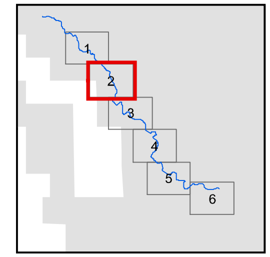

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Scale in Feet

Symbology
Zim Zim Creek
Creek Crossing Location
Knoxville Wildlife Area
Creek Bank Soil Stability Classification
A
B
B*

Notes:
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2. Bank stability classification widths are not drawn to scale.

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Figure 2-2

Zim Zim Creek
Bank Stability Maps
Page 2

Knoxville Wildlife Area

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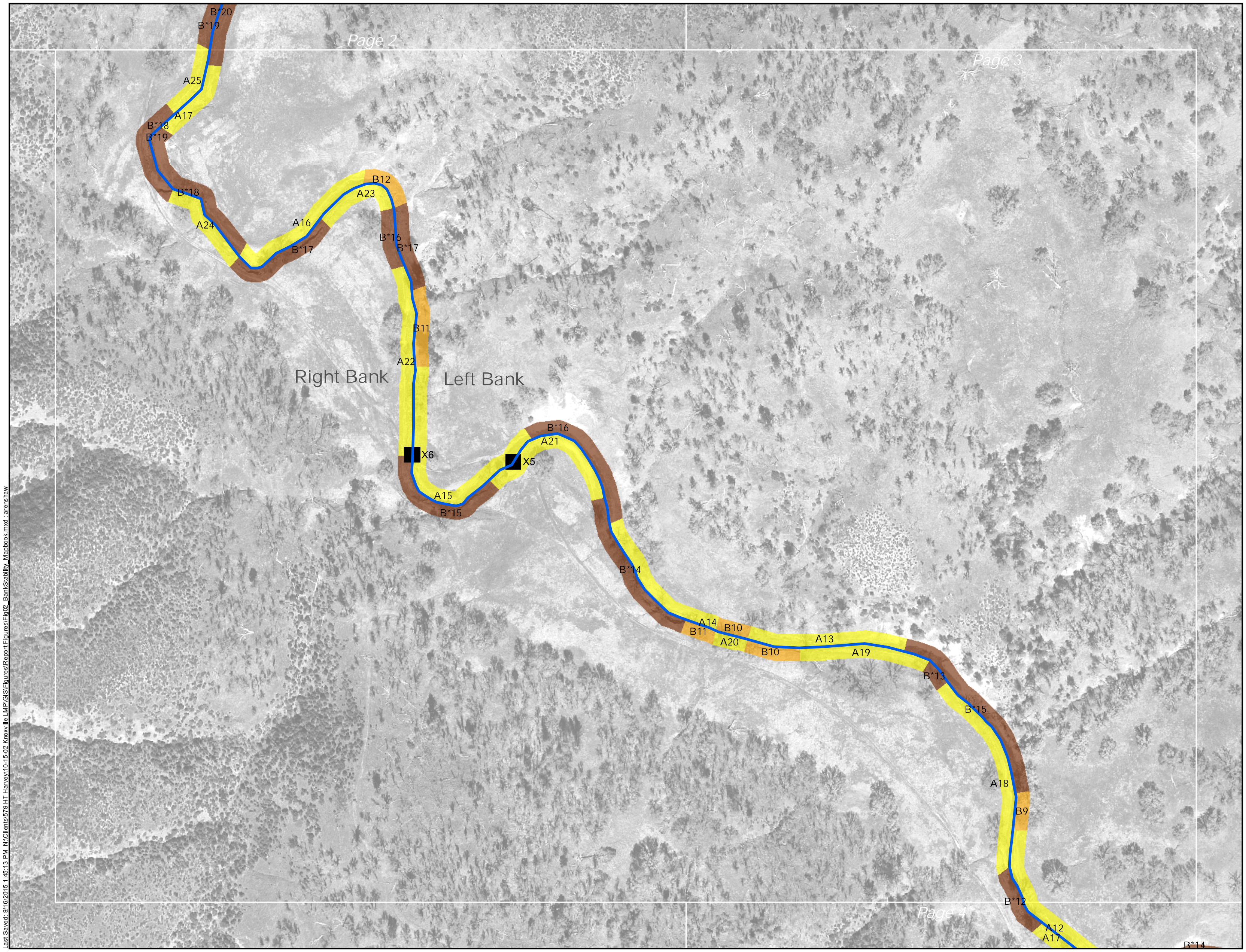

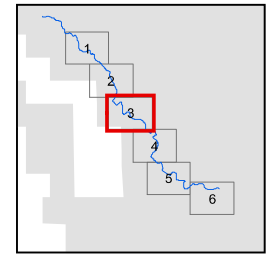

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Scale in Feet

Symbology
Zim Zim Creek
Creek Crossing Location
Knoxville Wildlife Area
Creek Bank Soil Stability Classification
A
B
B*

Notes:
1. Aerial photography was collected in 2011 for Napa County.
2. Bank stability classification widths are not drawn to scale.

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Figure 2-3
Zim Zim Creek
Bank Stability Maps
Page 3
Knoxville Wildlife Area

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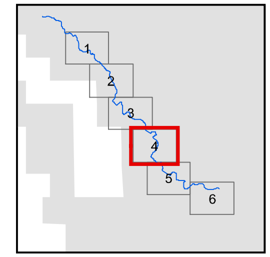

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Scale in Feet

Symbology

- Zim Zim Creek
- Creek Crossing Location
- Knoxville Wildlife Area

Creek Bank Soil Stability Classification

- A
- B
- B*

Notes:
1. Aerial photography was collected in 2011 for Napa County.
2. Bank stability classification widths are not drawn to scale.

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Figure 2-4

Zim Zim Creek
Bank Stability Maps
Page 4

Knoxville Wildlife Area

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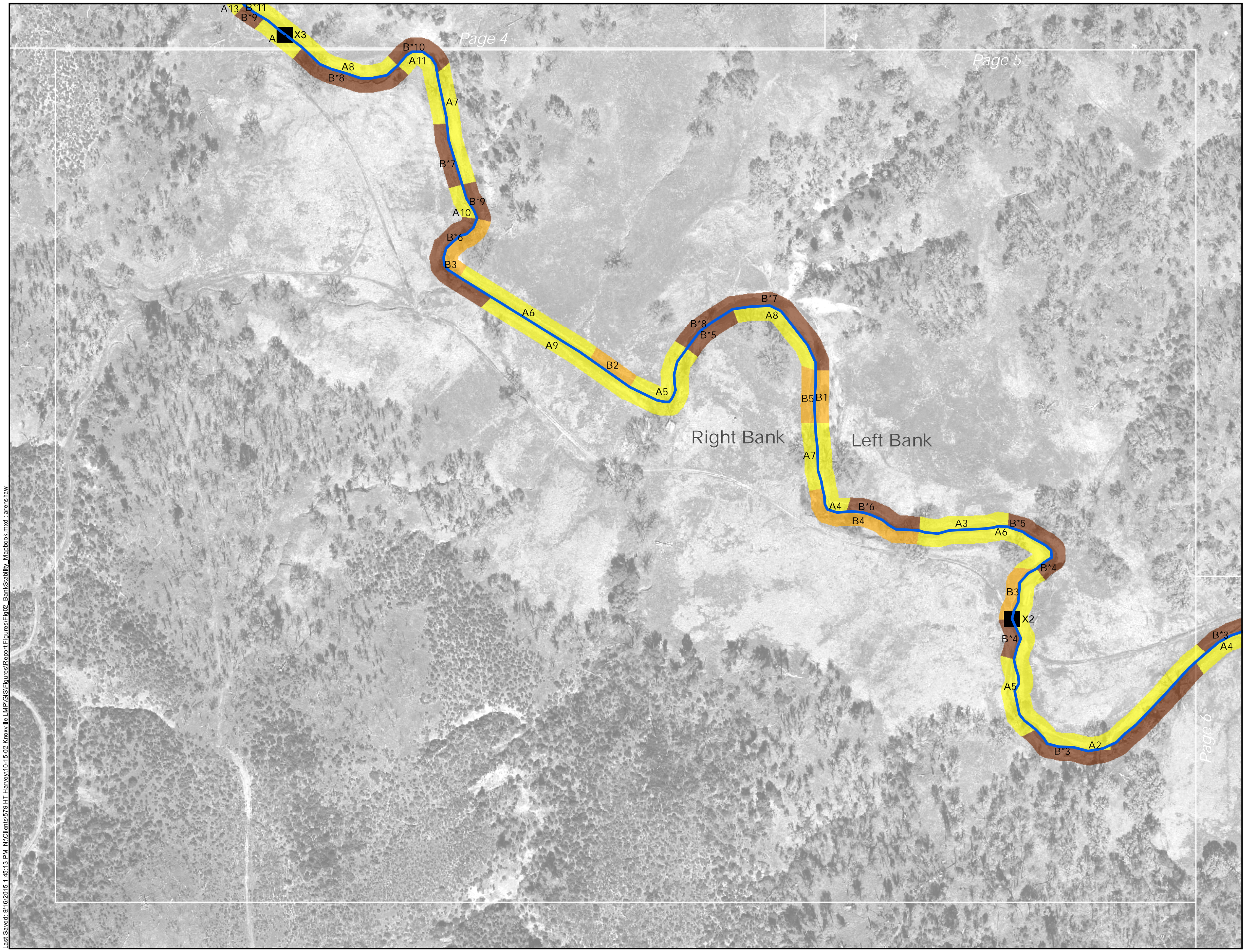

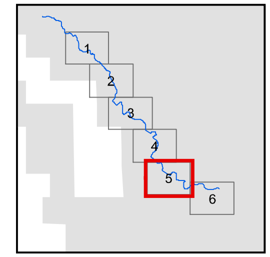

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Scale in Feet

Symbology

Zim Zim Creek

Creek Crossing Location

Knoxville Wildlife Area

Creek Bank Soil Stability Classification

A

B

B*

Notes:
1. Aerial photography was collected in 2011 for Napa County.
2. Bank stability classification widths are not drawn to scale.

Figure 2-5

Zim Zim Creek
Bank Stability Maps
Page 5

Knoxville Wildlife Area

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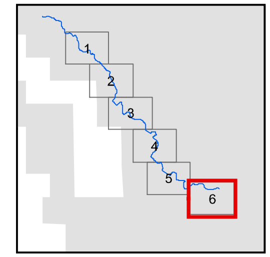

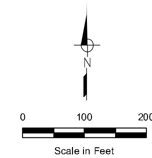

Symbology

- Zim Zim Creek
- Creek Crossing Location
- Knoxville Wildlife Area

Creek Bank Soil Stability Classification

- A
- B
- B*

Notes:
1. Aerial photography was collected in 2011 for Napa County.
2. Bank stability classification widths are not drawn to scale.

Figure 2-6

Zim Zim Creek
Bank Stability Maps
Page 6

Knoxville Wildlife Area

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ATTACHMENT 2

Tables 1 through 3

TABLE 1
ZIM ZIM CK
CREEK BANK STABILITY CLASSIFICATION

4/29/2015

RIGHT BANK

RB/LB	CLASS	#	ID1	DESCRIPTION
RB	A	1	A1	
RB	B	1	B1	
RB	A	2	A2	
RB	B*	1	B*1	4-5-FT-HIGH NR VERT BANK AT OB CH POS W EXTENSIVE EXPOSED ROOTS, NO BROC
RB	B	2	B2	HEAD OF FP BAR HAS STEEP ERODING EDGE AT IB CH POS, WELL VEGETATED
RB	A	3	A3	
RB	B*	2	B*2	CANYON WALL TOE, SHADY, OB CH POS, MATURE VEGETATION PRESENT
RB	A	4	A4	
RB	B*	3	B*3	OB CH POS WITH BROC TO WSE + 4-4.5 FT
RB	A	5	A5	
RB	B*	4	B*4	OB CH POS 5-FT-HIGH NR VERT BANK
RB	B	3	B3	
RB	A	6	A6	
RB	B	4	B4	
RB	A	7	A7	
RB	B	5	B5	
RB	A	8	A8	
RB	B*	5	B*9	OB CH POS AT 120 DEG LT TURNING CH BEND, 4-5-FT-HIGH NR VERT BANK, LWD JAM PRESENT
RB	A	9	A9	BOULDERY OLD ALLUVIUM LAYER EXPOSED IN BANK TOE CREATES SELF-LAUNCHING LAG RIP-RAP BANK TOE PROTECTION EFFECT
RB	B*	6	B*6	OB CH POS WITH BROC TOE TO WSE + 3-6 FT, POOL W NO COVER
RB	A	10	A10	
RB	B*	7	B*7	OB CH POS 4-5-FT-HIGH NEAR VERT BANK WITH BROC TO WSE + 2 FT
RB	A	11	A11	
RB	B*	8	B*8	OB CH POS BROC TO WSE + 0 FT, OLD COARSE ALLUVIUM TO WSE +1-3 FT
RB	A	12	A12	
RB	B*	9	B*9	OB CH POS WITH BROC TO WSE+2 FT, BANK 6 FT HIGH TOTAL
RB	A	13	A13	
RB	B*	10	B*10	OB CH POS BR TO WSE + 0-1 FT, OLD COARSE ALLUVIUM OVER TRANSITIONS TO RB CANYON WALL
RB	B	6	B6	
RB	A	14	A14	
RB	B	7	B7	
RB	A	15	A15	
RB	B	8	B8	
RB	A	16	A16	
RB	B*	11	B*11	SIDE CH CUT AT RB FP BAR W OLD COARSE ALLUVIUM TOE
RB	B	9	B9	
RB	A	17	A17	
RB	B*	12	B*12	RB CANYON WALL TOE, BROC TO WSE + 10 FT VAR
RB	A	18	A18	
RB	B*	13	B*13	LB ROCKFALL UPSTREAM CAUSES RB BANK EROSION BY LB ATTACHED LEE GRAVEL BAR DEPOSITION AND RESULTING CH STEERING TO RB
RB	A	19	A19	
RB	B	10	B10	OB CH POSITION WITH BROC PREVENTING ONGOING SUBSTANTIAL BANK EROSION
RB	A	20	A20	
RB	B	11	B11	
RB	B*	14	B*14	OB CH POSITION WITH BROC PREVENTING ONGOING SUBSTANTIAL BANK EROSION
RB	A	21	A21	
RB	B*	15	B*15	OB CH POS 6-10-FT-HIGH NR ERT BACK WITH BROC TO WSE +0-6 FT VAR.
RB	A	22	A22	
RB	B*	16	B*16	OB CH POS BROC TO WSE + 2 FT, COARSE ALL TO WSE + 4 FT, FINE GR TO WSE + 6FT, LONG-TERM LATERAL BANK EROSION SEVERAL FT INDICATED BY EXPOSED OAK ROOTS
RB	A	23	A23	
RB	B*	17	B*17	10-11-FT-HIGH NR VERT BANK WITH BROC TO WSE + 0-6 FT VAR. COARSE OLD ALLUVIUM OVER AND 2-FT-THICK CAP OF FINE GR; POTENTIAL ELJ SITE
RB	A	24	A24	
RB	B*	18	B*18	OB CH POS BROC ; CORNER POOL AT BROC
RB	A	25	A25	
RB	B*	19	B*19	2-FT-HIGH FINE GR CAP OVER OB CH POS BANK
RB	A	26	A26	
RB	A	27	A27	
RB	B*	20	B*20	RB CANYON WALL BROC WITH RECENT ROCKFALL IN CH, SANDSTONE, HIGH SED SUPPLY
RB	A	28	A28	
RB	B*	21	B*21	7-8-FT-HIGH NR VERT BANK AT OB CH POS WITH SANDSTONE BROC TOE AND 5-FT-THICK FINE GR CAP; EROSION-NARROWED ROADWAY AT TOB
RB	A	29	A29	
RB	B*	22	B*22	OB CH POS WITH BROC TO WSE + 2 FT VAR., COARSE OLD ALLUV TO WSE + 2-5 FT VAR. AND 3-FT-THICK FINE GR CAP; EROSION NARROWED ROADWAY AT TOB
RB	A	30	A30	
RB	B	12	B12	
RB	A	31	A31	
RB	B*	23	B*23	RECENT ACTIVE EROSION AT OB CH POS WITH BR TOE AND HIGH STEEP FINE GR CAP UP TO 19-20 FT HIGH ABOVE BED
RB	A	32	A32	
RB	B*	24	B*24	OB CH POS WITH BROC TOE TO WSE + 1 FT
RB	B	13	B13	OLD COBBLE BLDR ALLUVIUM DOMINATED EXPOSED BANKS; OLD B* SEGMENT NOW SELF-STABILIZING WITH MATURE VEG PRESENT
RB	B	14	B14	
RB	A	33	A33	
RB	B*	25	B*25	
RB	A	34	A34	
RB	B	15	B15	
RB	A	35	A35	
RB	B	16	B16	CEMENTED CONGOLMERATE AND OLD COARSE ALLUVIUM DOMINATED
RB	A	36	A36	
RB	B*	26	B*26	

ABBREVIATIONS:

BROC	BEDROCK OUTCROP
IB	INSIDE BEND
OB	OUTSIDE BEND
CH POS	CHANNEL POSITION
FP	FLOODPLAIN
WSE	WATER SURFACE ELEVATION
VAR.	VARIES
TOB	TOP OF BANK
LWD	LARGE WOODY DEBRIS
ELJ	ENGINEERED LOG JAM
US OR U/S	UPSTREAM
DS OR D/S	DOWNSTREAM

TABLE 2
ZIM ZIM CK
CREEK BANK STABILITY CLASSIFICATION

4/29/2015

LEFT BANK

RB/LB	CLASS	#	ID1	DESCRIPTION
LB	B*	1	B*1	
LB	A	1	A1	EROSION BELOW ROAD AT A1/B*2 TRANSITION - SUGGEST MONITORING
LB	B*	2	B*2	5-6 FT-HIGH ROAD EMBANKMENT AT OB
LB	B*	3	B*3	SUGGEST VEGETATION TO STABALIZE EROSION BELOW ROAD; SEASONAL FROG HABITAT MAY BE PRESENT IN THIS STRETCH (COMPLEX INSTREAM VEG)
LB	A	2	A2	
LB	B*	4	B*4	25 FT-HIGH NR VERT BANK W TOE ON DS SIDE
LB	B*	5	B*5	
LB	A	3	A3	
LB	B*	6	B*6	5-6 FT-HIGH VERT BANK
LB	A	4	A4	
LB	B	1	B1	
LB	B*	7	B*7	50 FT-HIGH NR VERT BANK W EROSION; INCREASE IN FINE SEDIMENT AT TRIBUTARY
LB	B*	8	B*8	5-6 FT-HIGH VERT BANK; REC: ESTABLISH VEGETATION
LB	A	5	A5	
LB	B	2	B2	
LB	A	6	A6	
LB	B	3	B3	
LB	B*	9	B*9	50-75 FT-HIGH NR VERT BANK W EROSION
LB	A	7	A7	
LB	B*	10	B*10	ERODING CANYON WALL WITH BROC (SUBVERTICAL SEDIMENTARY ROCK)
LB	A	8	A8	
LB	B*	11	B*11	9 FT VERT BANK W UNDERCUTTING
LB	B	4	B4	
LB	A	9	A9	BROC CHANGE IN THIS SECTION
LB	B*	12	B*12	UNDERCUTTING, EROSION, BARE ROOTS
LB	B	5	B5	
LB	A	10	A10	LRG BOULDER AND COBBLE ACCUMULATION
LB	B	6	B6	
LB	B*	13	B*13	5-20 FT-HIGH VERT BANK; MID CHANNEL AND LATERAL BARS
LB	A	11	A11	
LB	B	7	B7	
LB	B*	14	B*14	10-20 FT-HIGH SUBVERTICAL BANK WITH ABANDONED CHANNEL STREAM ON OB CH POS
LB	B	8	B8	
LB	A	12	A12	INSTREAM POOLS AND COMPLEX VEGETATION; HEADCUTTING BEDROCK TOE ON U/S END
LB	B	9	B9	
LB	B*	15	B*15	15-30 FT-HIGH UNSTABLE, SUBVERTICAL BANK WITH LOOSE SEDIMENT (ACTIVE EROSION)
LB	A	13	A13	GOOD CHANNEL EDGE HABITAT
LB	B	10	B10	
LB	A	14	A14	
LB	B*	16	B*16	50-100 FT-HIGH SUBVERTICAL BANK/CANYON WALL; BROC (DEFORMED SEDIMENTARY UNITS)
LB	A	15	A15	
LB	B	11	B11	
LB	B*	17	B*17	
LB	B	12	B12	
LB	A	16	A16	LARGE, DEEP POOLS WITH VEGETATION - GOOD HABITAT
LB	B*	18	B*18	7-9 FT-HIGH VERTICAL BANK; WATERFALL IN THIS SECTION JUST D/S OF BEDROCK TRANSITION
LB	B*	19	B*19	6 FT-HIGH VERTICAL BANK WITH EROSION OF UNCONSOLIDATED FINE SEDIMENTS; REC: LOG JAM TO DEFLECT ENERGY AND PLANTING MATRIX
LB	A	17	A17	
LB	B*	20	B*20	
LB	A	18	A18	
LB	B	13	B13	
LB	A	19	A19	PLANE-BEDDED CHANNEL SEGMENT
LB	B*	21	B*21	30 FT-HIGH VERTICAL BANK/CANYON WALL; BROC (FRACTURED SANDSTONE)
LB	A	20	A20	
LB	B	14	B14	
LB	A	21	A21	INSTREAM POOL FREQUENCY NOTABLY INCREASES FROM THIS POINT U/S
LB	B	15	B15	LAG/ RIP RAP BASE
LB	A	22	A22	
LB	B	16	B16	10-15 FT-HIGH SUBVERTICAL BANK WITH PAST EROSION; ESTABLISHED VEG ; POTENTIAL FOR MORE STABALIZATION WITH MORE PLANTINGS
LB	B*	22	B*22	SUB-VERTICAL TO VERTICAL BANK WITH LOOSE SOILS
LB	A	23	A23	
LB	B	17	B17	
LB	B*	23	B*23	RECENT LANDSLIDE WITH STEEP SLOPE AND LOOSE SOILS
LB	A	24	A24	
LB	B	18	B18	
LB	A	25	A25	HEAD CUTTING (3 FT); BROC CHANGE TO WELL-CONSOLIDATED PEBBLE-COBBLE CONGLOMERATE
LB	B	19	B19	
LB	A	26	A26	
LB	B	20	B20	
LB	B*	24	B*24	VERTICAL BANK W HIGHLY EROSIVE, LOOSE SOILS
LB	A	27	A27	
LB	B	21	B21	
LB	A	28	A28	SIGNIFICANT INCREASE IN INSTREAM VEGETATION; FEATURES NO LONGER VISIBLE AND ACCESS LIMITED; END OF MAPPING

ABBREVIATIONS:

BROC	BEDROCK OUTCROP
IB	INSIDE BEND
OB	OUTSIDE BEND
CH POS	CHANNEL POSITION
FP	FLOODPLAIN
WSE	WATER SURFACE ELEVATION
VAR.	VARIES
TOB	TOP OF BANK
LWD	LARGE WOODY DEBRIS
ELJ	ENGINEERED LOG JAM
US OR U/S	UPSTREAM
DS OR D/S	DOWNSTREAM

TABLE 3
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CROSSING

4/29/2015

FEATURE	ID	ID2	NOTE
XING	1	X1	PASSABLE - STABLE
XING	2	X2	PASSABLE - STABLE; HIGH CLEARANCE VEHICLE REQUIRED
XING	3	X3	PASSABLE - STABLE, MINOR GULLYING ON LB RAMP
XING	4	X4	IMPASSABLE -- LB RAMP ERODED AWAY; RB RAMP STABLE
XING	5	X5	PASSABLE - STABLE; HIGH CLEARANCE VEHICLE REQUIRED
XING	6	X6	IMPASSABLE - STABLE; COBBLE TO BOULDER SIZE ROCKS IN CREEK
XING	7	X7	PASSABLE - STABLE
XING	8	X8	PASSABLE - STABLE; RB RAMP COULD BECOME EROSIVE WITH FREQUENT USAGE
XING	9	X9	IMPASSABLE - STABLE; HIGH VEG AND DEEP CHANNEL

Appendix I. Grazing Plan

KNOXVILLE WILDLIFE AREA GRAZING PLAN

Introduction

This grazing plan, developed in collaboration with the California Department of Fish and Wildlife (CDFW) and the California Wildlife Foundation (CWF), describes a grazing program to support management goals and tasks that will ensure the long-term conservation of wildlife (invertebrates, amphibians, reptiles, birds, and mammals), special-status plants and plant communities and their habitats on the Knoxville Wildlife Area (KWA). The purpose of the plan is to develop a livestock grazing strategy to achieve vegetation and wildlife habitat goals. The Plan will describe specific grazing prescriptions, monitoring to evaluate adaptive grazing activities and habitat response. The Plan will be a component of the KWA's Land Management Plan (LMP) update, which is concurrently being developed.

Initiating grazing at KWA will be a major undertaking requiring investment in infrastructure (fences, gates, water developments and livestock handling facilities) and supportive lease agreements. Fence and stock water repairs are costly inputs required before grazing can start in each pasture or pasture. Additionally livestock handling facilities (loading chutes, corrals, etc.) need to be developed. This presents several challenges for CDFW and potential lessees.

1. CDFW does not have funding for needed infrastructure developments and state policies preclude trading grazing for infrastructure development in the lease agreement.
2. CDFW needs to find lessees that are willing and able to collaborate with KWA staff to meet CDFW management objectives. It will take time for the lessee to fully understand and engage CDFW's objectives. Therefore a long term lease of 5 years or more is critical to the long-term success of grazing management at KWA.
3. CDFW will need to vet potential lessees before entering into a long-term lease. A proposal and interview process could be used to vet potential lessees. KWA's long term plans should be part of the request for proposals so that potential lessees can gauge their ability to help CDFW meet grazing management objectives.
4. Vandalism is a concern on a wildlife area where public access and hunting are allowed. Damage to water tanks, troughs, pumps and other facilities can be expensive. Knowing and educating public users through an advisory committee might reduce vandalism.

Access is a problem for anyone managing a grazing operation on the KWA. The Knoxville-Berryessa Road is too rough, narrow and windy for cattle trucks to pass. Additionally there are currently no functional livestock handling facilities at either end of KWA. Consequently lessees will most likely access the KWA from the south end, possibly using the Airstrip Unit or other nearby flats at the south end as a holding field from which to move cattle onto the pastures. Because of access difficulty with cattle trucks it may be logical to start development of infrastructure on the south valley and gradually developing pastures in a northerly direction. Access by cattle trucks may be possible from Clearlake to the northern pastures using the improved road developed for the mine but handling facilities and a truck turn around will be required.

Because water storage facilities need repairs it may be best to limit initial leases to the rainy (green) season when surface water is available in the pastures. A stocker operation could fit this limitation with the lease starting in the late fall or early winter when surface water is available and ending in the late spring when surface water becomes limiting and forage is mature and drying.

Coordinating CDFW wildlife and land management goals with grazing management requires a management team (CDFW and lessee) that has a common understanding of management goals in each grazing unit (pasture) and the capacity to manage adaptively and sometimes instantly to avoid problems or seize opportunities. Successful grazing managers (ranchers) often have to make quick decisions. Management teams need sufficient trust and knowledge to allow the grazer to make instant adjustments in grazing. An annual operating plan (AOP) can facilitate this process. Including a rangeland manager with lease management experience in the management team for KWA would facilitate implementation of grazing of KWA.

Livestock Grazing Management

Management History

Beginning around 1927, the Gamble family began buying up homesteads within the KWA, and eventually consolidated up to 18 homesteads into the "Knoxville Ranch" which included the Knoxville mine and town site. The Gambles used the ranch to run their herd of 400 beef cows, and also continued to work the mine. To increase forage production, the Gambles removed oaks from 2000 to 4000 acres of the Knoxville Ranch, including some areas that were completely cleared. In 1976 George Gamble closed the mine, and several years later razed what remained of the mine and the town because of looting and squatting. The old furnaces and piles of calcine (roasted ore) were buried.

In 1981, Homestake Mining Company bought the nearby Manhattan Mine after discovering an economic gold deposit in the same geologic formation that had produced mercury ore. Homestake dug an open pit mine at the site of the Manhattan Mine, and named the new operation the McLaughlin Mine. The McLaughlin pit was adjacent to the Knoxville Ranch, and in 1992 Homestake bought the Knoxville Ranch from the Gamble family in order to expand the pit. In 2000, Homestake sold the South Knoxville Ranch to CDFW (they retained the mineral rights), and kept the North Knoxville Ranch, which included a portion of the McLaughlin pit, the Knoxville Mine, and most of the Knoxville town site. Excavation at the pit ceased in 1996, and in 2002 the McLaughlin Mine was decommissioned and dismantled. Also in 2002, Homestake Mining Company (by then a subsidiary of Barrick Gold Corporation) signed an agreement with the University of California allowing the University to manage the property as a unit within its statewide Natural Reserve System. The Homestake property is currently managed by UC Davis as the McLaughlin Reserve, its primary function is to serve as an outdoor laboratory for academic teaching and research.

The KWA was purchased in three phases. The original property in the north was purchased from Homestake Mining Company on July 27, 2000 and is approximately 8,196 acres. The southern acquisition occurred in December 2005 and added 12,575 acres. The 738-acre Todd Ranch is located in the southern portion of the KWA and was purchased in December of 2008. A Land Management Plan (LMP) for the original 8,196-acre acquisition was completed and approved in June of 2005. All portions of the KWA formerly supported beef cattle operations. Currently, as a public State Wildlife Area, the main activities that occur on the property are hunting (e.g. deer, quail, and turkey), hiking, and wildlife viewing.

Terminology

Grazing managers can influence or control the ***season, frequency, duration and intensity of grazing***. Grazing managers can also manipulate livestock distribution through the placement of fences, water developments, supplements and other attractants (George et al. 2007). Grazing may occur all year or it may occur just during a certain period or season of the year. ***Season of grazing*** has to do with when during the year that grazing occurs. A season can be fall, winter, spring or summer but it can also be some other specified time period such as targeting grazing during flowering or dry season grazing.

Frequency and duration of grazing have to do with how often a pasture is grazed, how long a pasture is grazed and how long it is rested between grazings. ***Intensity of grazing*** has to do with stock density, stocking rate and carrying capacity. ***Stock density*** is the number of animals per acre at any point in time. This term is often used in intensive grazing management systems. ***Stocking rate*** is the number of specific kinds and classes of animals grazing a unit of land for a specified time period. ***Carrying capacity or grazing capacity*** is the maximum stocking rate possible while maintaining or improving vegetation or related resources. It may vary from year to year on the same area due to fluctuating forage production caused by variations in the timing and amount of precipitation (Becchetti et al. 2016).

Stocking rate and carrying capacity are often expressed as ***animal unit months*** (AUMs). The original definition of an AUM was the amount of forage a cow and her calf would consume in 1 month. This definition worked reasonably well for several years until cows started getting bigger and calf weaning weights increased. To accommodate bigger cows and calves the definition of an AUM was put on a weight basis. Today an ***animal unit*** (AU) is commonly defined as 1000 lbs. of body weight and an AUM is the amount of forage that an animal unit will consume in 1 month. If the cow and her calf weigh 1000 lbs. then they are still 1 animal unit. More likely the cow weighs 1200 lbs. and her calf grows to 400 or 500 lbs. by weaning. So the cow without a calf is 1.2 animal units. However, by weaning time the cow and her calf are around 1.6 or 1.7 animal units. The 1000 lb. animal unit can be applied to most large herbivores to get a rough estimate of stocking rate.

Prescribed grazing is a term that covers application of season, intensity, frequency and duration of grazing to meet objectives for the site, pasture, ranch or refuge. Prescribed Grazing is a practice in the USDA Natural Resources Conservation Technical Guide (http://efotg.nrcs.usda.gov/references/public/NE/NE528.pdf) and it is applied all over the United States. It is defined as managing the controlled harvest of vegetation with grazing animals. Removal of herbage will be in accordance with site production limitations, rate of plant growth and the physiological needs of vegetation. Prescribed grazing is intended to manage the kind of animal, animal numbers, grazing distribution, length of grazing periods and timing of use to provide sufficient deferment from grazing during the growing period. Grazing prescriptions are designed to protect soil, water, air, plant and animal resources when locating livestock feeding, handling and watering facilities and to manage grazing animals to maintain adequate vegetative cover on sensitive areas (i.e. riparian, wetland, and habitats of concern).

Targeted grazing is a recent term that is the application of a specific kind of livestock at a determined season, duration, and intensity to accomplish defined vegetation or landscape goals. This concept has been around for decades and has taken many names, including prescribed grazing and managed herbivory. The major difference between good grazing management and targeted grazing is that targeted grazing refocuses outputs of grazing from livestock production to vegetation and landscape enhancement. With targeted grazing, the land manager must have a clear vision of the desired plant community and landscape, and the livestock manager must have the skill to aim livestock at the target to accomplish land management goals.

Carrying Capacity

Carrying capacity is an average based on long-term records of climate, forage production, stocking rate and experience. The historic stocking rate of the two main ranches that occupied the KWA in the past was about 800 cows on about 20,000 acres or about 25 acres per AUM. Range forage productivity estimates from USDA Natural Resources Conservation Service (NRCS) Ecological Site Descriptions suggest that this stocking rate was conservative and below the actual carrying capacity. NRCS has estimated forage production for favorable (above average), normal (average) and unfavorable (below average) production years for the ecological sites on the KWA (Table 1). Forage estimates in 2016 confirmed the estimates presented in the ecological site descriptions. Forage production is largely controlled by the amount and timing of rainfall and can result in large differences between years. (Becchetti et al. 2016).

For this plan we have estimated carrying capacity (AUM/acre) using a scorecard (Table 2) that adjusts for slope and canopy cover. This scorecard was adapted from that developed by McDougald et.al (1991). This method adjusts carrying capacity based on 4 slope classes (0-10 %, 10-25 %, 25-40% and >40%) and 4 canopy cover classes (0-25, 25-50, 50-75, and 75-100 %). A slope class map (Figure 1) was generated from a digital elevation model and a canopy cover map (Figure 2) was generated from a 1 m NAIPs image (1 m pixel). A map of carrying capacity was generated by merging canopy cover and slope classes in Arc GIS (Figure 3). Carrying capacity was then estimated for each pasture or pasture (Table 3). Carrying capacity will be highest on open grasslands with gentle slopes and lowest on brushlands on steep terrain. The total carrying capacity for the north and south pastures (14378 acres) is 5166 AUMs or 33 acres per AUM (Table 3). This would support 430 animal units (1000 lb cows) for one year which is equivalent to 430 one thousand pound cows for one year or 1720 five hundred pound stockers for 6 months.

Table 1. Forage production estimates(lbs/acre) for KWA soils and ecological sites during favorable, normal, and unfavorable years (Lake County Soil Survey).

Map Unit	Soil Series/Associations	Unfavorable	Normal	Favorable	Ecological Site
112	Bressia-Dibble complex, 5 to 15 % slope	2000	3000	3500	Fine Loamy Upland
113	Bressia-Dibble complex, 15 to 30 % slope	2000	3000	3500	Fine Loamy Upland
114	Bressia-Dibble complex, 30 to 50 % slope	2000	3000	3500	Fine Loamy Upland
115	Bressia-Dibble complex, 30 to 50 % slope	2000	3000	3500	Fine Loamy Upland
120	Contra Costa loam, 50 to 15 % slope	400	900	1300	Shallow Loamy Hills
128	Diablo clay, 15 to 30 % slope	1600	2500	3500	Deep Clay
129	Diablo clay, 30 to 50 % slope	1600	2500	3500	Deep Clay
151	Hambright-Rock outcrop complex, 2 to 30 % slope	600	1000	1600	Very Shallow Rocky
154	Henneke gravelly loam, 30 to 75 % slope	500	600	800	Rocky Serpentine
163	Maymen-Millsholm-Lodo association, 30 to 75 % slope	1300	900	400	Shallow Loamy Hills
166	Montara clay loam, 5 to 30 % slope	600	900	1400	Serpentine
175	Rock Outcrop	N/A	N/A	N/A	N/A
181	Yolo loam, 0 to 2 % slope	2000	3000	3500	
183	Water	N/A	N/A	N/A	N/A

N/A = not applicable

Table 2. Estimate carrying capacity (AUM/acre) for KWA based on slope and canopy cover.

Knoxville Wildlife Area Estimated Grazing Capacity				
	Slope Classes (%)			
Canopy Cover Classes (%)	< 10	10 - 25	25 - 40	> 40
	AUM/acre			
0 - 25	2	0.8	0.5	0.3
25 - 50	1.5	0.6	0.4	0.2
50 - 75	1	0.4	0.3	0.1
75 - 100	0.5	0.2	0.2	0.1
	RDM (lb/acre)			
	400	600	800	800

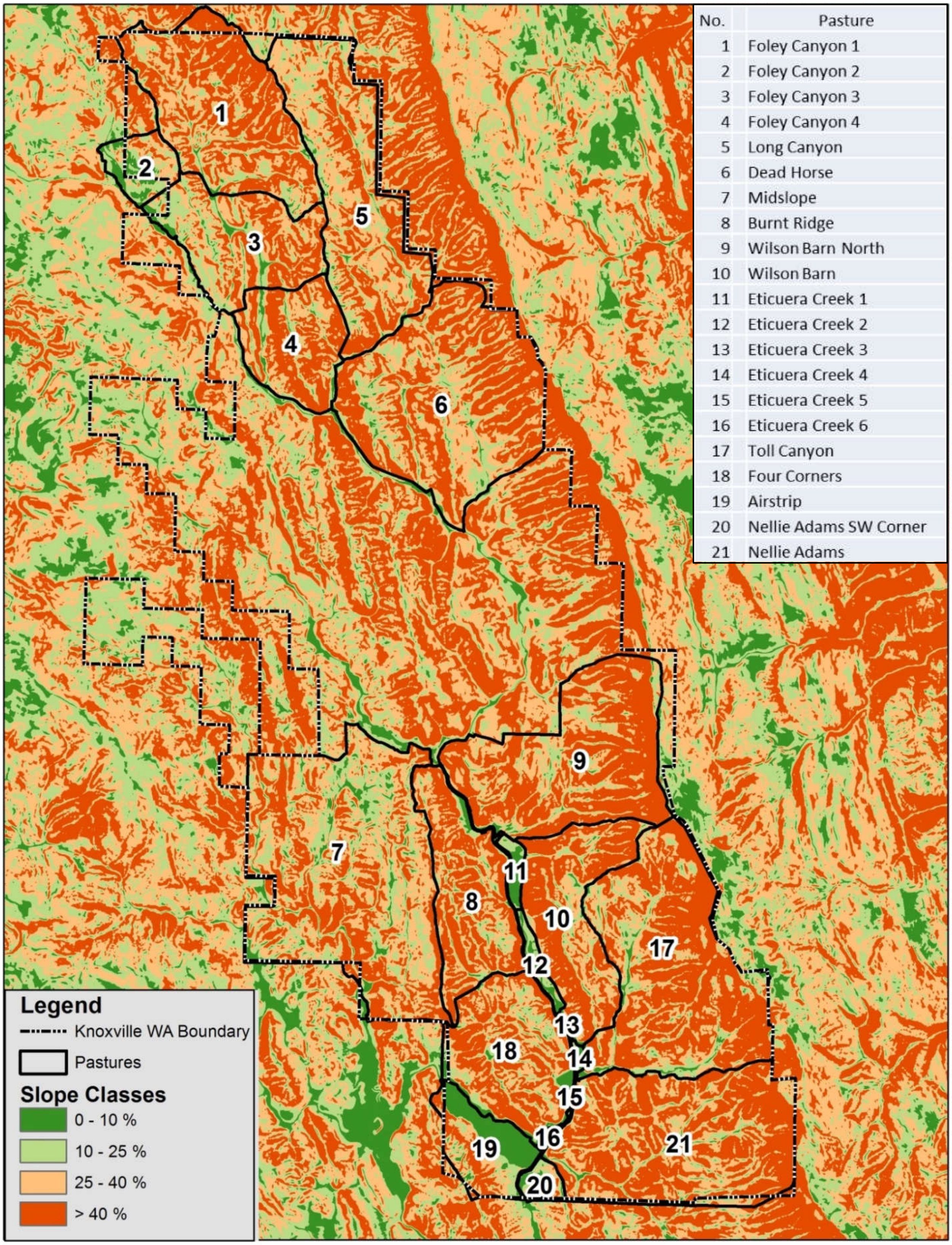


Figure 1. Knoxville Wildlife Area Slope Class Map

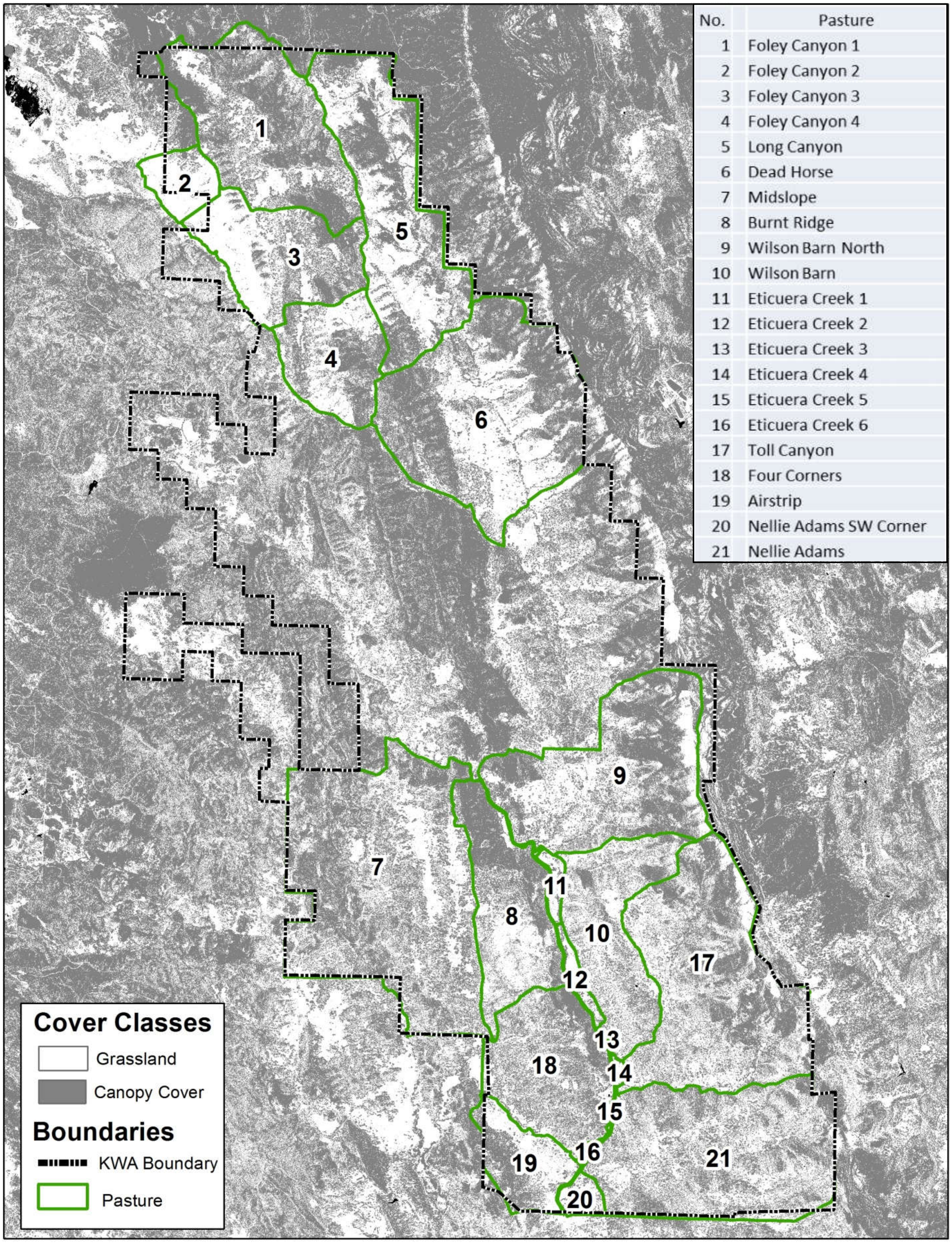


Figure 2. Knoxville Wildlife Area Vegetation Cover Map

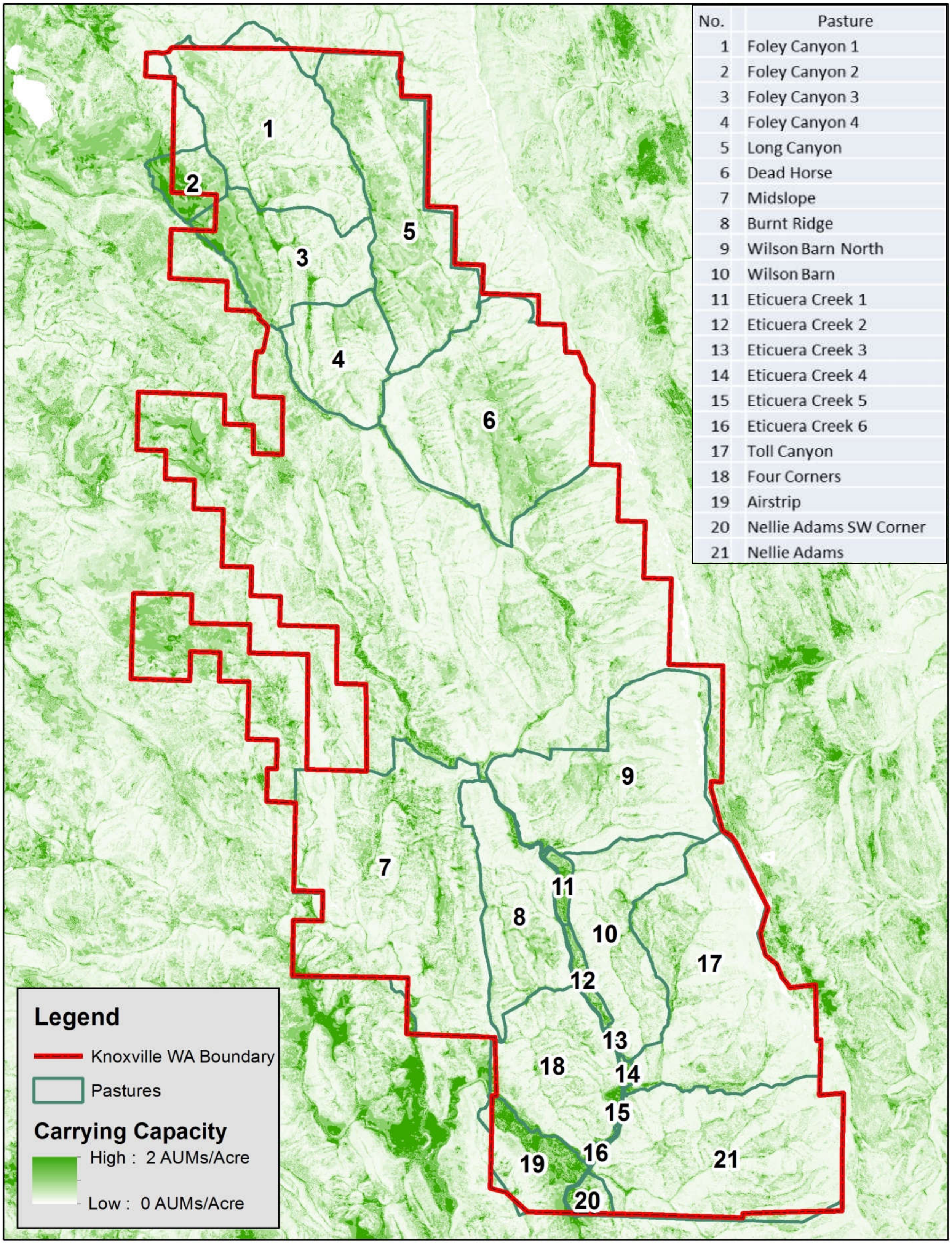


Figure 3. Knoxville Wildlife Area Carrying Capacity Map

Table 3. Pasture areas and carrying capacities for the North and South Pastures.

Map No.	Area (acres)	Carrying Capacity[1] (AUMs)	Stockers[2] (No./6 mo.)	Cows[3] (No./6 mo.)	Cows[4] (No./12 mo.)	Pasture Name
North Pastures						
1	1113	244	81	41	20	Foley Canyon 1
2	190	184	61	31	15	Foley Canyon 2
3	713	378	126	63	32	Foley Canyon 3
4	524	194	65	32	16	Foley Canyon 4
5	1171	423	141	71	35	Long Canyon
6	1586	469	156	78	39	Dead Horse
Total	**5297**	**1892**	**631**	**315**	**158**	
Footnotes:						
1	**1892**	divided by 12 months gives number of animal units that can be				
		supported for one year.			**158**	AUs can be supported
		for 1 year in the North Pastures combined.				
2	**631**	500 lb stockers (1/2 AU) can be grazed for 6 months (e.g. Dec.-May)				
		if you use all of the pastures for a total of 5297 acres.				
		This was determined by dividing 1892 AUMs by 1/2 AU and by 6 mo.				
3	**315**	1000 lb. cows (1 AU) can be grazed for 6 months (e.g. Dec.-May)				
		if you use all of the pastures for a total of 5297 acres.				
		This was determined by dividing 1892 AUMs by 1 AU and by 6 mo.				
4	***158***	1000 lb. cows (1 AU) can be grazed for 6 months (e.g. Dec.-May)				
		if you use all of the pastures for a total of 5297 acres.				
		This was determined by dividing 1892 AUMs by 1 AU and by 6 mo.				
To start out conservatively graze at a stocking rate that is about 1/2 of the carrying						
capacity. You can increase the stocking rate toward the carrying capacity as you gain						
experience. Therefore,		**315**	stockers would be a good starting point for the first year.			

Table 3 (cont).

Map No.	Area (acres)	Carrying Capacity[1] (AUMs)	Stockers[2] (No./6 mo.)	Cows[3] (No./6 mo.)	Cows[4] (No./12 mo.)	Pasture Name
South Pastures						
7	2076	738	246	123	62	Midslope
8	708	194	65	32	16	Burnt Ridge
9	1267	287	96	48	24	Wilson Barn North
10	738	239	80	40	20	Wilson Barn
11	51	78	26	13	7	Eticuera Creek #1
12	61	55	18	9	5	Eticuera Creek #2
13	4	4	1	1	0	Eticuera Creek #3
14	13	17	6	3	1	Eticuera Creek #4
15	6	9	3	2	1	Eticuera Creek #5
16	7	12	4	2	1	Eticuera Creek #6
17	1524	513	171	86	43	Toll Canyon
18	770	259	86	43	22	Four Corners
19	335	346	115	58	29	Airstrip
20	71	69	23	12	6	Nellie Adams SW Corner
21	1450	454	151	76	38	Nellie Adams
Total	**9081**	**3274**	**1091**	**546**	**273**	

Footnotes:		
1	**3274**	divided by 12 months gives number of animal units that can be supported for one year. **273** AUs can be supported for 1 year in the South Pastures combined.
2	**1091**	500 lb stockers (1/2 AU) can be grazed for 6 months (e.g. Dec - May) if you use all of the pastures for a total of 9081 acres. *This was determined by dividing 3274 AUMs by 1/2 AU and by 6 mo.*
3	**546**	1000 lb. cows (1 AU) can be grazed for 6 months (e.g. Dec - May) if you use all of the pastures for a total of 9081 acres. *This was determined by dividing 3274 AUMs by 1 AU and by 6 mo.*
4	***273***	1000 lb. cows (1 AU) can be grazed for 6 months (e.g. Dec - May) if you use all of the pastures for a total of 9081 acres. *This was determined by dividing 3274 AUMs by 1 AU and by 6 mo.*

To start out conservatively graze at a stocking rate that is about 1/2 of the carrying capacity. You can increase the stocking rate toward the carrying capacity as you gain experience. Therefore, **546** stockers would be a good starting point for the first year.

Livestock Distribution

Poor livestock distribution is often the source of livestock grazing impacts on water quality, habitat and biodiversity. Strategic application of livestock distribution practices as part of a prescribed grazing plan can modify livestock behavior and improve livestock distribution. Water development and fencing are the most common distribution practices. While fencing is designed to contain or exclude livestock, strategic placement of water developments or nutritional supplements have proven to be effective livestock attractants that can be useful in large pastures (Bailey et al. 2001, George et al. 2007, 2008). Following are some common livestock distribution practices that may be useful at KWA:

Pasture subdivision: Too facilitate weed management and to refine the creation of grazed and ungrazed mosaics, large pastures may eventually need to be cross-fenced and stock water developed.

Electric fencing: It is difficult to ground electric fencing on dry soils so electric fencing will be most useful during the wet season. Electric fencing requires daily monitoring to insure that it is functioning properly. Livestock must be trained to respect electric fences before they can be effective.

Permanent fencing: Most fencing on KWA needs to be replaced or requires substantial repair. Effective boundary fences and fences along Knoxville Road are a high priority to keep livestock off of the road and on the property. Internal fences are important for effective grazing management. Wildlife friendly fences are preferred to reduce their impact on wildlife. Good gates are critical to ease of management and property security. Functional fences and corals are essential to the control, movement and handling of livestock.

Water development: Water resources at KWA limit the opportunities to manipulate livestock distribution and to subdivide pastures. While there may be potential to add water lines, storage tanks, and troughs to the existing water systems, the opportunities to develop more water sources are limited. Water systems must be maintained and monitored throughout the year. Bullet proof storage tanks and troughs may be needed.

Nutrient supplements: Placement of protein and mineral supplements can be used to attract livestock into an area targeted for grazing. Research has shown that dehydrated molasses protein supplements (e.g. Crystalyx) will attract livestock into an area and increase grazing use up to 600 yards from the supplement site (Bailey et al. 2001, George et al. 2007, 2008). Supplement sites should be moved frequently to minimize trampling impacts. Trampled supplement sites may be good sites for native plant seeding trials.

Targeted Grazing Management

Targeted grazing is a term similar to prescribed grazing. It is the application of a specific kind of livestock at a determined season, duration, and intensity to accomplish defined vegetation or landscape goals. Spatial and temporal application of an array of grazing management practices have the potential to protect habitats and resource values in some pastures, and strategically reduce competition from non-native invasive species in other pastures. Following are some habitat goals where grazing could be used at KWA: 1) suppress non-native annual plants, 2) reduce fire hazard, 3) maintain native forb and perennial grass populations, 4) protect riparian areas and manage riparian vegetation, and 5) maintain a mosaic of herbaceous cover heights that provide hiding cover as well as low cover for some rodents and ground dwelling birds, 6) protect selected oak seedlings and saplings.

Grazing Effects

While grazing by wild and domestic herbivores is known to alter ecosystem structure and function, even partial knowledge of the grazing practices that led to these alterations can be used to apply grazing practices to partially reverse these alterations or move to some new desired ecosystem structure that meets society's needs for habitat, open space, biodiversity, clean water and other ecosystem services. Grazing has been shown to alter grassland species composition but removal of grazing also results in change. In the non-native annual dominated grasslands of California long term heavy grazing has contributed to the transition from a native perennial dominated state to a non-native annual dominated state but removal of grazing has not resulted in reversal to a pre-settlement state. There have been several studies that have reported that cessation of grazing may have detrimental effects on native flora and fauna. In a well documented study removal of grazing decreased native vernal pool plant and aquatic invertebrate species and application of grazing increased these species but ungrazed pools had 88% higher cover of exotic annual grasses and 47% lower relative cover of native species than pools grazed at historical levels (continuously grazed) (Marty 2005). Additionally the inundation period of the pools was reduced in ungrazed pools, which, based on the Pyke and Marty (2005) model with hypothesized climate changes, could make it difficult for some endemic vernal pool species to complete their life cycle. Weiss (1999) surveyed Bay checkerspot butterfly (*Euphydryas editha bayensis*) populations in serpentine grasslands south of San Jose, California and found grazing exclusion led to loss of the butterfly.

Benefits of grazing have also been documented in coastal grasslands. Hayes (1998) reports that cessation of grazing is a threat to annual wild flower displays. One species, Santa Cruz tarplant (*Holocarpha macradenia*), flourished with grazing but disappeared when grazing was removed. In another study Hayes and Holl (2003) found that native annual forb richness and cover were greater in grazed sites and this effect coincided with decreased vegetation height and litter depth. Native grass cover and species richness did not differ in grazed and ungrazed sites but cover and species richness of native perennial forbs was higher on ungrazed sites. Based on these results, Hayes and Holl (2003) concluded that their results suggested that cattle grazing may be a valuable management tool to conserve native annual forbs and possibly other species of concern.

Grazing management has been effective in controlling noxious weeds such as medusahead (*Taeniatherum caput-medusae*) and yellow starthistle (*Centaurea solstitialis*) (DiTomaso 2000, 2006a, 2008) although the authors concluded that gazing is unlikely to be a practical solution for management of large-scale infestations. Properly timed grazing can reduce flowering in non-native annual plants such as ripgut brome (*Bromus diandrus*), and red brome (*Bromus madritensis*) (Savelle and Heady 1970, Germano et al. 2004, McGarvey 2009 and Battles et al. in press). Grazing can also impede invasion of the grassland by shrubs such as coyote bush (*Baccharis pilularis*) McBride and Heady 1968). Grazing exclusion often leads to ripgut brome dominance (Heady 1968, Heady et al. 1991) while grazing can reduce ripgut brome by reducing residual dry matter (Heady 1958).

Managed grazing may also benefit animal habitat. The US Fish and Wildlife Service recognized that grazing and maintenance of stock ponds can provide suitable breeding habitat for the California red-legged frog (*Rana draytonii*) and the California tiger salamander (*Ambystoma californiense*). Germano et al. (2001) found that the cover of non-native grasses and forbs often creates an impenetrable thicket for small, ground-dwelling vertebrates. An on-going long term study in Kern County has found that populations of several animals are often higher on grazed plots than in ungrazed plots including short nosed kangaroo rats (*Dipodomys nitratoides brevinasus*), giant kangaroo rats (*Dipodomys ingens*), sage sparrows (*Artemisiospiza nevadensis*), horned larks (*Eremophila alpestris*), western meadowlarks (*Sturnella neglecta)* and blunt-nosed leopard lizards (*Gambelia sila)* (Germano et al. 2006).

Grazing may also reduce fire hazard. Fuel management studies have shown that spread rate and flame length are lower when dry grass fuel load is less than 800 lb/a when compared to dry grass fuel loads of 2200 lb/a (about 1 foot tall) (Scott and Burgan 2005).

Grazing and Native Plants

It is a goal for KWA to maintain native plant populations but extreme competition from non- native grasses threatens the existing plant biodiversity. This report focuses on grazing as a vegetation management practice for managing annual grassland and associated communities. Removal of grazing from reserves and conservation trusts has been common and has been shown to reduce diversity of herbaceous native and exotic plant species, in some cases to the detriment of threatened species that depend on non-grass species (Weiss 1999, Hayes and Holl 2003, Marty 2005, Pyke and Marty 2005).

A variety of experiments have shown that non-native annual grasses are able to reduce the growth and survival of native perennial grass individuals and to limit growth of native grass populations in and adjacent to California's central valley (Dyer and Rice 1997, 1999, Brown and Rice 2000, Marty 2005). The negative effects of non-native annual grasses on all purple needlegrass (*Stipa pulcra or Nasella pulcra*) life stages strongly suggest that exotic annuals have negative effect on many native perennial populations (Corbin et al. 2007).

While year-long heavy grazing is implicated in the reduction and loss of native species, the influence of prescribed grazing management practices such as seasonal grazing, reduced grazing intensities and rest from grazing on native species is not well studied. The effects of fire and grazing on purple needlegrass have been studied more than most other native species and results are inconclusive. However, moderate grazing intensities and rest between grazing have been observed to increase the vigor of purple needlegrass. Several species of native forbs (e.g., *Iris* spp., *Orthocarpus* spp., *Ranunculus californica*, *Limnathes* spp., and *Orcuttia* spp.) may increase under light to moderate grazing intensities (Edwards 1995, Barry 1998, Hayes and Holl 2003).

Species composition has been largely unaffected by manipulation of grazing intensity in non-native annual grassland sites with only negligible native plant cover (Pitt and Heady 1979, Rosiere 1987, Jackson and Bartolome 2002). In grasslands composed of mixed non-native annual grassland and native annual species, such as vernal pools and serpentine sites, grazing has been used to promote native annual wildflowers (Weiss 1999, Marty 2005). In mixed annual and perennial grasslands on mesic sites effects of grazing on native plant composition has been variable (Bartolome et al. 1980). However several studies have demonstrated that mulch removal can be beneficial or have no effect on native plant seed production, seedling establishment, and seedling density or mortality (Savelle 1977, Dyer et al. 1996, Reynolds et al. 2001 and Marty et al. 2005).

The effectiveness of seasonal grazing on native plant vigor, survival and productivity has been mixed. Early spring grazing has been observed to suppress faster germinating exotic annual grasses reducing the competitive suppression of perennial bunchgrasses or native forbs whose seed germinated later than the grasses (Love 1944, Langstroth 1991, Dyer et al 1996).

Management Goals and Objectives

The overall goals for managing the KWA are to:

- Maintain and improve habitat for native plants and animals; improve biodiversity
- Reduce potential for hot, catastrophic fire; encourage low burns
- Maintain and increase native grasses and forbs
- Manage invasive weeds

Reaching these goals will require development of grazing infrastructure and vegetation management objectives.

Infrastructure Development Objectives

A livestock grazing operation requires fences, gates, stock water and livestock handling facilities. The extent of these developments depends on the kind of livestock operation. A beef stocker operation grazes calves on green grass in winter and spring and then markets the calves as the dry season approaches. Because there is water in the creeks during this grazing period a stocker operation can usually rely on surface water and may not require extensive water development. A stocker operation may also get along without livestock handling facilities, especially if the lessee has portable chutes and corrals or lives close enough to trail the cattle to on-ranch handling facilities. A winter-spring lease could also be used by a cow-calf operation but would have to leave when surface water was no longer available. An additional advantage of a winter-spring grazing lease is that it avoids deer and bear hunting season (Figure 4).

A seasonal sheep operation is also an alternative but the potential for predator losses and special fence requirements may preclude a sheep operation. However, the use of sheep and/or goats for targeted weed control by the lessee should not be precluded in the lease agreement. A year-around cow-calf operation requires stock water throughout the year but without water developments, handling facilities and other improvements KWA is not currently a viable site for a year around cow-calf operation.

A stocker operation or seasonal cow-calf operation would be viable initial operations at KWA. Such an operation could be initiated when sufficient boundary fences were in place. Internal fencing could be developed as grazing proceeds and during the summer-fall when grazing is not present.

Figure 4. Calendar of hunting seasons and stocker operations.

	J	A	S	O	N	D	J	F	M	A	M	J
Deer (Archery)	2nd Saturday in July to 1st Sunday in Aug											
Deer (Rifle)		2nd Sat in Aug to 3rd Sat in Sep										
Mourning Dove			Sep 1 -15		2nd Sat of Nov to end of 30 days							
California Quail				Last Sun in Sep to last Sun in Jan								
Turkey (Spring, Archery)											1st Mon in May to 3rd Sun in May	
Turkey (Fall)					2nd Sat in Nov to 2nd Sat in Dec							
Pigs						Pig hunting all year						
Bear	During deer hunting season											
Stocker												

Objective: Develop lease policies and a lessee selection process

CDFW does not have funding for needed infrastructure developments and state policies preclude trading grazing for infrastructure development in the lease agreement. KWA staff propose to use lease fees for habitat management including fencing to contain livestock. The fencing will be purchased by CDFW and installed by the lessee. The lessee will factor installation cost into the lease. CDFW needs to find a lessee with the willingness and ability to collaborate with CDFW on achieving KWA management objectives.

Some guidelines for developing a lease agreement.

1. Develop a lessee selection process that will identify a lessee willing to collaborate as a partner with CDFW to develop KWA grazing infrastructure.
    a. Develop a “request for grazing proposals” that will identify potential lessees.
    b. Review proposals and select a potential lessee(s).
    c. Interview lessees.
    d. Select a lessee and negotiate a lease agreement. A long-term lease (5 to 10 years) may be necessary to attract a lessee.
2. Develop an annual operating plan (AOP) with the lessee.

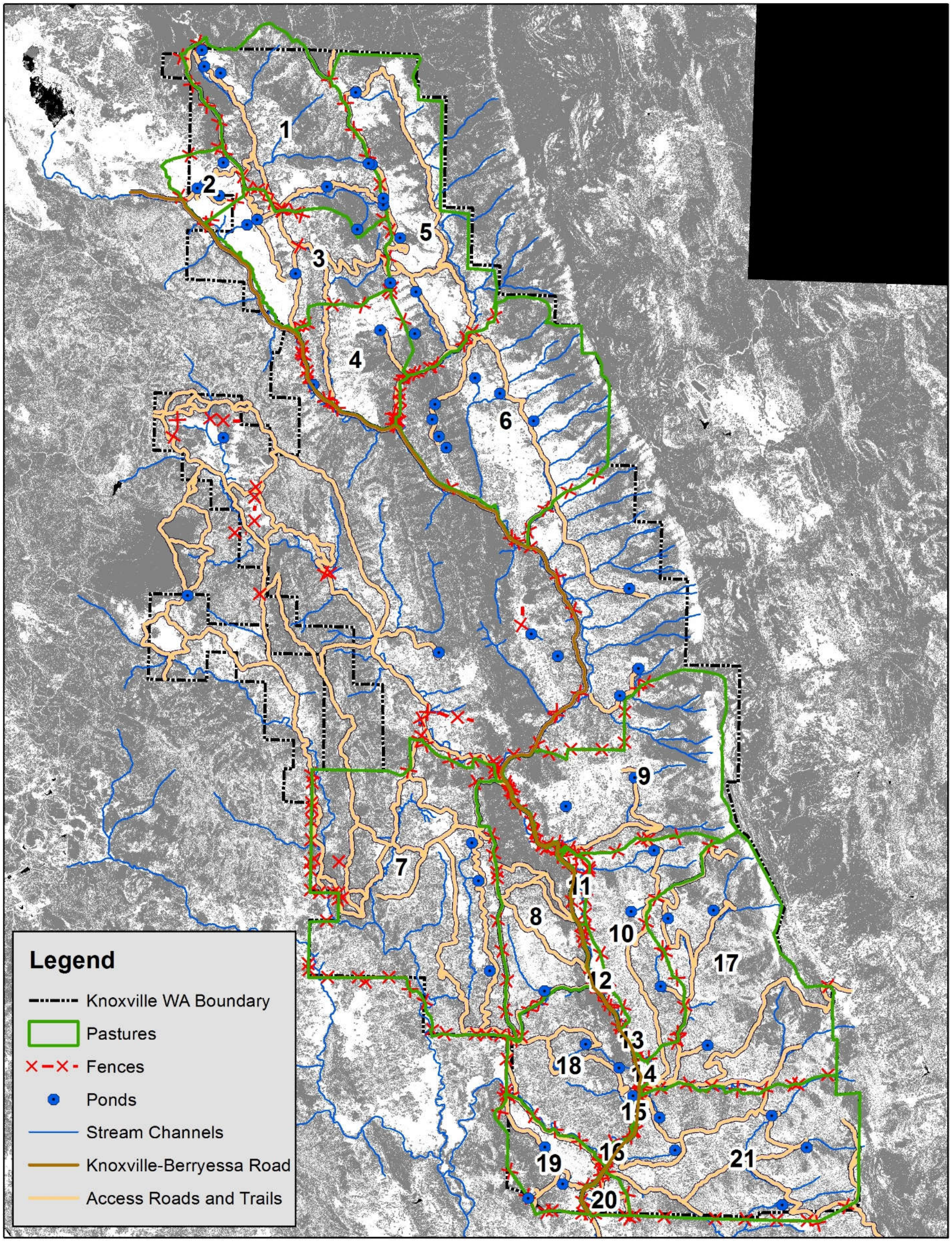
Objective: Replace or improve pasture fencing, stock water developments and handling facilities.

Existing fences need to be replaced or repaired throughout the KWA (Figure 5). Appendix A is an estimate of material costs for the east side of Knoxville Road from the southern boundary to the Wilson Barn North pasture (Appendix A1) and the north fence of the Wilson Barn North pasture (Appendix A2). There are no handling facilities at the south end of KWA and those at the north end (Figure 5) will require significant repair. There are more than 50 stock water ponds on KWA (Figure 5) but many need repair. Stockwater costs will vary greatly depending on lessee needs. Stockwater storage tanks may be needed as well as new pipelines and water troughs. Infrastructure requirements are extensive and must be prioritized in collaboration with a lessee. Initial grazing leases should rely on winter/spring surface water until water developments are installed or repaired. To provide an estimate of potential material and labor costs, Appendix B, the 2015 payment schedule for the USDA EQIP Program, is provided.

Fencing guidelines

1. Prioritize fence replacement and repair.
    a. Propose yearly fence replacement and repair and gate locations in the AOP.
    b. Install and repair fences and gates along the south pastures adjacent to Knoxville Road .
    c. Install and repair the north boundary fence of the Wilson Barn North p
    d. Install and repair the remaining boundary fences and gates around the south grazing area.
    e. Install and repair internal pasture fences and gates in the south grazing area.

Figure 5. Knoxville Wildlife Area pastures, fences, ponds, roads and streams.



   f. Install and repair fences and gates along the north pastures adjacent to Knoxville Road .
   g. Install and repair boundary fences and gates around the north grazing area.
   h. Install and repair internal pasture fences and gates in the north grazing area
2. Use a four wire fence with gates for road, boundary and internal fencing (see Appendix A for material/costs, see fence design from "A Landowner's Guide to Wildlife Friendly Fences", Paige 2012, pg. 21).
3. For ease of entry use steel gates on roads and at main passages between pastures.

Handling Facility Guidelines
1. Determine the need for handling facilities with lessee.
2. Plan and develop handling facilities including adequate space for trucks to turn around.

Water Developments
1. Determine the need and priorities for water developments with the lessee.
2. Prioritize stock pond repair and termination.
3. Determine and prioritize pipeline, storage tank and water trough needs with lessee.

Vegetation Management Objectives
Reducing invasive weeds especially yellow starthistle, medusahead and barbed goatgrass (*Aegilops triuncialis)* and increasing native grasses and forbs are high priority objective for KWA. Reducing fuel loads is also an objective at KWA. Reaching these objectives on 20,000 acres of diverse plant communities and ecological sites at KWA is a major long-term undertaking that must be prioritized. The KWA has been divided into pastures and grazing and restoration practices have been proposed for each unit (Table 4). Priority should be given to maintaining existing native populations and increasing natives on sites with a high potential to support native populations. Grazing practices should be targeted to support reduction of invasive weeds and fuel load while supporting native plant populations and restoration projects. Habitat and watershed values should be protected by apply grazing practices that protect and improve food and cover for wildlife, wetland and riparian vegetation, and erosion and sediment delivery.

Generic Management Unit Practices
Following are generic practices that may be implemented in each pasture (pasture). Objectives and priorities in each pasture will guide application of these practices.

Objective: Maintain and improve competitive ability of existing native grass populations.
Native grasses, mainly purple needlegrass, are widespread in grassland and oak-woodland communities at KWA. The objective for these existing stands should be to maintain the stands and improve their competitive ability. Proper grazing practices can maintain and improve the competitive ability of native grasses but increasing density will require seeding or transplanting of native grasses. These practices may receive priority in the Airstrip and Eticuera pastures.

Table 4. Pasture areas, carrying capacities, RDM targets and management priorities for the south and north pastures.

Pasture Name	Map No.	Management Priority
South Pastures		
Midslope	7	grazing to manage medushahead and goat grass.
Burnt Ridge	8	grazing to manage medushahead and goat grass.
Wilson Barn North	9	grazing to manage medushahead and goat grass.
Wilson Barn	10	grazing to manage medushahead and goat grass.
Eticuera Creek #1	11	yellow star thistle control, perennial grass seeding
Eticuera Creek #2	12	yellow star thistle control, perennial grass seeding
Eticuera Creek #3	13	yellow star thistle control, perennial grass seeding
Eticuera Creek #4	14	yellow star thistle control, perennial grass seeding
Eticuera Creek #5	15	yellow star thistle control, perennial grass seeding
Eticuera Creek #6	16	yellow star thistle control, perennial grass seeding
Toll Canyon	17	grazing to manage medushahead and goat grass.
Four Corners	18	grazing to manage medushahead and goat grass.
Airstrip	19	yellow star thistle control, perennial grass seeding
Nellie Adams SW Corner	20	grazing to manage medushahead and goat grass.
Nellie Adams	21	grazing to manage medushahead and goat grass.
North Pastures		
Foley Canyon 1	1	grazing to manage medushahead and goat grass.
Foley Canyon 2	2	grazing to manage medushahead and goat grass.
Foley Canyon 3	3	grazing to manage medushahead and goat grass.
Foley Canyon 4	4	grazing to manage medushahead and goat grass.
Long Canyon	5	grazing to manage medushahead and goat grass.
Dead Horse	6	grazing to manage medushahead and goat grass.

Grazing guidelines for existing native grass populations:

1. First, do no harm! Avoid grazing closely and continuously over many months and years
2. Apply early spring grazing to reduce competition from invasive annuals.
    a. On productive soils, use heavy spring grazing to reduce invasive species and follow with rest during flowering and hard summer–fall grazing to reduce litter and produce a harsh microclimate for germination and seedling establishment the following growing season.
    b. On less-productive soils, limit heavy spring grazing to high-production years and follow with rest during flowering and hard summer–fall grazing to reduce litter and produce a harsh microclimate for germination and seedling establishment the following growing season.
3. Graze during the dry season to create a harsh soil surface microclimate during germination and seedling establishment the following year. This also reduces fuel load.
4. Rest for at least 4 weeks following spring grazing to allow regrowth and tillering. Rotational grazing can facilitate application of this rest treatment.
5. Rest during flowering to allow for seed set before soil moisture is depleted. Depending on the timing of spring grazing, Guideline 4 could accomplish this objective.
6. Avoid close grazing during the growing season. Minimum stubble height of 5–10 cm (2–4 inches) will ensure regrowth and tillering. Close grazing (less than 2.5 cm) throughout the growing season for two growing seasons in a row can result in plant mortality.
7. It might be logistically difficult to apply all of these guidelines in a timely manner to all pastures. If rest cannot be applied to all pastures during flowering and seed set annually, then this rest treatment should be rotated annually so that purple needlegrass has a chance to flower and set seed in each pasture every few years.
8. Rotational grazing can facilitate application of most of these practices. Rotational grazing that provides for at least 4 weeks of rest (Table 5) following grazing during the growing season, avoids grazing the same pasture during flowering each year, avoids grazing below a stubble height of 5 cm during the growing season, and removes standing litter during the dry season should maintain the vigor and competitive ability of purple needlegrass.

Objective: Restore native grasses and forbs

There are numerous sites where invasive weeds have replaced native grasses and are suppressing existing populations of native plants. On these sites grazing can suppress the invasive weeds but strategic application of herbicides and seeding may be required to increase the density and extent of native plant populations..

Guidelines for Native Grass and Forb Restoration

Site preparation is required before planting native plants. Site preparation involves weed control and seedbed preparation. Weed control can be accomplished by application of herbicides, burning, disking, mowing and often a combination of these control methods. The objective is to reduce competition from existing vegetation. It is important to begin weed control on the site as early as possible, even several years before planting. One of the least expensive ways to clear the weeds from the site before planting native grasses is simply to till the soil over a long enough period of time to exhaust the seed bank. You till and kill seedlings before they produce seeds, then till again to kill the next crop of seeds in the soil. Eventually (1-3 years, with 3-4 tillage cycles each year) the number of seeds in the soil's "bank" of seeds

Table 5. Example of a 5 year grazing rotation sequence with grazing level and RDM targets assuming an annual early January in-date and late June out-date.

	Graze													Date														RDM
Pasture Name	**Level**	**J3**	**J10**	**J17**	**J24**	**J31**	**F7**	**F14**	**F21**	**F28**	**M6**	**M13**	**M20**	**M27**	**A3**	**A10**	**A17**	**A24**	**M1**	**M8**	**M15**	**M22**	**M29**	**J5**	**J12**	**J19**	**J26**	**Target**
												YEAR 1																
Nellie Adams	Close									Medusahead Control:					X	X	X	X	X	X	X	X	X					500 to 800
Toll Canyon	No											No Grazing																Ungrazed
Wilson Barn	Mod	X	X					X	X															X	X			800 to 1000
Airstrip	R											Restoration Area may be grazed as needed																
Four Corners	Mod			X	X					X	X	X														X	X	800 to 1000
Burnt Ridge	No											No Grazing																Ungrazed
Midslope	Light					X							X															2000+
Wilson Barn North	Light						X							X														2000+
												YEAR 2																
Nellie Adams	Close									Medusahead Control:					X	X	X	X	X	X	X	X	X					500 to 800
Toll Canyon	Mod	X	X					X	X															X	X			800 to 1000
Wilson Barn	Light						X							X														2000+
Airstrip	R											Restoration Area may be grazed as needed																
Four Corners	No											No Grazing																Ungrazed
Burnt Ridge	Light					X							X															2000+
Midslope	No											No Grazing																Ungrazed
Wilson Barn North	Mod			X	X					X	X	X														X	X	800 to 1000
												YEAR 3																
Nellie Adams	Mod	X	X					X	X				X	X										X	X			800 to 1000
Toll Canyon	Light						X																					2000+
Wilson Barn	No											No Grazing																Ungrazed
Airstrip	R											Restoration Area may be grazed as needed																
Four Corners	Light					X																						2000+
Burnt Ridge	Mod									X	X	X														X	X	800 to 1000
Midslope	No											No Grazing																Ungrazed
Wilson Barn North	Close									Medusahead Control:					X	X	X	X	X	X	X	X	X					500 to 800
												YEAR 4																
Nellie Adams	Close									Medusahead Control:					X	X	X	X	X	X	X	X	X					500 to 800
Toll Canyon	Light					X																						2000+
Wilson Barn	Mod	X	X					X	X				X	X										X	X			800 to 1000
Airstrip	R											Restoration Area may be grazed as needed																
Four Corners	No											No Grazing																Ungrazed
Burnt Ridge	No											No Grazing																Ungrazed
Midslope	Mod			X	X					X	X	X														X	X	800 to 1000
Wilson Barn North	Light						X																					2000+
												YEAR 5																
Nellie Adams	Mod	X	X					X	X				X	X										X	X			800 to 1000
Toll Canyon	Light																											2000+
Wilson Barn	No											No Grazing																Ungrazed
Airstrip	R											Restoration Area may be grazed as needed																
Four Corners	Light																											2000+
Burnt Ridge	Mod			X	X					X	X	X														X	X	800 to 1000
Midslope	No											No Grazing																Ungrazed
Wilson Barn North	Close									Medusahead Control:					X	X	X	X	X	X	X	X	X					500 to 800

is exhausted. Where cultivation is possible growing a crop of oats for hay or grazing with broadleaf weed control has been used in preparation for perennial grass seedings. Seeding should be done in fall just before the beginning of the rainy season.

Objective: Suppress invasive weeds.

Published guides for controlling medusahead, goatgrass and yellow starthistle are available online. These reports cover chemical, mechanical, cultural and burning practices that research has shown to be effective in control of these weeds. In this plan we will concentrate on grazing as a method of weed management. For other practices managers should refer to the publications below. Because research is constantly working to find effective control practices it can be useful to check with the local UC Cooperative Extension livestock and range management farm advisor.

Medusahead: http://wric.ucdavis.edu/publications/MedusaheadManagementGuide_pub_2014.pdf

Barbed goatgrass: https://ucanr.edu/repository/fileaccess.cfm?article=158157&p=LGLOUW

Yellow starthistle: http://www.cal-ipc.org/ip/management/pdf/YSTMgmtweb.pdf

Guidelines for medusahead

Medusahead is an aggressive winter annual grass that has invaded millions of acres of California and western rangelands. It appears more commonly on high shrink-swell clay soils. Infested rangelands have suffered up to 75% reductions in grazing capacity. Control of small, isolated infestations is critical to keep it from becoming widespread. Kyser et al. (2014) have reviewed the ecology and management of medusahead.

Medusahead germinates after the first fall rains with smaller germination events occurring later in the wet season. Medusahead does not produce seed heads until late April or May, after most annuals have completed their life cycle. This late maturity date may allow medusahead to take advantage of late spring rains.

Methods for controlling medusahead have been studied and implemented since the 1950s. Control approaches have often targeted windows for burning when medusahead is still growing, but when most associated species are mature and dry (Kyser et al. 2008, Murphy and Lusk 1961, McKell et al. 1962). Grazing management approaches have successfully reduced flowering by targeting a narrow period just before the flower emerges in April or May (DiTomaso et al. 2008). Glyphosate can be an effective control method when applied in early spring to young medusahead plants. However, it is non-selective and can damage desirable broadleaf or grass vegetation, including native perennial grasses at moderate to high rates. In the correct ecosystem, proper timing and low rates of glyphosate can control medusahead without damaging desirable perennial plants (Kyser et al. 2012a). Fall applications of aminopyralid at high rates have been shown to prevent medusahead germination throughout the season (Kyser et al. 2012b).

Grazing

Grazing medusahead closely just before the flower emerges in the spring is a proven method to control this species. However, high stock densities are often necessary to get the close grazing required to reduce flowering. In one study this required 5 to 10 sheep on a 100 sq meter plot for one to two days

(DiTomaso et al. 2008). This is equivalent to 185 to 370 sheep per acre during the narrow window of treatment. With a window of 1 to 2 weeks for grazing before the flower emerges and the high stock densities necessary to reduce flowering, the area that can be treated annually will be small. Thus this method requires some planning and monitoring of medusahead as the time window approaches. This method may not be practical over large and/or scattered populations because livestock may graze on other species or may not be able to graze all individual plants prior to seed set.

Timing and Intensity of Grazing

1. Graze from late November to February to reduce thatch.
2. Graze from March to June to reduce medusahead flowering and seed set, target an RDM of 500-600 lb/a.
3. In years with late spring rainfall (May-June) the grazing season should be extended beyond June to impact medusahead regrowth following late rains.
4. Increase stock density in target areas just before medusahead flowers (April-May). Stock density can be increased by decreasing the size of the pasture using electric fencing. Graze the target area as close as possible.
5. Repeat the treatment in year 2.
6. Placement of protein supplements (e.g. Crystalyx) near medusahead patches may increase grazing and trampling in the patch.

Guidelines for barbed goatgrass

Barbed goatgrass is an aggressive winter annual that has spread rapidly throughout northern and central California below 3600 feet elevation. Barbed goatgrass populations create devastating monocultures that diminish species diversity and forage quantity and quality. Barbed goatgrass often grows within medusahead patches. Davy et al. (2008). have reviewed the life cycle and methods of control of barbed goatgrass.

The most important factor in controlling barbed goatgrass is early detection. Since seeds do not fall far from the mother plant, early infestations are generally restricted to small areas. However, the barbed awns attach easily to livestock and wildlife, enabling widespread seed distribution through animal movement. In as little as 3 years, an entire pasture or ranch can become infested with barbed goatgrass. Seeds of barbed goatgrass are also dispersed in hay from dryland pastures, thus spreading to more distant feeding areas and roadsides. Small patches are manageable; however, control of large infestations is extremely difficult. Various control methods have been tested with differing levels of success. In all cases where treatment requires the removal of litter, such as burning, desirable clover or grass species should be reseeded to prevent reinfestation or establishment of another undesirable species.

Mowing and Grazing

Early-growing-season mowing alone has shown limited benefit in barbed goatgrass control, as low growing or prostrate plants often escape injury. Heavy grazing during the growing period, followed by rest in late spring, tends to increase the density of barbed goatgrass due to the elimination of competing plants and barbed goatgrass's strong ability to regrow. Although livestock typically avoid barbed goatgrass, intensive grazing or mowing at early stages of seedhead emergence negates the selective feeding behavior of animals and can be very successful in preventing goatgrass seed formation. Heavy defoliation at and just prior to seed head emergence can be very effective in limiting seed production, because plant maturity typically occurs when soil moisture is depleted for the growing season and root reserves are nearly exhausted from attempting seed formation. Mowing provides a longer window for defoliating plants because grazing time is limited by the protrusion of unpalatable awns once the seedheads emerge.

Guidelines for yellow starthistle

Yellow starthistle is a native of Eurasia and was first recorded in California in 1869. Now common on roadsides, rangeland, hay fields, pastures and waste areas, it is estimated to infest close to 8 million acres in California. The disturbance created by cultivation, poorly timed mowing, road building and maintenance or grazing favors this rapid colonizer. Yellow starthistle forms dense infestations and may produce allelochemicals that prevent growth of competing species, allowing starthistle to take over large areas of land. DiTomaso et al. (2006a) have reviewed the ecology and management of yellow starthistle.

Yellow starthistle plants develop a deep taproot allowing it to proliferate on dry sites or in dry years. The deep taproot extends below the zone of root competition of associated annual species and allows growth and flowering to occur well into the summer, long after other annual species have died and dried up. Yellow starthistle is able to regrow after top removal from mowing or grazing. Seed output can be as high as 29,000 seeds per square meter with about 95 percent of the seeds being viable. Most seeds germinate the following year, but some seeds can last 10 years or more in soil.

Grazing

Targeted grazing, when performed successfully, will reduce the population of yellow starthistle, minimize damage to desirable species, and support a more integrated approach to weed management. Cattle, sheep and goats have all been successful in controlling yellow starthistle. Choosing which species to use will depend on the stage of the yellow starthistle. Grazing can enhance other control methods for yellow starthistle such as herbicide applications.

Timing and Intensity of Grazing

High intensity grazing at bolting (May-June) can reduce flowering and seed production in yellow starthistle. Timing is critical to the success of grazing for yellow starthistle control. The ideal time to graze is when plants are most susceptible to defoliation or when the impact on desirable vegetation is minimal. Thomsen et al. (1989, 1990, 1993) showed that properly timed (May and June) intensive grazing by cattle or goats resulted in reduced growth, canopy cover, survivability, and reproductive capacity of yellow starthistle.

Repeated high-intensity cattle grazing reduced flowering heads of yellow starthistle by 78-91% (Thomsen et al. 1993). These plants were grazed after the stems had bolted but before the development of spiny seed heads. Cattle and sheep tend to avoid starthistle once the buds produce spines, whereas goats continue to browse plants even in the flowering stage (Thomsen et al. 1993). For this reason, goats have become a more popular method for controlling yellow starthistle in relatively small infestations. Thomsen et al. (1990, 1993) also reported that grazing the weed during the bolting stage could provide palatable high protein forage (8 to 14%). This can be particularly useful in late spring and early summer when other annual species have senesced.

Monitoring weed control effectiveness
Weed control effectiveness should be determined by estimating the cover of the target weed before and after control. The line point intercept method is a common means of estimating cover and can also determine changes in species composition in a treatment area. The line-point intercept method involves placement of permanent transects and determination of plant species above and below points along the transect. Line-point intercept procedures have been well described by Herrick et al. (2005, pg 9-15). For management purposes photo-monitoring that shows change in weed populations at the same site before and after treatment is often adequate and it is less time consuming.

Objective: reduce fuel loads.

Guidelines for reducing fuel loads
Grazing Intensity: Livestock grazing can decrease the severity of fires by reducing fuel load. In grasslands with 2000 lbs/acre of grassy fuels, flames can be more than 50 feet long and difficult to control. In moderately grazed rangelands with 1,000 lbs/acre of grassy fuels, flames can be 4-10 feet long and thus more controllable. In heavily grazed areas with less than 500 lbs/acre of fuels, fires generally burn only in isolated patches because the fuels are usually discontinuous (Barry et al. 2011).

Season of Use: Areas grazed only during the early part of the growing season will tend to regrow during the late spring. Grazing late in the growing season and early in the dry season is the most effective time to lower flammable herbage levels prior to the dry vegetation period.

Livestock class: All classes of livestock can effectively reduce fuel load.

Monitoring: Residual dry matter (RDM) is usually monitored to determine grazing intensity but it can also be used to estimate fine fuel loads (Bartolome et al. 2006). Additionally fire resistance to control and rate of spread can be based on a combination of fuel load and type, slope, wind speed, and humidity.

Objective: Maintain and improve riparian areas

Guidelines for maintaining and improving riparian areas.
Ponds, intermittent streams and permanent streams are present on KWA. Because livestock grazing has not occurred on KWA for several decades there are no riparian areas that are currently impacted by livestock. Some riparian areas are fenced and others are too steep for cattle to access but others will be congregation areas for livestock as they access surface water or cross riparian zones on roads and trails. Uncertain of the location of these potential impact areas, KWA staff should monitor riparian areas for livestock impacts during and after grazing.

The degree of impact in riparian zones will vary depending on the number of head and their residence time in the riparian zone (George et al. 2011). During the growing season there is usually sufficient green forage away from the riparian zone that residence time in the riparian zone is minimized. However, as upland forage matures and dries riparian zones may become more attractive to grazing livestock. Practices such as placement of livestock attractants (water troughs, salt and other nutritional supplements) away from the riparian zone can reduce residence time. Rotational grazing among several pastures reduces residence time in each pasture's riparian zones and provides for recovery from grazing. Exclusionary fencing is an expensive but certain method of reducing livestock residence time in a riparian zone that may be applied to critical areas identified by monitoring grazing impacts over the first few years of grazing. As a first line of defense we recommend that livestock be rotated among four or more pastures during the grazing season to reduce residence time and to provide recovery time (rest) for riparian zones. Table 5 is an example of a rotation scheme for the south pastures that reduces residence time in each pasture, provides for medusahead control and results in a mosaic of herbaceous vegetation heights ranging from closely grazed to ungrazed.

Objective: Maintain and increase habitat diversity

Guidelines for maintaining and increasing habitat diversity

Barry et al. (2011) have compiled grazing practices that may be used to manipulate habitat values and animal populations. Grazing can be used to diversify habitat by leaving a mosaic of herbaceous vegetation levels ranging from closely grazed to ungrazed. Close grazing tends to increase low growing forbs such as filaree and various legumes while light to moderate grazing tends to support a grass dominated ground cover. A vegetation mosaic insures that tall vegetation is available for fawning and hiding habitat, while short to moderate vegetation is available to certain rodents and ground dwelling birds. Target vegetation levels can be rotated annually so that each pasture is not grazed every few years providing tall herbaceous vegetation. A closely grazed year might be followed by an ungrazed or lightly grazed year to provide for vegetation recovery from close grazing. A mosaic of herbaceous vegetation levels can be achieved using rotational grazing that is planned annually in the AOP (Table 6).

Guidelines for rotational grazing

Rotational grazing of four or more pastures in a planned sequence can reduce impacts in riparian zones and facilitate a mosaic of herbage levels. By changing the herbage level treatment annually each pasture will provide a different herbage level over a period of years and no pasture will be closely grazed several years in a row. When a pasture is targeted for medusahead control it could be one of the closely grazed pastures in the annual sequence. Table 5 is an example of a grazing rotation plan for the south pastures at KWA assuming an in date of the first week in January and an out date at the end of June. Of course the sequence in this plan would be changed depending on available livestock numbers and herbage level monitoring during the grazing season. If livestock numbers are low the herbage levels for each pasture may not be achievable unless additional pasture are ungrazed or grazed less than suggested in this example.

Guidelines for stock ponds

Stock pond and associated wetland habitat can be protected by fencing these areas from grazing and installing a pipeline, storage tank and trough downstream. This should enhance amphibian and reptile habitat around stock ponds and wet areas.

Table 6. Example of an annual plan for the south pastures that rotates end of grazing residue levels over a 10 year period.

Pasture Name	Year									
	1	2	3	4	5	6	7	8	9	10
South Pastures										
Nellie Adams	Close	Close	Mod	Close	Mod	Close	No	Mod	Light	Mod
Toll Canyon	No	Mod	Light	Light	No	Light	No	No	No	Light
Wilson Barn	Mod	Light	No	Mod	No	Light	Close	Close	Mod	Close
Four Corners	Mod	No	Light	No	Mod	Mod	LIght	Mod	No	Light
Burnt Ridge	No	Light	Mod	No	Light	Mod	Light	No	Light	No
Midslope	Light	No	No	Mod	Close	Close	Mod	Close	Mod	Close
Wilson Barn North	Light	Mod	Close	Close	Mod	Close	Mod	Close	No	Mod

Objective: Protect oak seedlings and saplings.

Competition for soil moisture by annual plants, rodent populations, fire and livestock and wildlife grazing and browsing contribute to poor regeneration of oaks. Since the 1980s the University of California Division of Agriculture and Natural Resources in collaboration with state and federal agencies have developed methods for improving oak regeneration (McCreary 2001). Weed control, mulching, seedling screens have been used to successfully protect oak seedlings to the sapling and young tree stage. Research at the University of California Sierra Foothill Research and Extension Center has shown that 4 foot tree shelters are adequate to protect oaks from grazing and browsing by cattle and deer (McCreary 2001).

Drought Management

Drought can be defined as a deficiency in precipitation over an extended period of time, usually a season or more. In a grazing plan the focus is on reduced precipitation and resulting loss of vegetation and water resources. Monitoring monthly precipitation and comparing to averages (Table 7) can help managers determine if precipitation is below average. Monitoring forage levels and surface water availability can help managers determine the need for adjustments in the annual grazing plan including in dates, out dates and stocking rate.

Ranchers anticipate the start of the rainy season every fall. Receiving rain by mid-November is a good start but does not guarantee a good rainfall or forage year. Low or late Fall rainfall will result in low forage levels at the end of December and beginning of the following year. As the growing season progresses in the new year rainfall is stored in the soil to support rapid spring growth that usually starts in March or late February. If rainfall is adequate during this period forage production for the year may reach average levels. However if rainfall is low spring forage production may be below average and result in a decision to reduce stocking rate or shorten the grazing season (earlier end date).

Table 7. Average temperature and precipitation for Lake Berreyessa.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Annual
Average Max. T (F)	93.4	93.3	88.1	79.1	65.4	56.2	56.1	60.3	63.5	69.9	77.4	85.9	74
Average Min. T (F)	60.4	60.6	56.9	51.6	44.4	39.6	38	40.9	41.8	44.8	50.2	56.7	48.8
Average Precipitation (in.)	0.02	0.19	0.22	1.32	3.05	4.01	6.07	4.39	2.76	1.88	0.3	0.23	24.44

CDFW and the grazing lessee should jointly develop a drought plan that addresses forage and water constraints and habitat needs at KWA. This should include changes to in dates and out dates and stocking rate for the grazing season. It may also include feeding of hay or other supplements.

Drought monitoring

- Monitor rainfall starting in September.
- Low rainfall, lack of surface water and poor forage production in the fall may require a delay in the grazing in-date and adjustment in the initial stocking rate.
- Because it commonly turns cold around the middle of November, forage levels may increase slowly or not at all through the cold winter months until warm weather begins in late February or March.
- If rainfall in December and January are low then forage levels will be low during the early part of the growing season and grazing capacity will be reduced. I
- If February and March rainfall is low then spring forage production may be low.
- If there is little or no rainfall during early April then the growing season will end in May.

Management Unit Plans

Table 4 lists some management priorities for each KWA pasture. Generally, yellow star thistle control and perennial grass planting are priorities in the Airstrip and Eticuera Creek pastures. Grazing to reduce medusahead will be a priority in the Toll Canyon, Nellie Adams and Wilson Barn South pastures but these practices can be applied to only one or two pastures each year depending on the number of cattle available for close grazing in March and April. The remaining pastures will be ungrazed or grazed to moderate (RDM=800 to 100 lb./a) or light (RDM=2000 lb. +) levels. These treatments will be rotated to provide a mosaic of short to tall herbaceous ground cover. Rotation also insures that pastures are not grazed at the same time each year or closely grazed for several years in a row. Table 5 is an example of annual grazing sequences for five years. This table should be revised annually as part of the A.O.P. This table includes approximate in-dates (January 3 in the example), out-dates (week of June 26 in the example) and carrying capacity of the pasture in animal units months.

During annual grazing planning the desired herbage level at the end of the growing season will be identified in the grazing level column of the table. The target RDM for the end of the grazing season will reflect the desired grazing level treatment. Next weekly periods of grazing will be proposed for each pasture. The pasture grazed for medusahead control should be designated first as it requires grazing during a specific period (April and May) to reduce medusahead flowering. The grazing periods for other pastures can be then be designated.

As grazing periods and grazing levels are proposed managers should insure 1) that a pasture is not grazed at the same time every year, 2) that grazing starts in a different pasture each year, 3) a mosaic of RDM levels is identified for the pastures and 4) the desired grazing level for a pasture is not the same for several years in a row.

Finally, actual stocking rate should never exceed carrying capacity. Initially it is recommended that the stocking rate be low and then increased as managers gain experience and monitoring indicates that there is additional unused grazing capacity.

Annual Planning and Reporting

With prescribed grazing the timing and intensity of grazing for each pasture should be planned with the lessee annually before the grazing season starts. Plans should address low and high production years. There should be agreement on supplement locations and fence and other maintenance requirements. The lessee and KWA manager should sign and date the AOP.

An annual report could be published each year. Livestock numbers, stocking rates, in and out dates and death losses should be recorded and published in the annual report. Grazing management (season, intensity, duration, frequency) and RDM should be reported for all pastures, grazed and ungrazed. Any other vegetation management practices and their effectiveness should also be described. An annual report is an important way for CDFW to communicate with the public.

Advisory Committee

KWA staff should consider establishing an advisory committee. An advisory committee to KWA could be a way to establish communications and support for developing the grazing program and other management activities. An advisory committee that included local conservation groups, local hunters, ranchers and natural resource professionals could help CDFW by communicating with conservation groups, hunters, range management organizations and other interest groups about proposed management. Communication with hunters might reduce vandalism of KWA infrastructure.

Steps for Getting Started

- Develop a request for grazing proposals
- Organize a committee to review proposals and interview applicants
- Send the RGP to livestock and range management organizations

- Hold an informational meeting for interested grazers.
- Set a deadline for proposals.
- Review proposals and interview selected applicants.
- Complete lease agreement.
- Complete an Annual Operating Plan for the first grazing season.
- Start grazing.
- Complete an annual report following the first year.
- Complete an Annual Operating Plan for the second year.

Important References

We have cited several reports in this plan and they are listed in the Literature Cited section. Following are a few references that can guide managers in the application of weed control or grazing management practices. Copies of these reports are available on the internet.

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Plan Contractor

This plan was completed on October 24, 2016 by Melvin R. George, Certified Range Manager No. 27.