

Pleasants Creek Project

Solano County, California

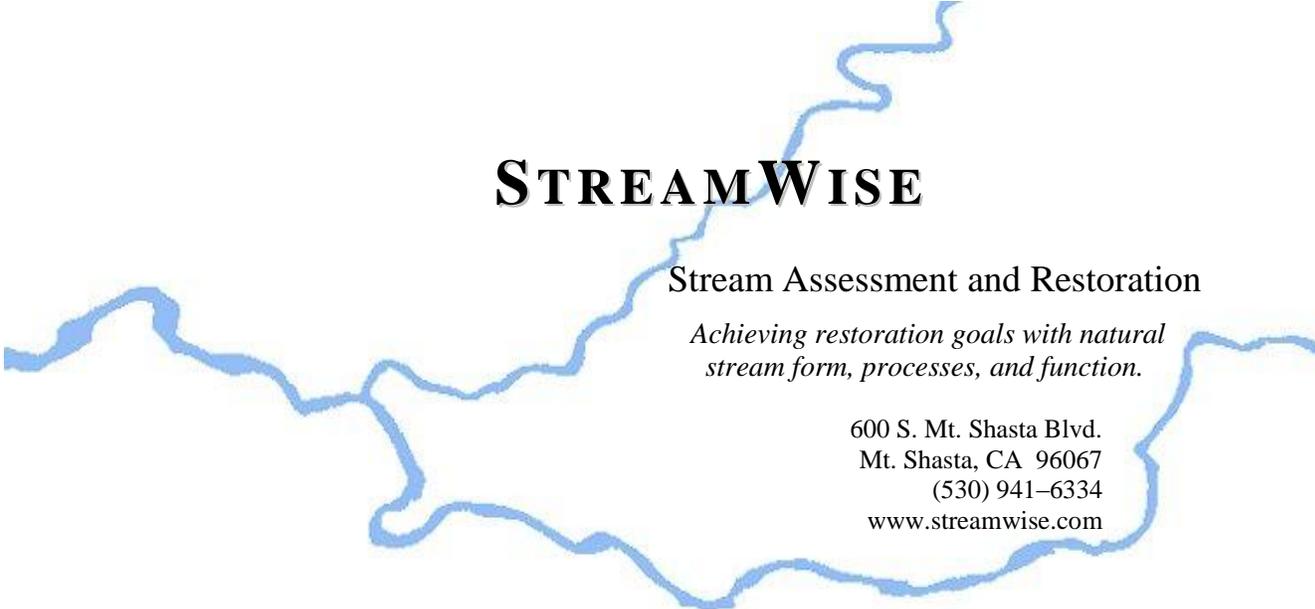
Watershed & Stream Assessment Reach-Based Comparative Analysis

prepared for

Solano County Water Agency
and

Lower Putah Creek Coordinating Committee

February 16, 2013



STREAMWISE

Stream Assessment and Restoration

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stream form, processes, and function.*

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Report Purpose: To provide a conceptual design document as a basis for action to stabilize eroding banks and enhance the riparian resource values within the Pleasants Creek Project area. The Report suggests application of stabilization methodologies that have proven effective in the region, and offers a means of ranking each property in order of significance. The ranking criteria was developed to reflect objectives to reduce accelerated sediment supply, slow rates of lateral bank erosion and land loss, enhance native riparian habitat, and control spread of exotic invasive plant species.

Background: StreamWise was contacted in 2010 by Rich Marovich, Streamkeeper with the Lower Putah Creek Coordinating Committee, (LPCCC) working in cooperation with the Solano County Water Agency (SCWA) to provide an assessment of the stream channel and riparian resource conditions along Pleasants Creek, a tributary to Putah Creek. StreamWise was asked to produce an assessment using field survey work on which to base recommendations for actions to stabilize banks and/or enhance the riparian resource values in the project area.

The Report provides the required initial assessment, and is intended to serve as the basis for future efforts to restore the functionality and stability of the stream channel and associated riparian resources.

Surveys and field reconnaissance were made in November and December 2010 and finalized following landowner access approval in December 2012. These surveys were conducted to provide the baseline data required to develop alternatives for stabilization or enhancement along the riparian corridor. Survey work required to complete the design specifications included GPS survey of features along Pleasants Creek. Digital data features were collected of various project aspects using a Trimble GPS data collection unit. Photo points were also taken to document various conditions. Additional baseline data was derived from Lidar topographic survey work provided by LPCCC (*see Appendix D, GPS Features and Site Plots*). Data from these surveys were used in alternative considerations and recommended construction design.

Narrative

A. Goals and Objectives

LPCCC and SCWA provide the following goals and objectives to be addressed by the assessment and restoration design effort:

Pleasants Creek Watershed Survey

Goals:

- G1. Reduce erosion and sediment sources within Pleasants Creek watershed which significantly contribute to downstream sedimentation in Putah Creek and Putah South Canal.
- G2. Enhance riparian habitat on Pleasants Creek for resident and migratory wildlife, migratory birds, and fish.
- G3. Reduce public safety hazards and property damage due to periodic bank collapse.
- G4. Control proliferation of invasive species within riparian corridor, especially those that have negative impacts on stream stability and riparian diversity.

Objectives:

- O1. Complete a watershed survey of Pleasants Creek using LIDAR and other available data as well as on the ground GPS surveys. Prepare GIS layers of data.
- O2. Develop criteria to objectively prioritize areas of erosion or sedimentation for restoration.
- O3. Develop draft restoration designs for priority erosion or sedimentation areas.
- O4. Prepare a draft and final report discussing the data, results, prioritization criteria and draft restoration design including assumptions for the designs and estimated budgets.
- O5. Complete one or more meetings with SCWA and LPCCC staff or designated committee, and resource agencies to discuss the draft design and provide comment and direction for final products.

B. Assessment Methodology

Due to the specific nature of the erosional issues within Pleasants Creek, and the relative homogeneity of the project reach, a customized evaluation method was developed that allows for a numeric comparison of individual reaches within the lower six miles of channel. Within Pleasants Creek, it has been established that the lower seven miles of channel have become deeply incised with significant extent of bare vertical banks. Data collection prior to past stabilization projects support the conclusion that the morphology of the stream channel is out of balance with the localized runoff and sediment supply conditions.

An efficient comparative analysis of the sub-reach sections of Pleasants Creek requires a customized approach. StreamWise incorporates the goals and objectives provided by SCWA and LPCCC within an evaluation criteria designed specifically to produce a rating value for each sub-reach. This yields a numeric comparison of the relative priority for action to address the erosion issues for each reach. The matrix format is borrowed from similar evaluation methods, but condensed to focus on the specific issues deemed most critical to the resource issues within the watershed. While such evaluation will not provide comparison values to other streams, it will provide a "ranking" of each reach for future consideration of project implementation.

The following factors were determined to be the major influences that contribute to the overall priority level for action. By making this comparison, grant funding for sediment reduction within the watershed can be allocated, with highest priority reaches targeted for early intervention. The list below is not in order of importance. To assign greater influence to more important factors, each of the ten factors were assigned a numeric range of values that could be assigned to a given reach. The higher the range values, the more weight a particular factor will tend to have in the final priority rating. Of the ten factors below, landowner cooperation, bank height, invasive species presence, and threats to structural improvements (especially homes and major roads), were given a greater potential value due to the perception that these factors have the greatest influence on project prioritization.

Pleasants Creek Assessment Criteria **(factors influencing site priority level)**

1. Landowner cooperation (Are landowners "on-board" with resource protection efforts?)
 - a. secured / supportive
 - b. pending further discussions
 - c. opposed
2. Erosion potential (How severe is the problem at the site and does the site contribute significant volumes of sediment to the overall problem?)
 - a. bank height
 - b. soil erodibility
 - c. native vegetation coverage
3. Project continuity (Does the site fit within a larger reach that is considered a priority area for treatment, or is the site an isolated point of instability with a lower possibility of interaction within a longer section of treated stream channel?)
 - a. contiguous with other priority reaches
 - b. non- contiguous, but significant reach length within project site
 - c. isolated erosion point
4. Invasive species presence (Are invasive species likely to have negative impacts on channel stability?)
 - a. arundo
 - b. Himalayan blackberry
 - c. other invasives (tree of heaven, etc.)
5. Structural improvement proximity (Are buildings or improvements in danger of damage from continuation of lateral or vertical stream erosion?)
 - a. roads
 - b. bridges
 - c. homes
 - d. barns and agricultural buildings
 - e. orchards or crops
 - f. irrigation systems
6. Potential to apply methodology (Are the recommended stabilization methods suitable for this site? Will the actions help to slow erosion rates and reduce downstream transport of sediment? Will the riparian resources also benefit from the recommended actions?)

- a. floodplain bench construction
 - b. bank shaping and revegetation
 - c. rock vane protection
 - d. grade control
7. Access potential (Is it possible to access the site with construction machinery and can future access be established that allows for long-term project maintenance?)
 - a. construction
 - b. long-term maintenance
 8. Vegetation recovery potential (Are conditions present that would help to establish native riparian vegetation to stabilize the project following construction or invasive removal?)
 - a. drip line connections
 - b. natural sub-irrigation
 9. Natural or historic resource factors (Are there any important resource factors that may influence the priority rating for the site?)
 - a. sensitive plant or animal species
 - b. historic significance
 - c. aesthetic values
 10. Risk potential
 - a. flood disruption
 - b. vehicle or access damage
 - c. other potential factors (vandalism, etc)

Once the above factors were established as the primary influences on the stability and priority of actions to address the erosional issues along Pleasants Creek, a matrix was developed to incorporate numeric values that allow for each factor to carry an appropriate weight in the final priority rating for the stream reach. (The above considerations were abbreviated when applied to the matrix.)

Pleasants Creek

Erosion and Sediment Source Assessment Project - site assessment priority scoring table

(one sheet to be completed for each reach)

site #	date	landowners	field crew	start sta	end sta	reach L	reach R	photo points
						0		
general notes								
1 Landowner cooperation (strong support raises score)								
		a. secured / supportive				mark	range	site score
		b. pending further discussions					5 to 25	
		c. opposed					0 to 5	
							-25 to -200	
							sub-total	0
2 Erosion potential (degraded condition raises score)								
		a. bank height (ft)				est.	range	site score
		b. soil erodibility (highest = 10)					0 to 30	
		c. bare banks (100% bare = 10)					0 to 10	0
							0 to 10	
							sub-total	0
3 Project continuity (adjacent and longer reaches raise score)								
		a. contiguous with other priority reaches				reach L	range	site score
		b. non-contig; but sign. reach length					0 to 20	
		c. isolated erosion point					0 to 10	
							-5 to -10	
							sub-total	0
4 Invasive species presence (invasive extent raises score)								
		a. arundo				mark	range	site score
		b. Himalayan blackberry					0 to 50	
		c. other invasives					0 to 15	
							0 to 10	
							sub-total	0
5 Structural improvement proximity (proximity raises score)								
		a. roads				mark	range	site score
		b. bridges					0 to 20	
		c. homes					0 to 10	
		d. barns and agricultural buildings					0 to 20	
		e. orchards or crops					0 to 10	
		f. irrigation systems					0 to 10	
							sub-total	0

6 Potential to apply methodology		(suitability to site raises score)		mark	range	site score	(mark all)	
	a. floodplain bench construction				0 to 20			
	b. bank shaping and revegetation				0 to 10			
	c. rock vane protection				0 to 10			
	d. grade control				0 to 10			
	e. riffle augmentation				0 to 10			
					sub-total		0	
7 Access potential		(better access raises score)		mark	range	site score	(mark all)	
	a. construction				0 to 20			
	b. long-term maintenance				0 to 10			
					sub-total		0	
8 Vegetation recovery potential				mark	range	site score	(mark all)	
	a. irrig. line connections				0 to 10			
	b. natural sub- irrigation				0 to 20			
					sub-total		0	
9 Natural or historic resource factors		(presence raises score)		mark	range	site score	(mark all)	
	a. sensitive plant or animal species				0 to 10			
	b. historic significance				0 to 10			
	c. aesthetic values				0 to 10			
					sub-total		0	
10 Risk potential (possible damage to project)		(higher risk reduces score)		mark	range	site score	(mark all)	
	a. flood disruption				0 to -25			
	b. vehicle or access damage				0 to -20			
	c. other potential factors (vandalism, etc)				0 to -10			
					sub-total		0	
	maximum possible rating				370			
					site score	0		notes
					adjust. ?			
					final score	0		
recommended actions		priority	by	due	additional notes			
1								
2								
3								
4								
5								

C. Setting, History, and Current Condition

Setting: The site is located in the northwest section of Solano County, California, about 5-7 miles west of Interstate 505. Pleasants Creek flows from south to north, flowing into Lake Solano west of Winters, CA. Orchard and livestock operations dominate the flat alluvial plain with upland live-oak hills bracketing the valley. Riparian species such as buckeye, bay, alder, and willow are common near the stream.

History: The valley was first settled in the mid 1800's, with most income derived from hunting that supplied mining camps. Light farming and ranching followed, with orchard crops appearing very early in the Pleasants Creek development. Wheat crops were also introduced, and ground at a stone wheel mill found in the valley (*Personal communication, Ethel Hoskins, Dec. 2010*).

Prior to European settlement, Native Americans (Patwins, a subset of the Wintun Tribe) used the canyon for seasonal gathering and food processing, as evidenced by the grinding mortars located throughout the valley. Acorns from live oak were likely the primary food resource. The Patwins were probably gone from the area by 1850, either driven out by settlement, or died of smallpox.

Current Conditions:

1. Vegetation: The entire valley is heavily infested with exotic invasive species that threaten the stability and productivity of the region. Many upland areas are invaded by dense stands of star thistle. A large percentage of the riparian corridor is lined with thick arundo and/or Himalayan blackberry. These species have replaced native grasses and willow, redirected flood flow energy, and caused erosion of valuable agricultural and residential property.

2. Pleasants Creek Channel: The dominant feature of the valley is the deeply incised Pleasants Creek channel. The gully feature is actively eroding, primarily laterally. Vertical incision has reached bedrock layers in many locations, providing some resistance to further vertical erosion. Valley soils are comprised of soft alluvial deposition that continues to collapse into the stream as flood flows erode laterally into the exposed vertical banks. Incision ranges from 2 to 4 feet in the uppermost drainage reaches, to over 25 feet in many reaches downstream. This deep cut into the former floodplain tends to draw the water table to the lower level and prevent flood flows from recharging the groundwater resource.

3. Roads: Pleasants Valley Road is an important access route for residents of the valley. The road connects Winters to Vacaville, running parallel to I-505 through the bucolic valley. It is also a favorite for cyclists, due to the rural setting and light traffic. The road and bridge system is in excellent condition, with most bridge structures replaced within the past ten years. Several areas of road have been re-aligned due to the lateral erosion from the Pleasants Creek gully causing mass failures and severe damages. At such times, the road is closed until repairs can be made, forcing traffic to access property either by the north or south routes.

During infrequent large peak runoff events, bridges have failed, resulting in emergency actions to provide temporary crossing structures. New bridge structures incorporate significant rip-rap components to resist pier scour and bridge abutment damages.

4. Tributaries: Contribution of runoff from the steep hillslopes is carried through ephemeral channels that enter the main stem at regular intervals along the profile. Most are well-vegetated and stable, but several have become highly degraded gullies, especially in the vicinity of the confluence with the main channel. This is due to the incised nature of the main stream channel. The tributaries are responding to the lower base elevation by headcutting in the upstream direction as a direct result of increased slope and velocity at the point where tributary flows fall into the lowered main channel.

5. Road Culvert Crossings: Other tributary erosion is being caused by the concentration of flows through culverts at each road crossing, resulting in downstream scour and periodic culvert failure during high flows. Sections of the tributaries have been severely impacted by this practice and remain highly unstable. Significant volumes of sediment are contributed by this process.

D. Fishery Resource Considerations

While not a current top priority for restoration, Pleasants Creek was considered to be historic spawning territory for salmonid species, probably steelhead (*pers. commun.*, *Ethel Hoskins, family historic records*). Some possibility exists that Pleasants Creek could be restored as spawning habitat if fish passage issues at Putah Diversion Dam are addressed by some future project. However, even if salmonid species were given open access to the creek, the current habitat conditions are not likely to provide significant benefits to the species. This is due to the incised nature of the channel, preventing the natural groundwater storage function of the former floodplain surface. Due to the lack of flood infiltration, the base flow of Pleasants Creek has been greatly diminished, leaving a degraded flow regime for fishery habitat and spawning cycle success.

At the current time, fishery resources might be best served by focusing efforts on stabilization of the eroding banks, both to provide improved in-stream habitat, and prevent further degradation of downstream resources. Improvement of summer return flow to the channel from groundwater storage is more difficult to enhance. Past project efforts to provide a narrow inset floodplain surface within the existing gully system may have some capacity to improve groundwater storage, but the primary function of these projects is the dissipation of flood flows across a well-vegetated floodplain surface to reduce the power of the flood forces.

E. Future Consequences

Future flood flows within Pleasants Creek are very likely to cause additional lateral channel erosion, vertical channel incision, culvert scour, damage to roads and crossing points, and accelerated sediment impacts to downstream resources. While some of the channel reaches have reached a pseudo-equilibrium with the current conditions, it is suspected that in many areas the channel bed and banks do not have sufficient resistance to additional shear stress imposed by greater depth of flow and increased velocities.

The current eroded gully reaches have no connection to an active floodplain and lack the necessary function of the floodplain to dissipate the energy of high flood flows. This excessive energy is therefore transferred to the bed and banks of the gully system,

resulting in the lateral and vertical incision commonly observed along the lower reach of the stream.

In reaches open to cattle grazing, riparian fencing may reduce the rate of channel erosion and help protect vegetation from grazing effects, but will not resolve the issue of loss of functional floodplain to dissipate flood energy. In some areas where grazing has been removed, non-native invasive vegetation within the channel accelerates lateral erosion, as flood flows are forced to find alternate paths of least resistance.

In some aspects, lateral erosion is a natural process of channel recovery, as the channel widens to reform a floodplain within the gully bottom, and eventually achieve equilibrium at the lower elevation. The introduction of non-native invasive species such as arundo, tamarix, and Himalayan blackberry disrupt this natural recovery process by capturing excessive volumes of suspended sediment during inundation periods and robbing the new inset floodplain surface of any function to dissipate flood flows. Instead, the rapid expansion of the invasive growth redirects flood flows to exposed banks and increases the rate of lateral bank collapse. Alternatively, native grass and willow species tend to "fold over" during flood flows, helping to dissipate energy and protect the floodplain surface from erosion.

If development of inset floodplains could be maintained free of such invasives, the recovery process would be considered beneficial to the eventual stabilization of the channel. This process is in the early stages, and will require decades of continued channel adjustment to allow for sufficient floodplain width and vegetative strength to allow for the channel to exist in a state of equilibrium with the surrounding landscape. Typical floodplain widths for this channel type are 12 or more times the width of the bankfull channel. However, the narrow inset floodplain features that have begun to form in many areas are only a few feet wide, at best.

Lateral and vertical erosional trends are exacerbated by the frequency of bridge crossings that concentrate flows and create chronic scour erosion and occasional bridge failures. Recent bridge replacements have incorporated significant efforts to armor the banks in the bridge vicinity with rip-rap. Most of this work appears to provide stability in the immediate reach surrounding the bridge, but impact to downstream banks continues to be chronic.

In summary, given the current channel morphology, invasive species spread, and management activities, future consequences in reference to the channel stability will likely include continued maintenance on bridge structures, periodic failure of road sections and culvert systems, continued lateral and vertical channel erosion, loss of some structural improvements, damage to riparian planting efforts, and accelerated rates of sediment contribution from bank erosion.

F. Results of Reach Assessment

Using the assessment matrix during field survey work, each reach of lower Pleasants Creek was evaluated and given numeric ratings for each major factor that influences stream channel stability. The reach distances vary due to the delineation into reaches of similar conditions, or consideration of changes in land ownership. Bridges were often used as end points for reach assessment, primarily due to the fact that land ownership

typically changes at these locations. Some landowner sections of the channel were combined into a single reach due to the similarity of conditions and land-use activities. The reach delineations are defined according to the following landowner surnames with the reach length measured along the thalweg of the channel.

Evaluation criteria is subject to change over time, as factors change (such as securing landowner agreements, or rapid infestation of invasive species). Ranking of priorities can be adjusted to reflect current conditions as they evolve.

Reach Delineation - Lake Solano (station 0.0') to Bridge 6 (station 33,408')

Reach #	Landowner(s)	Reach Description	Length (ft)
1	Bur. Recl. / Martin	Lake Solano (Station 0.0') to low-water crossing (Martin)	2207
2	Flaherty / Carrion	low-water crossing to Winters Rd. bridge (Brg 1)	3381
3	Shurnas/Murdoch	from Winters Rd bridge (Brg1) to Doud property line	2492
4	Doud	Shurnas prop line to 1st Pleasants Valley Rd. bridge (Brg 2)	1186
5	Beall	tight meander just west of 1st Pleasants Valley Rd. bridge (Brg 2)	1604
6	Hudson	Beall prop line past 2nd Plsnt Vly Rd. brg (Brg 3) to Nichols prop line	4807
7	Bill Nichols / Echols	Hudson property line to 3rd Plsnts Vly Rd. brg (Brg 4)	1023
8	Coy Nichols / Joan Gates	3rd Plsnt Vly brg (Brg 4) to Bertagnolli/Levi prop boundary	1820
9	Bertagnolli / et. al.	Gates prop line to Hoskins prop. at 4th Plsnts Vly Rd brg. (Brg 5)	2863
10	Hoskins	4th Plsnts Vly brg (Brg 5) to Guglielmoni property line	3900
11	Guglielmoni	Hoskins property line to Campbell property line - "flag" lot	772
12	Campbell	Guglielmoni property line to Roschen property line	1389
13	Rochen	Campbell property line to Boshoven property line	942
14	Boshoven	Roshen property line to Powell property line	930
15	Powell	Boshoven property line to Milner property line w/ headcut R bank trib entry	716
16	Milner	Rowell property line to small 5th Plsnt Vly Rd. brg. (Brg 6 at station 33408')	3376

Rating Table Results:

(refer to Appendix A - Site Specific Survey Data - Assessment Worksheets)

Pleasants Creek Assessment Criteria
TALLY from site assessment priority scoring table

site data collected Nov. 9-12, 2010 and
Dec. 18-19, 2012

site #	12/18/2012	reach L	score
1	Bur. Recl. - Martin	2207	203
2	Flaherty - Carrion	3381	151
3	Shurnas/Murdoch	2492	258
4	Doud	1186	86
5	Beall	1604	194
6	Hudson	4807	264
7	Bill Nichols / Echols	1023	220
8	Coy Nichols / Joan Gates	1820	188
9	Bertagnolli et al	2863	264
10	Ethel Hoskins	3900	262
11	Guglielmoni	772	105
12	Campbell	1389	217
13	Roschen	942	210
14	Boshoven	930	128
15	Rowell	716	115
16	Milner	3376	207

sites ranked by priority scoring results				
site #	landowner names	reach L	score	priority
9	Bertagnolli et al	2863	264	1
6	Hudson	4807	264	2
10	Ethel Hoskins	3900	262	3
3	Shurnas/Murdoch	2492	258	4
7	Bill Nichols / Echols	1023	220	5
12	Campbell	1389	217	6
13	Roschen	942	210	7
16	Milner	3376	207	8
1	Bur. Recl. - Martin	2207	203	9
5	Beall	1604	194	10
8	Coy Nichols / Joan Gates	1820	188	11
2	Flaherty - Carrion	3381	151	12
14	Boshoven	930	128	13
15	Rowell	716	115	14
11	Guglielmoni	772	105	15
4	Doud	1186	86	16

G. Alternative Actions

The following discussion outlines **general conclusions and recommendations that apply to the Pleasants Creek watershed in general terms**. Several options for stream stabilization and riparian enhancement were considered as a result of existing data review, field investigations, and review of survey data. These options were weighed with respect to the SCWA, resource agencies, and landowner goals stated in Section A. The alternatives are based on past project design and monitoring evaluations within the same watershed, along Putah Creek, or on adjacent tributaries. (Specific recommendations for each site are listed in order of priority ranking in Section H.)

1. Invasive Species Proliferation:

Alternatives Considered:

- a) No action.
- b) Project-by-project treatment.
- c) Watershed invasive removal program.

Which alternatives are most likely to meet project goals? Considering current erosion rates and chronic structural failures, the rate of invasive vegetation growth along the stream channel, especially arundo, exacerbates the lateral land loss and sediment contribution to a significant degree. The precise contribution invasive species make above background erosion rates is unknown and difficult to pinpoint, but field evidence of fresh lateral erosion at each site of arundo invasion supports the conclusion that any effort to reduce accelerated sediment influx must first consider arundo control.

Recommendation: Relying on the conclusion that arundo (and to a lesser degree Himalayan blackberry and tree of heaven) contribute significantly to the instability of the Pleasants Creek channel, it is recommended that SCWA and LPCCC pursue an aggressive control program that covers the entire drainage system. The second alternative treats individual project areas on an opportunistic basis, as has been done in the past. However, arundo stands from adjacent parcels can quickly infest treated areas, causing costly maintenance efforts to prevent repeated infestations. Long-term success of any large-scale stabilization effort depends on a watershed approach to invasive species control.

2. Public Transportation Issues (Pleasants Valley Road Stability):

Alternatives Considered:

- a) No Action: Continue current maintenance activities.
- b) Engineered Solutions: Continue to place rip-rap at key areas of bank collapse adjacent to Pleasants Valley Road and relocate road surface in response to lateral erosion advancement.
- c) Arundo Control: Prioritize key areas of road collapse in invasive control program.
- d) Inset Floodplain Development: Physically remove dead arundo following treatment, regrade and revegetate key areas to promote inset floodplain

formation.

- e) Native Revegetation: Focus native riparian revegetation efforts at key lateral erosion reaches near Pleasants Valley Road to ensure floodplain recovery and function.

Which alternatives are most likely to meet project goals? The no-action alternative forces Solano County Highway Department to devote scarce financial resources to emergency reactions to road failures. This scenario has been repeated numerous times in recent years, with road and bridge failures increasing in frequency as arundo stands redirect flood flows into vulnerable banks. Without invasive control and maintenance along the channel, expenditures for emergency road work are likely to accelerate. Public safety is also at risk due to the likelihood of additional catastrophic road failures during major flood flows. It is likely that such expenditures far exceed preventative costs to reduce bank shear stress and reduce risk of road collapse.

Recommendation: Rather than continue a reactionary response to emergency road failures, a combination of 2c, 2d, and 2e can be applied at key stress areas identified later in this report. This recommendation relies on landowner cooperation that must be developed through outreach and education by LPCCC staff.

3. Channel Stability:

Alternatives Considered:

- a) No Action.
- b) Passive Natural Channel Recovery: Develop invasive control program and allow for natural erosional processes to establish channel stability. This process is already underway in many reaches of Pleasants Creek, but is compromised by invasive arundo stands that prevent the newly formed inset floodplain surface from helping to dissipate the energy of flood forces.
- c) Apply Engineered Solutions: Attempt to rip-rap key areas of lateral erosion in all gully reaches.
- d) Geomorphic Restoration: Attempt to fully restore the channel and floodplain connection by restoring the historic channel conditions prior to incision.
- e) Enhance Channel Recovery Processes: Combine invasive control program with active widening of the current elevation of the inset floodplain to help dissipate the energy of flood flows. Stabilize and maintain inset areas and graded banks with native vegetation. This method allows natural processes of inset floodplain recovery to partially dissipate flood energy.

Which alternatives are most likely to meet project goals? Resource damages within the gully reaches of Pleasants Creek are a dramatic departure from stable conditions. The vertical incision and subsequent lateral instability are not the result of natural processes. The degraded conditions of the Pleasants Creek gully were caused by a combination of the same stress factors that commonly cause gully formation throughout the western United States. These factors can include: a) lowering of the base elevation at the confluence area, b) increase in peak runoff from urbanization, c) bed and bank

disturbance from management pressures, d) vegetation removal that results in increased velocities, entraining exposed bed material, e) enlargement of the channel area (gully erosion), f) chronic erosion damage due to excessive flood forces within the gully.

3a. No Action: No action is somewhat a misnomer, due to the fact that "*no action*" inevitably leads to "*emergency action*" with costly engineered repairs as the deep gully responds to the increasing proliferation of arundo stands that redirect the erosional processes into the path of valuable resources. Evidence of this cause-and-effect scenario is apparent in all reaches where channel instability is in proportion to arundo infestation. Conversely, the most stable reaches are those with the least volume of invasive species.

3b. Passive Natural Channel Recovery: Natural recovery is a viable option for the gully reaches, and must be considered in parallel with other, more intrusive restoration alternatives. Natural processes are already underway within the gully reaches, as can be documented by the presence of inset floodplain features in many areas. This tendency is encouraging, although the width of these features is insufficient to dissipate periodic flood energy, and the function of many such areas are being lost as invasive species advance. Coupled with invasive species control and removal, the Natural Channel Recovery option is a viable alternative for many reaches.

3c. Apply Engineered Solutions: One common engineered solution to channel erosion is the use of rock rip-rap to armor key sections of bed or banks from the erosive forces of flood flows. This often works to protect the particular section of bank that is treated, if the armoring is properly placed and well-keyed into the bed and banks. Rip-rap has some negative issues that must be considered. First, the length of bank susceptible to lateral erosion (measured as *Moderate* or *Severe* bank erosion within the GIS-based data set) is over 7000 linear feet. Estimation of rock quantities to protect such an expanse could be derived by using Lidar cross-sectional estimates to extrapolate area of coverage, but this exercise is not necessary, because the rip-rap proposal can be demonstrated not to meet several of the stated goals of the project. Rip-rap treatment targets erosional forces in a specific area, but does not lower the overall sediment load to the stream. Armoring sections of an enlarged stream channel may stabilize those areas, but tends to transfer the high energy of flood flows to downstream unprotected reaches. While rip-rap rock armor may appear to have a high roughness value, this roughness is confined to a relatively thin boundary zone, effectively speeding velocities through the reach, rather than slowing flows. Little is done to dissipate flood energy by rip-rap surfaces. Maintenance increases in areas below armored banks, habitat is not improved, sediment loading remains high, and erosional tendencies continue unabated. In addition to being prohibitively expensive, alternative 3c, at best, provides only a temporary solution in limited areas.

3d. Geomorphic Restoration: This technique has been used on many incised channels to restore the form and function of the channel and floodplain to a more natural condition. Typically, ponds are cut to supply fill material for the enlarged gully, or material is borrowed from the surrounding landscape to erase the gully feature and return the connection of the channel to a broad floodplain surface. The flow is redirected into a remnant channel or a constructed design channel with dimensions, sinuosity and slope that closely mimic the historic stable condition. This technique works exceptionally well in low-gradient valleys with newly formed gullies and a wide floodplain on which to redirect flows. If historic remnant channels are present, they are commonly used as primary flow channels. Groundwater elevations are restored by eliminating the deep

gully that drains surrounding soils. Flood flows are spread across a wide surface and dissipated, protecting bed and banks from erosion.

This alternative might be recommended for the Pleasants Creek gully sections, if it were not for the influence of several factors that must be considered.

- The current gully system reaches are not newly formed. Mature native vegetation indicates that some of the gully sections are decades old. Filling these reaches would require a significant loss of valuable, mature riparian habitat, as well as loss of considerable acreage of valuable land for the location of borrow ponds.
- The gully formation has progressed to a point where a complete geomorphic restoration would be cost-prohibitive due to the deep incision, lateral erosion, and subsequent enlarged cross-sectional area of the gully. Elimination of the gully or reduction to the historic cross-sectional area would require excessive volume of fill material and high cost.
- The abandoned floodplain of Pleasants Valley is now populated and developed to a degree that prevents realistic consideration of restoring flood flows to the former floodplain.
- The lowered elevation of the Putah Creek confluence remains, making the transition to the lower elevation problematic and risky. Flood damage to any high-gradient transition structure would be difficult to prevent.
- Remnant channels that assist in the design of primary flow courses are not common. Most reaches do not have well-defined historic remnants.
- The series of bridges along Pleasants Valley prevent the continuous function of the historic floodplain, if periodic flood flows were returned. These constrictions would likely cause localized vertical erosion of the channel, due to the increased velocities created by constriction of the floodplain. Unless the road system had been designed to allow for floodplain function, it prevents consideration of a restored floodplain.

For the reasons stated above, alternative 5d is considered to be a restoration alternative that may meet several of the project objectives, but is not appropriate given the valley type, the current conditions, and the listed impediments to restoration.

3e. Enhance Channel Recovery Processes: This alternative considers actions to improve the energy dissipation function of an inset floodplain within the confines of the existing gully walls. Conceptually, this action is based on current tendencies of natural channel recovery. Taking into consideration the previous impediments, a solution is needed that promotes channel stability without causing undo risk of project failure. In one sense, alternative 3e concedes that any effort to "restore" the Pleasants Creek to historic functional condition at the prior elevations is highly improbable. However, the current tendencies of lateral erosion and inset floodplain formation indicate that natural recovery processes are at work to rebuild the stream system with a lower floodplain surface. Alternative 3e builds on that tendency by widening the inset floodplain and disposing of excavated soils in nearby depressions or erosional features.

There are several benefits of this alternative:

- The technique can be applied opportunistically in open areas with good access and little mature riparian vegetation. It does not require treatment of entire channel lengths, and can therefore be "phased" to meet seasonal and financial restrictions.
- Treatment of one reach does not increase pressure on downstream banks. The more floodplain surface that is exposed to flood flows, the more absorption and dissipation of energy is achieved.
- The current survey work can be used to estimate cut and fill volumes, making project cost estimation efficient.
- The proposed alternative is far less disruptive and can avoid most existing fencing, structural improvements, and irrigation infrastructure.
- Similar work on adjacent properties is proving to be a cost-effective method of promoting riparian stability.

The disadvantages include:

- Full floodplain function is not achieved.
- Continued lateral erosion in untreated areas.
- Some disruption of the landscape during operations.
- Requires invasive arundo and blackberry control and removal to be effective.
- Difficulty and expense of establishing riparian wetland vegetation across the new inset floodplain and raw bank.

Channel Incisement Alternative Comparisons:

The disadvantages of the 3e alternative must be weighed against the benefits for treatment of the gully reaches. There are clear advantages to the 3e alternative over the more intrusive and risky 3d option, but it is more difficult to judge the relative benefits of mechanically widening the inset floodplain when compared with the enhanced natural recovery option (3b). The key questions in this decision are:

1. Would active project intervention (alternative 3e) speed recovery and reduce accelerated rates of sediment influx from lateral erosion?
2. Would either alternative 3b or 3e achieve the project goals over time?
3. Which alternative best meets the goal of sediment reduction from the Pleasants Creek watershed and other goals?

Conclusions:

Question #1. Yes. Intervention with the inset floodplain alternative (3e) would speed natural processes of lateral erosion and widen an inset floodplain in some reaches that would help to dissipate energy of flood flows. However, it may be unrealistic to construct a new inset floodplain surface of sufficient width to fully mitigate for the enlarged cross sectional area of the gully. Although the inset floodplain will dissipate energy, lateral erosion will not be fully mitigated.

Question #2. Yes. Both passive natural recovery (alternative 3b) and inset floodplain construction (alternative 3e) ultimately result in a move toward a more stable channel condition by providing some dissipation of flood energy across a floodplain feature. The goal to reduce sediment input is better met with intervention (3e) in the short term, as the

removed sediment is no longer available to the system. Riparian habitat would be temporarily disrupted by the 5e construction, but should return to current levels within the first few seasons following completion.

Question #3. The third question must be answered before deciding on action alternatives. The study and survey data provide a point in time look at current conditions for most of the affected gully reaches and answers some of the uncertainties surrounding the causal factors that underlie the degradation of the riparian resources. We know the decline of the channel has taken place over a very long time, and we also suspect that the process of natural recovery will take decades to achieve. Whether this is acceptable depends on one's perspective and the available alternatives (and funding) if natural recovery timeframes are deemed to be unacceptable.

Recommendations: Due to the availability of grant funding and the desire of the local landowners to protect valuable resources, StreamWise recommends that LPCCC use the priority rating results table on Page 14 to target key properties for active intervention. First and foremost, a watershed-based program to control invasive species, especially arundo and Himalayan blackberry, must be implemented to ensure long-term success of intervention projects. Efforts should be made to include all landowners along the channel to reduce re-infestation from upstream sources.

Past projects that develop the inset floodplain surfaces and promote recovery of native vegetation have proven to be cost effective and relatively stable. Much has been learned from these early efforts, and these lessons can be applied to the design of future projects to further improve function and stability.

Each project should survey the new inset floodplain sites to document pre-project and as-built conditions and implement a monitoring plan to help judge rates of recovery, bank erosion, floodplain stability, etc. Establishing photo points will help with assessment of project success. With this annual data, compare to untreated gully reaches with surveyed cross-sections to make a determination of the relative benefits of expanding the inset floodplain alternative to other areas.

4. Tributary Stability:

Alternatives Considered:

- a) No action.
- b) Rock drop structures at confluence.
- c) Headcut treatments.

Discussion: Tributaries to Pleasants Creek have responded to the lower base elevation by headcutting into the upstream landscape, causing moderate to severe instability and sediment influx to the system. Treatment of the resulting gully system is problematic, due to the steep nature of the entry into the main channel. Structural rock drop structures might be built to raise the bed of the tributary, but the runoff is then forced to make an abrupt gradient drop, creating high risk of structural failure. Treating the headcut point upstream of the confluence by using rock to dissipate the flow energy may delay the advance of the incision, but will require periodic maintenance and enhancement to resist

further erosion. Of course, the "no action" alternative is likely to result in further land loss, advance of the headcut, and other collateral damages to the landscape.

Recommendation: Treat headcut points in key areas where headcuts are likely to advance rapidly. Use rock to construct a step-pool dissipation ramp down to the incised gradient elevation. Filter fabric lining may be incorporated to improve stability. Inspect each treated headcut regularly to note any adjustments or threats to stability and modify structure to accommodate any such changes. Do not construct large rock or boulder drop structures at the confluence, as the abrupt gradient change creates excessive risk of structural failure. All step-pool ramps should lower water surface elevation as gradually as practical and incorporate as many dissipation features as the site allows. These must be constructed by personnel trained in channel dynamics and geomorphic concepts. Standard "rock lining", regardless of the engineering design, will not suffice to stabilize the tributary erosion.

5. Road Culvert Crossings:

Alternatives Considered:

- a) No action.
- b) Rock dissipation pools.
- c) Culvert drop pipes.

Discussion: Some tributaries along Pleasants Creek have headcut to a point where the incision intersects with Pleasants Valley Road at culvert crossings. These scour areas at the outlet of the culverts undermine the road base due to the excessive scour forces on the bed of the channel below the culvert. Fortunately, the culvert crossing acts as a grade control structure, preventing channel incision from traveling further upstream. Tributary reaches upstream of the road typically have a more stable morphology and most do not show signs of active vertical erosion.

Recommendation: To prevent failure or damage to the road surface, it is suggested that the county consider installation of rock dissipation pools below each culvert outlet. In some cases, it may be helpful to first lower the elevation of the culvert outlet with a drop pipe and extension downstream. In either case, the dissipation pools should be designed to retain water within the pools during outflow periods and center the downstream exit flow onto a rock step-pool ramp. The dissipation pool is designed to allow culvert flow to pass into pooled water, preventing the excessive scour potential. Currently, the flow falls directly onto the bed of the channel. Once the dissipation pool is formed with large rock or boulder, a rock step-pool system can be designed to lower the outflow elevation to the existing tributary gradient. If no drop pipe is used, additional rock will likely be required to line the bank around the culvert outlet to prevent further damage to the road.

6. Surface Drainage Issues

Alternatives considered:

- a) Survey and design improved surface drainage systems to reduce bank collapse during runoff events.
- b) Consider use of drop pipes and rock dissipation pools to reduce channel erosion at pipe.
- c) Regrade terrace surface elevation to route surface flows toward less vulnerable areas.

Discussion: Surface drainage from residential and agricultural fields contributes to the instability of the banks in numerous locations. As the Pleasants Creek channel has become more deeply incised, the surface drainage issues have become more pronounced. At some point during surface runoff events, the water must find a low point in the topography and fall twenty feet or more into the incised channel. This rapid gradient change has resulted in deep gouges into the pastures as the torrential flow headcuts rapidly.

Over the years, many landowners have attempted to arrest this process by dumping anything at hand into the headcut feature. Brush, root-wads, fence wire, appliances and even car bodies are commonly found at bank cuts, placed in an effort to slow the rate of headcutting. Some efforts have been marginally successful, but for the most part, the dumping of such material tends to redirect the runoff either around or under the obstruction. This exacerbates the issue and supplies the stream channel with a source of waste debris that degrades the natural riparian habitat.

Recommendation: Because the surface runoff erosion is a function of the landscape responding to the new, lower elevation of the channel, it is necessary to design methods to lower surface runoff to the new elevation without expecting the soft depositional soils to absorb the energy. The following alternatives can be considered on a site-by-site basis:

- a) Line the entry gully with filter fabric and rock to form a resistant chute for the runoff to pass to the lower elevation.
- b) Place a drop-inlet box with metal brush grate at the collection point, and direct flows into a culvert pipe that is placed into the gully feature, passing water downhill to a level near the active channel surface. Then provide a rock dissipation apron to prevent scour near the channel. Grade the upper bank edge to ensure the surface flows collect at the drop-inlet. Revegetate all disturbed areas for long-term stability.

The primary factor that will influence the choice of methods is cost. In areas where a minor amount of rock will suffice to arrest minor erosion points, then method "a" is appropriate. In more advanced erosion sites, it will probably be more effective, less risky, and less expensive to treat the site with the drop-inlet alternative. If this alternative is selected, it is suggested that a flap-valve be installed at the pipe outlet to prevent backflow blockage and animal entry.

If the drop-inlet alternative is constructed, the landowner will be required to check the brush grate periodically and clear any blockage. Severe damage could occur if the inlet is not kept open. This minor maintenance consideration is likely to be less cumbersome than maintenance of the eroding headcut feature.

H. Site Specific Recommended Actions

(Refer to Site Plots in Appendix D and Assessment Worksheets in Appendix A for additional detail regarding the following site specific narratives that recommend actions to promote channel stability and riparian enhancement.)

Priority Ranking Table (from Page 14)

site #	landowner names	reach L	score	priority
9	Bertagnolli et al	2863	265	1
6	Hudson	4807	264	2
10	Hoskins	3900	262	3
3	Shurnas/Murdoch	2492	258	4
7	Bill Nichols / Echols	1023	220	5
12	Campbell	1389	217	6
13	Roschen	942	210	7
16	Milner	3376	207	8
1	Bur. Recl. - Martin	2207	203	9
5	Beall	1604	194	10
8	Coy Nichols / Gates	1820	188	11
2	Flaherty - Carrion	3381	151	12
14	Boshoven	930	128	13
15	Rowell	716	115	14
11	Guglielmoni	772	105	15
4	Doud	1186	86	16

Priority 1 - Site #9 - Gary Bertagnolli et. al.- 2863' Station 18,520' to 21,383'

See Site Map #4

Primary factors affecting priority rating:

1. Proximity to Pleasants Valley Road
2. Proliferation of arundo along banks.
3. Unstable bank height.
4. History of bank and road collapse induced by channel erosion.

Site 9 ranked most important for immediate action with a score of 265 out of a maximum of 370 possible points due to the factors mentioned above. The Bertagnolli property lies on the south bank, with Lopez, Kowalski, Johnson and Levi along the north bank. All landowners have given initial indications of support for channel stabilization.

Site #9 - Recommended Actions

1. Invasive Species Proliferation:

- Watershed invasive removal program.

2. Transportation Issues:

- Arundo Control: Include key areas of road collapse in invasive control program. Road failure can be directly traced to arundo proliferation as a major factor in lateral erosion.
- Inset Floodplain Development: Physically remove dead arundo following spray treatment and regrade key areas to promote inset floodplain formation. This is recommended along the north bank (opposite the road) to allow for better flood dissipation and reduced lateral erosion at the toe of the roadside bank.
- Native Revegetation: Focus native riparian revegetation efforts at key lateral erosion reaches near Pleasants Valley Road to ensure bank stability, floodplain recovery and energy dissipation function.

3. Channel Stability:

- Promote Channel Recovery Processes: Combine invasive control program with active widening of the current elevation of the inset floodplain to help dissipate the energy of flood flows (See Transportation Issues above). An inset floodplain surface should be built along the left bank (north) of the channel in all areas where arundo is controlled. The lower bankfull surface elevation will assist re-establishment of riparian grass (sedge and rush species) that promote channel stability, yet allow for passage of flood flows. This elevation is critical not only for establishment of these native species, but to inhibit the regrowth of the invasive arundo and Himalayan blackberry that contribute to accelerated lateral erosion.
- Protect high-risk bank reaches by installation of a series of rock vane structures, especially along outside meanders adjacent to Pleasants Valley Road these structures have been proven to provide a cost-effective means

of providing bank slope protection when installed in conjunction with inset floodplain design.

- Stabilize and maintain inset areas and graded banks with native vegetation. Once the invasive species are controlled, an inset floodplain can be graded to an elevation approximately 2.5ft. above the low flow water surface elevation, with a gradual 1% to 2% slope toward the steep bank. Inset floodplain width will be variable to accommodate variations in available terrain, and restrictions on grading due to proximity to structures, orchards, etc. One goal of inset floodplain design is to maintain as wide and consistent flood-flow belt width as possible to prevent concentration of flood energy at constriction points.

Discussion: Bertagnolli property ranks first priority due to the combination of heavy arundo infestation, proximity to the Pleasants Creek Road, and past public transportation issues due to lateral bank erosion. Control of the arundo stands requires immediate action to prevent future bank collapse and road failure. It is recommended that once arundo is controlled, an inset floodplain can be graded and revegetated with native riparian species. This will benefit bank stability and reduce sediment contribution from this reach. The inset floodplain will dissipate energy of high flows, reduce lateral erosion rates, and allow for maintenance access for invasive control.

Access ramps will need to be developed during initial treatment to allow for machinery and maintenance requirements. Several points along the south bank afford access with minimal construction grading.

Rock vanes are recommended along the two sites of past rip-rap damage, adjacent to Pleasants Creek Road. This will provide additional resistance to erosion at the toe of the road prism in these two locations.

Priority 2 - Site #6 - Hudson (contact: Sharon Domler) - 4807' Station 10,870' to 15,677'

See Site Map #3

Primary factors affecting priority rating:

1. Proximity to Pleasants Valley Rd.
2. Proliferation of arundo along banks.
3. Unstable bank height.
4. History of bank and road collapse induced by channel erosion.
5. Significant reach length (4807').

Site #6 ranked second with a score of 264 out of a maximum of 370 possible points due to the factors mentioned above. The Hudson property encompasses property on both sides of Pleasants Creek. Landowner has given initial indications of support for channel stabilization.

Site #6 - Recommended Actions

1. Invasive Species Proliferation:

- Watershed invasive removal program.

2. Transportation Issues:

- Arundo Control: Include key areas of road collapse in invasive control program. Road failure can be directly traced to arundo proliferation as a major factor in lateral erosion.
- Inset Floodplain Development: Physically remove dead arundo following spray treatment and regrade key areas to promote inset floodplain formation. This is recommended along the north bank (opposite the road) to allow for better flood dissipation and reduced lateral erosion at the toe of the roadside bank.
- Native Revegetation: Focus native riparian revegetation efforts at key lateral erosion reaches near Pleasants Valley Road to ensure bank stability, floodplain recovery and energy dissipation function.

3. Channel Stability:

- Promote Channel Recovery Processes: Combine invasive control program with active widening of the current elevation of the inset floodplain to help dissipate the energy of flood flows (See Transportation Issues above). An inset floodplain surface should be built along the inside meanders of the channel in all areas where arundo is controlled. The lower bankfull surface elevation will assist re-establishment of riparian grass (sedge and rush species) that promote channel stability, yet allow for passage of flood flows. This elevation and soil moisture content is critical not only for establishment of native species, but will inhibit the regrowth of the invasive arundo and Himalayan blackberry that contribute to accelerated lateral erosion.

- Protect high-risk bank reaches by installation of a series of rock vane structures, especially along outside meanders adjacent to Pleasants Valley Road. These structures have been proven to provide a cost-effective means of providing bank slope protection when installed in conjunction with inset floodplain design.
- Stabilize and maintain inset areas and graded banks with native vegetation. Once the invasive species are controlled, an inset floodplain can be graded to an elevation approximately 2.5 ft. above the low flow water surface elevation, with a gradual 1% to 2% slope toward the steep bank. Inset floodplain width will be variable to accommodate variations in available terrain, and restrictions on grading due to proximity to structures, orchards, etc. One goal of inset floodplain design is to maintain as wide and consistent flood-flow belt width as possible to prevent concentration of flood energy at constriction points.

4. Road Culvert Crossings:

- Construct a rock dissipation pool below culvert outlet on south bank. Current conditions indicate active severe scour and culvert failure due to inadequate dissipation of flow energy as it exits this drainage culvert that passes under Pleasants Valley Road.
- Consider installation of a culvert drop pipe to lower the flow to channel elevation.

Discussion: Hudson property ranks second priority, just behind Bertagnolli, due to the combination of heavy arundo infestation, proximity to the Pleasants Creek Road, and past public transportation issues due to lateral bank erosion. The same recommendations apply to this property due to the similarity of conditions to the Bertagnolli property.

Control of the arundo stands requires immediate action to prevent future bank collapse and road failure. It is recommended that once arundo is controlled, an inset floodplain can be graded and revegetated with native riparian species. This will benefit bank stability and reduce sediment contribution from this reach. The inset floodplain will dissipate energy of high flows, reduce lateral erosion rates, and allow for maintenance access for invasive control.

Access ramps will need to be developed during initial treatment to allow for machinery and maintenance requirements. Several points along the south bank allow for relatively easy construction of access ramps with minimal disturbance.

Rock vanes are recommended along the northeast meander adjacent to Pleasants Creek Road to provide additional resistance to erosion along the outside of the bend.

Priority 3 - Site #10 - Ethel Hoskins - 3900' Station 21,383' to 25,283'

See Site Map #5

Primary factors affecting priority rating:

1. Unstable bank height.
2. History of past project cooperation.
3. Upstream limit of arundo invasion.
4. Historic and aesthetic impacts.
5. Proven effectiveness of recommended methodology.

Site #10 ranked third with a score of 262 out of a maximum of 370 possible points due to the factors mentioned above. The Hoskins property lies on the south bank, with Lopez and Kowalski along the north bank. Landowner has given initial indications of support for channel stabilization.

Site #10 - Recommended Actions

1. Invasive Species Proliferation:

- Watershed invasive removal program.

2. Transportation Issues:

- Mostly resolved during construction of new bridge following failure of bridge foundation during recent flood event, however, tributary headcutting threatens to undermine Pleasants Valley Road at two points. (See Tributary section below.)

3. Channel Stability:

- Promote Channel Recovery Processes: Combine invasive control program with active widening of the current elevation of the inset floodplain to help dissipate the energy of flood flows (See Transportation Issues above). An inset floodplain surface should be built along the inside meanders of the channel in all areas where arundo is controlled. The lower bankfull surface elevation will assist re-establishment of riparian grass (sedge and rush species) that promote channel stability, yet allow for passage of flood flows. This elevation is critical not only for establishment of these native species, but to inhibit the regrowth of the invasive arundo and Himalayan blackberry that contribute to accelerated lateral erosion.
- Protect high-risk bank reaches by installation of a series of rock vane structures, especially along outside meanders. These structures have been proven to provide a cost-effective means of providing bank slope protection when installed in conjunction with inset floodplain design.
- Stabilize and maintain inset areas and graded banks with native vegetation. Once the invasive species are controlled, an inset floodplain can be graded to an elevation approximately 2.5 ft. above the low flow water surface elevation, with a gradual 1% to 2% slope toward the steep bank. Inset floodplain width will be variable to accommodate variations

in available terrain, and restrictions on grading due to proximity to structures, orchards, etc. One goal of inset floodplain design is to maintain as wide and consistent flood-flow belt width as possible to prevent concentration of flood energy at constriction points.

4. Tributary Stability:

- Construct large boulder energy dissipation structures at two culvert outlets adjacent to Pleasants Valley Road to prevent further scour and undermining of road prism.
- Rock drop structure at confluence with main Pleasants Creek channel.
- Headcut treatment. Utilize large rock to stabilize vertical incision process at key locations.

5. Road Culvert Crossings:

- See Tributary section above.

6. Surface Drainage Issues:

- Survey and design improved surface drainage systems to reduce bank collapse during runoff events.
- Consider use of drop pipes and rock dissipation pools to reduce channel erosion at pipe outlets.

Discussion: The Hoskins reach has been the focus of past stabilization projects, and the owner was the earliest cooperator in the effort to address Pleasants Creek resource issues. Much has been learned from these efforts, and current construction methods are based, in part, on evaluation of project performance at the Hoskins Ranch.

While several meanders along the property have been treated to reduce erosion rates, others remain susceptible to flood flows and have shown recent damage in peak runoff events. Due to the past cooperation and program support, coupled with historic value of the homestead and property, this reach is recommended for early intervention to protect the newly developing erosion issues. Lateral erosion is evident along the west bank near the old house. This is due to channel avulsion and relocation at the toe of the steep bank. It is recommended that the channel be directed into the former location and the new cut filled and revegetated to prevent further bank collapse. A series of rock vanes will be required to prevent future avulsion and bench erosion. Native revegetation is recommended for all disturbed areas.

Additionally, there are two significant tributaries crossing under Pleasants Valley Road that are severely incised immediately downstream of the culvert crossings. These scour areas should be included in county efforts to stabilize the road prism and reduce downstream impacts during tributary runoff events.

Surface runoff issues are apparent at only one or two sites, but these should be treated with drop-inlet collection basins and pipe to lower the surface flow to streambed elevation.

Ramp access is already in place, but may need minor adjustment to allow for equipment passage.

Priority 4 - Site #3 - Pat Shurnas/Murdoch - 2492' Station 5,588' to 8,080'

Primary factors affecting priority rating:

1. Proliferation of arundo along banks.
2. Unstable bank height.
3. Adjacent to Pleasants Valley Rd. 900' reach
4. Good access points.
5. Past project cooperater.

Site #3 ranked fourth with a score of 258 out of a maximum of 370 possible points due to the factors mentioned above. The Shurnas property lies on the west bank, with Murdoch along the east bank. Landowners have given initial indications of support for channel stabilization.

Site #3 - Recommended Actions

1. Invasive Species Proliferation:

- Watershed invasive removal program.

2. Transportation Issues:

- Arundo Control: Include key areas of road collapse in invasive control program.
- Inset Floodplain Development: Physically remove dead arundo following spray treatment and regrade key areas to promote inset floodplain formation.
- Native Revegetation: Focus native riparian revegetation efforts at key lateral erosion reaches near Pleasants Valley Road to ensure floodplain recovery and function.

3. Channel Stability:

- Promote Channel Recovery Processes: Combine invasive control program with active widening of the current elevation of the inset floodplain to help dissipate the energy of flood flows (See Transportation Issues above). An inset floodplain surface should be built along the inside meanders of the channel in all areas where arundo is controlled. The lower bankfull surface elevation will assist re-establishment of riparian grass (sedge and rush species) that promote channel stability, yet allow for passage of flood flows. This elevation is critical not only for establishment of these native species, but to inhibit the regrowth of the invasive arundo and Himalayan blackberry that contribute to accelerated lateral erosion.
- Protect high-risk bank reaches by installation of a series of rock vane structures, especially along outside meanders. These structures have been proven to provide a cost-effective means of providing bank slope protection when installed in conjunction with inset floodplain design.
- Stabilize and maintain inset areas and graded banks with native vegetation. Once the invasive species are controlled, an inset floodplain can be graded to an elevation approximately 2.5 ft. above the low flow

water surface elevation, with a gradual 1% to 2% slope toward the steep bank. Inset floodplain width will be variable to accommodate variations in available terrain, and restrictions on grading due to proximity to structures, orchards, etc. One goal of inset floodplain design is to maintain as wide and consistent flood-flow belt width as possible to prevent concentration of flood energy at constriction points.

4. Tributary Stability:

- Tributary damage was not noted at Shurnas/Murdoch property.

Discussion: Shurnas/Murdoch property ranks fourth priority due to the combination of heavy arundo infestation, vertical bank height, and lateral bank erosion. Previously detailed recommendations for invasive control and removal apply to this property.

Control of the arundo stands requires immediate action to prevent future bank collapse and accelerated contribution of sediment to the system. It is recommended that once arundo is controlled, an inset floodplain can be graded and revegetated with native riparian species. This will benefit bank stability and reduce sediment contribution from this reach. The inset floodplain will dissipate energy of high flows, reduce lateral erosion rates, and allow for maintenance access for invasive control.

The most active lateral bank erosion location occurs on the Murdoch property just upstream of the Winters Road bridge. This outside meander is eroding at an accelerated rate proportional to the advance of heavy infestations of arundo on the opposite bank.

Access ramps will need to be developed during initial treatment to allow for machinery and maintenance requirements. Repair of existing access points may be possible with landowner consent.

Rock vanes may be needed in key location to provide additional resistance to erosion along the outside of the bend. Further evaluation will be needed following arundo removal to define rock vane specifications and location.

Priority 5 - Site #7 - Bill Nichols - 1023' Station 15,677' to 16,700'

Primary factors affecting priority rating:

1. Visibility from Pleasants Valley Rd.
2. Major contributor of sediment to the Pleasants Creek system.
3. Unstable bank height.
4. History of bank collapse induced by channel erosion.
5. Past project cooperater.

Site #7 ranked fifth with a score of 220 out of a maximum of 370 possible points due to the factors mentioned above. The Bill Nichols/Echols property extends from the new Pleasants Valley Road bridge downstream approximately 1023' to property owned by Hudson (Site # 6). Landowners have given initial indications of support for channel stabilization.

Site #7 - Recommended Actions

1. Invasive Species Proliferation:

- Nichols property should be included in the invasive species control program to monitor continued native plant recovery. However, at this time, Site #7 has a low level of Himalayan blackberry and arundo. Star thistle and other non-native species are present, but do not directly threaten bank stability.

2. Transportation Issues:

- Past damages to the county bridge have been largely resolved with construction of new bridge and stabilization of the foundation slopes with large rock.

3. Channel Stability:

- Promote Channel Recovery Processes: No inset floodplain development is necessary at Site #7 due to the existing inset floodplain surface that lies opposite the vertical eroding wall on the west bank extending from the bridge 500' downstream. Some additional dissipation of energy may be achieved by grading the narrow point of land separating the deep tributary and main channel at the downstream end of the vertical bank.
- Protect high-risk bank reaches by installation and/or repair of a series of rock vane structures along outside meander. These structures have been proven to provide a cost-effective means of providing bank slope protection when installed in conjunction with inset floodplain design. The 30' vertical wall on the right bank of Nichols property is a challenging task for stabilization using rock vanes alone, so additional rock should be incorporated into the design of vanes to help protect the base of the bank and structures during peak runoff events.
- Stabilize and maintain inset areas and graded banks with native vegetation. Utilize native seed and container stock to promote native revegetation of the inset floodplain areas.

- Develop a strategy with the landowner to ensure exclusion of cattle from the area to allow for vegetation to recover.

4. Tributary Stability:

- Headcut treatment. Utilize large rock to stabilize vertical incision process at key locations in the incised tributary.

5. Road Culvert Crossings:

- The roadside culvert installed during recent bridge construction is inadequate to carry peak runoff. The rock and cobble used to line the channel below the small culvert is undersized and shows signs of destabilization and entrainment. This roadside drainage should be redesigned and repaired to prevent further erosion and private property damages.

6. Surface Drainage Issues:

- Survey and design improved surface drainage systems to reduce bank collapse during runoff events. Focus efforts on pasture drainage along the top of vertical right bank.
- Consider use of drop pipes and rock dissipation pools to reduce channel erosion at pipe outlets.

Discussion: Bill Nichols property exhibits a vertical exposed bank that is perhaps the most severe case of lateral instability in the entire Pleasants Creek extent. It is not coincidental that this highly unstable bank is situated just downstream of a constriction point formed by Pleasants Creek Road Bridge #4. Past efforts at stabilization using rock vanes have been effective in most areas, but the sharp radius of curvature along the meander bend, combined with the severity of the vertical wall, have caused continuing bank failure and sediment contribution to the system.

While not a perfect solution to such an extreme condition, the rock vanes situated along the outside of the meander have been a partial success at stabilizing the reach. It is possible to enhance the existing rock vane series with an additional vane to better control the high-velocity core that attacks the toe of the wall. Additional rock will be required to bolster the other vanes and ensure they work in tandem to protect the bank.

Even with a significant effort to redesign the vane series, the vertical wall is still subject to rill erosion from surface runoff from above. This issue should be addressed by directing surface flow to a drop-inlet box and lowered to channel elevation with a drop pipe.

The tributary entering from the downstream end of the vertical wall is also subject to severe erosional tendencies. It is recommended that the "point" of land remaining between the main channel and the tributary be lowered to floodplain bench elevation to provide for additional lateral dissipation of energy and prevent the eventual collapse into the main channel. The base of the tributary should be treated with a rock step-pool system to prevent further erosion at the confluence. This work can be conducted as part of the rock vane repair process.

Priority 6 - Site #12 - Jim Campbell - 1389' Station 26,055' to 27,444'

Primary factors affecting priority rating:

1. Proximity to residential structures.
2. Active erosion and structural damages.
3. Unstable bank height.
4. Landowner cooperation and support.

Site #12 ranked sixth with a score of 217 out of a maximum of 370 possible points due to the factors mentioned above. The Campbell property extends across the entire channel from Guglielmoni upstream to Roshen downstream. Landowner has given initial indications of support for channel stabilization.

Site #12 - Recommended Actions

1. Invasive Species Proliferation:

- Watershed invasive removal program.

2. Transportation Issues:

- The main stream channel is situated far enough from Pleasants Valley Road to prevent direct impact to public transportation.

3. Channel Stability:

- Passive Natural Channel Recovery: (Most of channel length) Develop invasive control program and allow for natural erosional processes to establish channel stability.
- Promote Channel Recovery Processes: (High-risk vertical bank adjacent to home and deck.) Combine invasive control program with active widening of the current elevation of the inset floodplain to help dissipate the energy of flood flows. Stabilize and maintain inset areas and graded banks with native vegetation. Utilize a series of rock vanes to protect the bench stability at the base of the vertical wall near deck.

4. Tributary Stability:

- Headcut treatment. Utilize large rock to stabilize vertical incision process at key locations.

5. Road Culvert Crossings:

- Rock dissipation pool.
- Culvert drop pipe.

6. Surface Drainage Issues:

- Survey and design improved surface drainage systems to reduce bank collapse during runoff events.

- Consider use of drop pipes and rock dissipation pools to reduce channel erosion at pipe outlets.

Discussion: Campbell property is in relatively stable condition, with only moderate bank erosion potential along most of the reach. Much of the erosion is due to the proliferation of Himalayan blackberry stands that redirect flood energy towards the banks. Once this is controlled, the natural inset floodplain development is likely to decrease rates of lateral instability.

The exception is a 200' reach of vertical bank adjacent to a deck area that is actively collapsing and undermining the deck structure. The deck segment of the channel should be treated with construction of a stable floodplain elevation bench to provide a toe area at the base of the steep slope. Rock vanes may need to be constructed at this bench to provide long-term protection.

The property would benefit from grading of the inset floodplain to better dissipate energy and also allow for maintenance access for invasive control. Most of this reach will allow for effective bench grading following Himalayan blackberry control. The existing ramp feature will require work to improve access. Consideration should be given to establishment of a rock crossing and ramp construction to the east side of the channel to facilitate future maintenance and access.

Priority 7 - Site #13 - Ethan Roshen - 942' Station 27,444' to 28,386'

Primary factors affecting priority rating:

1. Historic structures threatened by tributary collapse.
2. Erosion along access causing risk of road failure.
3. Unstable bank height.
4. Landowner support.

Site #13 ranked seventh with a score of 210 out of a maximum of 370 possible points due to the factors mentioned above. The Roschen property spans both sides of the creek, with Boshoven property at the upstream end and Campbell at the downstream end. Landowner has given initial indications of support for channel stabilization.

Site #13 - Recommended Actions

1. Invasive Species Proliferation:

- Watershed invasive removal program. Arundo is not prolific, but present. Himalayan blackberry is rampant and causing channel instability.

2. Transportation Issues:

- Include key areas of road collapse in invasive control program.
- Treat tributary collapse along driveway with large rock step-pool system to arrest vertical erosion in vicinity of crossing and historic China houses.
- Native Revegetation: Focus native riparian revegetation efforts at key lateral erosion reaches.

3. Channel Stability:

- Passive Natural Channel Recovery (North - downstream - half of property): Develop invasive control program and allow for natural erosional processes to establish channel stability.
- Promote Channel Recovery Processes (South - upstream - half of property) : Combine invasive control program with active widening of the current elevation of the inset floodplain to help dissipate the energy of flood flows. Stabilize and maintain inset areas and graded banks with native vegetation. Utilize rock structures as needed to protect toe of bank from continuing lateral erosion.

4. Tributary Stability:

- Construct rock drop structures at driveway crossings and historic China houses, as mentioned above in Transportation Issues section.
- Headcut treatment. Utilize large rock to stabilize vertical incision process at key locations.

5. Road Culvert Crossings:

- Rock dissipation pool.
- Culvert drop pipe.

6. Surface Drainage Issues:

- Survey and design improved surface drainage systems to reduce bank collapse during runoff events.
- Consider use of drop pipes and rock dissipation pools to reduce channel erosion at pipe outlets.

Discussion: The most glaring issues facing the Roschen property is the instability of the tributary that crosses the driveway. The lower elevation of the main channel has induced headcutting that has migrated to the driveway culvert and threatens to undermine and collapse that access point. Additionally, three historic "China houses" are adjacent to the eroding tributary. These are relicts of times when Chinese workers were housed on-site for orchard harvest. Continued erosion of the tributary banks has undermined one foundation, and may affect the others in time.

It is recommended that this tributary feature be treated with large rock dissipation structures that step the flow volume gradually downstream to the elevation of the main channel. This will require a significant volume of large rock and boulders to properly construct such a system. An alternative would be to collect all flow from the tributary into a culvert system that carried the flow to the lower elevation. This type system would require attention to the inlet brush guard to prevent blockage and failure. Benefits and drawbacks of each alternative should be discussed with the landowner prior to finalization of a treatment plan.

Much of the Pleasants Creek channel erosion potential is due to the proliferation of Himalayan blackberry stands that redirect flood energy towards the banks. Once this is controlled, the natural inset floodplain development is likely to continue with decreased rates of lateral instability.

The main channel reach would benefit from grading of the inset floodplain to better dissipate energy and also allow for maintenance access for invasive control. Most of this reach will allow for effective bench grading following Himalayan blackberry control.

Priority 8 - Site #16 - Jim Milner - 3376' Station 30,032' to 33,408'

Primary factors affecting priority rating:

1. Proximity to Pleasants Valley Road bridge.
2. Proliferation of Himalayan blackberry along banks.

Site #16 ranked eighth with a score of 207 out of a maximum of 370 possible points due to the factors mentioned above. The Milner property lies across the entire channel, with the Rowell property downstream. Milner is the uppermost property in the area under consideration for treatment. Landowner has given initial indications of support for channel stabilization.

Site #16 - Recommended Actions

1. Invasive Species Proliferation:

- Watershed invasive removal program. Focus is on Himalayan blackberry that is prolific along both banks for nearly the entire reach.

2. Transportation Issues:

- Some past flood damages have occurred to the upstream county bridge on Pleasants Valley Road. This bridge may not be replaced soon due to the historic status, so erosion concerns should be addressed within the channel. Construction of rock cross vane and additional rock at bridge piers may prevent further damage.
- Inset Floodplain Development: Physically remove dead blackberry following spray treatment and regrade key areas to promote inset floodplain formation.

3. Channel Stability:

- Passive Natural Channel Recovery: Develop invasive control program and allow for natural erosional processes to establish channel stability.

4. Tributary Stability:

- Tributary issues were not identified as a priority action item.

5. Road Culvert Crossings:

- None identified.

Discussion: The Milner property is in relatively stable condition, with only moderate bank erosion potential along the upstream 1000' reach. Much of the erosion potential is due to the proliferation of Himalayan blackberry stands that redirect flood energy towards the banks. Once this is controlled, the natural inset floodplain development is likely to continue with decreased rates of lateral instability.

The property would benefit from grading of the inset floodplain to better dissipate energy and also allow for maintenance access for invasive control. Most of this reach will allow for effective bench grading following Himalayan blackberry control.

Priority 9 - Site #1 - Bureau of Reclamation (Martin) - 2207' Station 0' to 2,207'

Primary factors affecting priority rating:

1. Landowner support.
2. Proliferation of arundo along banks.
3. Severe damage to primary agricultural access road.

Site #1 ranked ninth with a score of 203 out of a maximum of 370 possible points due to the factors mentioned above. The Martin property lies along both sides of the channel, with a narrow strip of property along the active channel owned by Bureau of Reclamation. This ownership was established in conjunction with the Lake Solano Project and represents the high water line during peak runoff events. Both Bureau of Reclamation and the surrounding landowner have given initial indications of support for channel and access crossing stabilization.

Site #1 - Recommended Actions

1. Invasive Species Proliferation:

- Watershed invasive removal program.

2. Transportation Issues:

- Arundo Control: Include key areas of road collapse in invasive control program. Tree of heaven is also common near the crossing.
- Native Revegetation: Focus native riparian revegetation efforts at key lateral erosion reaches near the crossing to ensure channel recovery and stability.

3. Channel Stability:

- Passive Natural Channel Recovery: Develop invasive control program and allow for natural erosional processes to establish channel stability.
- Construct a rock weir immediately below the existing crossing and backfill arms with cobble rock to seal weir rocks and stabilize the crossing site.

4. Tributary Stability:

- No tributary issues were identified on the property.

5. Road Culvert Crossings:

- No road culvert issues were identified during the initial surveys.

6. Surface Drainage Issues:

No surface drainage issues were identified during the initial surveys.

Discussion: While most of the channel remain in relatively stable condition, the confluence area with Lake Solano does have moderate erosion points. Most of the lateral bank erosion issues are directly related to arundo proliferation that is throughout the entire reach. Arundo treatment is the highest priority, followed closely by construction of a rock weir to control the scour issues that threaten the agricultural road crossing. This crossing has been rebuilt several times to repair scour damage and is currently severely undercut and in danger of collapse.

Equipment access is feasible, and landowner is fully supportive on immediate action to stabilize the reach.

Priority 10 - Site #5 - Beall - 1604' Station 9,266' to 10,870'

Primary factors affecting priority rating:

1. Multiple active erosion sites.
2. Proliferation of arundo and tree of heaven along banks with direct influence on stability.
3. Unstable bank height.
4. Possible inset floodplain formation under arundo.

Site #5 ranked tenth with a score of 194 out of a maximum of 370 possible points due to the factors mentioned above. The Beall property consists of a horseshoe shaped meander beginning at the Hudson property at the upstream end and ending at the new county bridge (Bridge #2) on Pleasants Valley Road. Landowner has given initial indications of support for channel stabilization.

Site #5 - Recommended Actions

1. Invasive Species Proliferation:

- Watershed invasive removal program.

2. Transportation Issues:

- Construction of a new bridge at the Pleasants Creek crossing has reduced risk of transportation disruption from lateral bank erosion. However, continuing proliferation of arundo may influence this stability if not controlled.

3. Channel Stability:

- Passive Natural Channel Recovery: Develop invasive control program and allow for natural erosional processes to establish channel stability in the central portion of the meander.
- Promote Channel Recovery Processes: In areas designated as heavy arundo infestation, combine invasive control program with active widening of the current elevation of the inset floodplain to help dissipate the energy of flood flows. Stabilize and maintain inset areas and graded banks with native vegetation.

4. Tributary Stability:

- The two tributaries that enter the channel from the northwest appear to have reached an elevation that allows for moderate stability. No actions to treat these two sites are recommended at this time.

5. Road Culvert Crossings:

- No roadside culvert outlets were identified on the property.

6. Surface Drainage Issues:

- No surface drainage issues were identified on the property.

Discussion: Most of the lateral bank erosion issues are directly related to arundo proliferation that is throughout the entire reach. Arundo treatment is the highest priority, followed by establishment of inset floodplain width that will dissipate the energy of flood flows. Tree of heaven is also common, especially along the northeast corner of the meander bend.

Equipment access is feasible but must be constructed to facilitate construction of inset floodplain and for long-term invasive species maintenance.

Priority 11 - Site #8 - Coy Nichols/Joan Gates - 1820' Station 16,700' to 18,520'

Primary factors affecting priority rating:

1. Past project cooperator.
2. Unstable bank height.
3. Adjacent to some residential structures.
4. Good access possibility.

Site #8 ranked eleventh with a score of 188 out of a maximum of 370 possible points due to the factors mentioned above. The Nichols/Gates property consists of a sinuous section of channel from Bertagnolli at the upstream end, to Pleasants Valley Road bridge #4 and Bill Nichols property at the downstream end. Landowners have given initial indications of support for channel stabilization. The properties are being considered together as a single consideration for action.

Site #8 - Recommended Actions

1. Invasive Species Proliferation:

- Watershed invasive removal program. The property does not currently have heavy arundo or Himalayan blackberry infestations, but should be spot treated for existing clumps and included in the watershed monitoring and control program.

2. Transportation Issues:

- Damages to county Bridge #4 have been addressed with construction of the new bridge and bank slope stabilization with heavy rip-rap armoring. The channel does not influence the public road system at any other point.

3. Channel Stability:

- Passive Natural Channel Recovery: Develop invasive control program and allow for natural erosional processes to establish channel stability.
- Promote Channel Recovery Processes: Combine invasive control program with grading of the current elevation of the inset floodplain to help dissipate the energy of flood flows. Stabilize and maintain inset areas and graded banks with native vegetation. Construct a series of rock vanes to protect the left north bank of the meander along Gates property.

4. Tributary Stability:

- Rock drop structure at confluence with main Pleasants Creek channel.
- Headcut treatment. Utilize large rock to stabilize vertical incision process at key locations.

5. Road Culvert Crossings:

- No road culvert issues were identified along the property.

6. Surface Drainage Issues:

- Survey and design improved surface drainage systems to reduce bank collapse during runoff events.
- Consider use of drop pipes and rock dissipation pools to reduce channel erosion at pipe outlets.

Discussion: While most of the channel along the Nichols portion remains in relatively stable condition, the Gates portion upstream shows moderate to severe erosion areas. The north bank of Gates would rank as severe, but the shale substrate is resistant to erosion and helps reduce lateral erosion rates. The tributary entering from the north at the edge of Gates property is severely downcut and would benefit from use of rock grade control at key areas to reduce sediment contribution to the system.

Existing rock vane series on Nichols meander appears to be functioning as designed to stabilize that section of channel. Any minor repair, if necessary, to that series of structures could be done during future project work.

Equipment access is feasible, and landowner is fully supportive on immediate action to stabilize the reach.

Priority 12 - Site #2 - Dianne Flaherty/Carrion - 1851' Station 3,737' to 5,588'

Primary factors affecting priority rating:

1. Landowner support.
2. Good access potential.

Site #2 ranked twelfth with a score of 151 out of a maximum of 370 possible points due to the factors mentioned above. The Flaherty/Carrion properties will be considered together. The upstream boundary of Carrion property begins at Winters Road (Bridge #1) and extends about 500' downstream to the Flaherty property line, then another 1350' of channel length to the Martin/Bureau of Reclamation property line. Landowners have given initial indications of support for channel stabilization.

Site #2 - Recommended Actions

1. Invasive Species Proliferation:

- Watershed invasive removal program. Invasive arundo is not prolific, but clumps are common and will spread quickly if not controlled.

2. Transportation Issues:

- A section of the channel is adjacent to Winters Road and arundo is gaining a hold in this reach. Road stability is not yet affected, but damage is expected to increase as arundo begins to shift high velocity flood flows against the banks.

3. Channel Stability:

- Passive Natural Channel Recovery: Develop invasive control program and allow for natural erosional processes to establish channel stability. The channel is relatively stable at the moment, due to lack of heavy invasive infestation and coarse streambed substrate, but arundo spread is likely to have negative impacts on channel stability.

4. Tributary Stability:

- No major tributaries were identified in the reach.

5. Road Culvert Crossings:

- No road culvert issues were identified in the reach.

6. Surface Drainage Issues:

- Survey and design improved surface drainage systems to reduce bank collapse during runoff events.
- Consider use of drop pipes and rock dissipation pools to reduce channel erosion at pipe outlets.

Discussion: While most of the channel remain in relatively stable condition, arundo clumps have become more common through the reach and will likely cause negative impacts within the next few years unless controlled.

The primary landowner concern is related to surface drainage issues that cause bank erosion and land loss at several points. These points should be treated to reduce sediment contributions and loss of productive agricultural land.

Equipment access is good, and landowner is fully supportive on immediate action to stabilize the reach.

Priority 13 - Site #14 - Bob Boshoven - 930' Station 28,386' to 29,316'

Primary factors affecting priority rating:

1. Landowner support.

Site #14 ranked thirteenth with a score of 128 out of a maximum of 370 possible points due to the factors mentioned above. The Boshoven property lies across the entire channel, with Rowell upstream and Roschen downstream. Landowner has given initial indications of support.

Site #14 - Recommended Actions

1. Invasive Species Proliferation:

- Watershed invasive removal program.

2. Transportation Issues:

- None. Channel is situated well away from public roads.

3. Channel Stability:

- Passive Natural Channel Recovery: Develop invasive control program and allow for natural erosional processes to establish channel stability.
- Active floodplain enhancement is possible once invasive blackberry is removed, but should be assessed at that time.
- Utilize large woody debris within channel to stabilize inset floodplain features. Current location may promote bank instability.

4. Tributary Stability:

- Headcut treatment. Utilize large rock to stabilize vertical incision process at key locations.

5. Road Culvert Crossings:

- No road culvert issues were identified.

6. Surface Drainage Issues:

- Survey and design improved surface drainage systems to reduce bank collapse during runoff events.
- Consider use of drop pipes and rock dissipation pools to reduce channel erosion at pipe outlets.

Discussion: Most of the Boshoven property is very deeply incised with steep banks, but riparian vegetation is prolific and tends to stabilize most bank reaches. Himalayan blackberry is the most common invasive species and should be aggressively controlled. After control, it may be possible to grade inset floodplain elevations to enhance flood dissipation, or these inset surfaces may adjust over time to a more functional elevation.

Following the initial assessment in Nov. 2010, high flows have deposited debris jams in the central reach of the property. These should be removed or adjusted as soon as possible to prevent lateral bank collapse and sediment influx.

Equipment access is feasible, especially down the west bank, but will require ramp construction to access the east bank. Construction of a stable crossing at this point would facilitate maintenance access to the east side of the property. The landowner is fully supportive on action to improve access and control invasive species.

Priority 14 - Site #15 - Marina Rowell - 716' Station 29,316' to 30,032'

Primary factors affecting priority rating:

1. Active channel relocation and bank erosion.
2. Proximity of bank collapse to residential structure.

Site #15 ranked fourteenth with a score of 115 out of a maximum of 370 possible points due to the factors mentioned above. The Rowell property is bisected in the center by the north/south flowing channel. Landowner has given initial indications of support for channel stabilization.

Site #15 - Recommended Actions

1. Invasive Species Proliferation:

- Watershed invasive removal program.

2. Transportation Issues:

- The channel is situated well away from public roads.

3. Channel Stability:

- **Passive Natural Channel Recovery:** Along the entire southern portion of the property, develop invasive control program and allow for natural erosional processes to establish channel stability.
- **Promote Channel Recovery Processes:** At the northern end of property (downstream), combine invasive control program with active widening of the current elevation of the inset floodplain to help dissipate the energy of flood flows. This should be done in conjunction with relocation of the active flow channel to the original location prior to recent flood flows that cut a new channel at the base of the slope. Stabilize and maintain inset areas and graded banks with native vegetation.

4. Tributary Stability:

- No tributary issues were identified.

5. Road Culvert Crossings:

- No roadside culverts are present.

6. Surface Drainage Issues:

- Survey and design improved surface drainage systems to reduce bank collapse during runoff events.
- Consider use of drop pipes and rock dissipation pools to reduce channel erosion at pipe outlets.

Discussion: While most of the channel remain in relatively stable condition, the northern 200' reach at the downstream end has been negatively affected by channel avulsion in recent flood flows. This avulsion has destabilized the toe of a steep bank and threatens to impact a mobile home structure on the east bank. The former channel is still apparent, and could be used for the active channel, if the new cut were filled to inset floodplain elevation and revegetated to prevent future damage. Material for this fill and inset floodplain grading could be derived from shaping of the vertical bank.

Equipment access is feasible, but will require ramp construction to access the east bank. Construction of a stable crossing at this point would facilitate maintenance access to the east side of the property. The landowner is fully supportive on action to arrest rates of lateral erosion at the northern boundary line, improve access and control invasive species.

Additional surface drainage issues were noted and should be addressed at the time of the bank and channel work as recommended above.

Priority 15 - Site #11 - Guglielmoni - 772' Station 25,283' to 26,055'

Primary factors affecting priority rating:

1. Stable channel reach.
2. Good access across bridge to east bank.

Site #11 ranked fifteenth with a score of 105 out of a maximum of 370 possible points due to the factors mentioned above. The Guglielmoni property lies downstream of Campbell and upstream of Hoskins.

Site #11 - Recommended Actions

1. Invasive Species Proliferation:

- Watershed invasive removal program. Invasive species are not prolific along the property, but Himalayan blackberry is somewhat common, especially near the private bridge.

2. Transportation Issues:

- There are no public transportation issues, but the private bridge to the east side of the property could be at risk of foundation damage if invasive species are allowed to proliferate.

3. Channel Stability:

- Passive Natural Channel Recovery: Develop invasive control program and allow for natural erosional processes to establish channel stability.

4. Tributary Stability:

- No tributary issues were noted.

Discussion: The Guglielmoni property is one of the most stable reaches in the project area. While the channel is incised in this reach, the banks have reached an angle of repose that allows for strong vegetative cover. Fortunately, most vegetation is native riparian, and the lack of invasive species such as arundo contributes to the relative stability of the reach.

It is important to develop a cooperative agreement with the owners of the Guglielmoni property due to the possibility that all-season access to the east bank may be made using the existing private bridge.

Priority 16 - Site #4 - Doud - 1186' Station 8,080' to 9,266'

Primary factors affecting priority rating:

1. Proximity to Pleasants Valley Road.
2. Aesthetic values.

Site #4 ranked sixteenth with a score of 86 out of a maximum of 370 possible points due to the factors mentioned above. The Doud property lies Adjacent to Pleasants Valley Road with Bridge #2 at the upstream boundary and Shurnas property at the downstream end. The channel is in relatively stable condition with few invasives.

Site #4 - Recommended Actions

1. Invasive Species Proliferation:

- Watershed invasive removal program.

2. Transportation Issues:

- The proximity of the channel to the public road is a matter of concern, but current lack of arundo or Himalayan blackberry have allowed for the banks in this reach to remain relatively stable.

3. Channel Stability:

- Passive Natural Channel Recovery: Develop invasive control program and allow for natural erosional processes to establish channel stability.

4. Tributary Stability:

- No tributary issues were identified.

Discussion: The stability of this reach is directly related to the lack of arundo. Although very common upstream and downstream, infestation has not yet affected channel stability. Even so, several clumps were located at the top and bottom of the reach, and proliferation is likely to occur at a rate similar to adjacent properties. Despite current stability it is recommended that the property be included in the watershed invasive species control program.

Equipment access is feasible, and landowner is supportive of action to control invasives.

I. CONSTRUCTION COST ESTIMATES

sites ranked by priority scoring results				
site #	landowner names	reach L	score	priority
9	Bertagnolli et al	2863	264	1
Construction cost range:		\$75,000 to \$115,000		
6	Hudson	4807	264	2
Construction cost range:		\$75,000 to \$115,000		
10	Ethel Hoskins	3900	262	3
Construction cost range:		\$50,000 to \$75,000		
3	Shurnas/Murdoch	2492	258	4
Construction cost range:		\$40,000 to \$60,000		
7	Bill Nichols / Echols	1023	220	5
Construction cost range:		\$65,000 to \$95,000		
12	Campbell	1389	217	6
Construction cost range:		\$40,000 to \$50,000		
13	Roschen	942	210	7
Construction cost range:		\$75,000 to \$115,000		
16	Milner	3376	207	8
Construction cost range:		\$30,000 to \$40,000		
1	Bur. Recl. - Martin	2207	203	9
Construction cost range:		\$50,000 to \$75,000		
5	Beall	1604	194	10
Construction cost range:		\$25,000 to \$35,000		
8	Coy Nichols / Joan Gates	1820	188	11
Construction cost range:		\$20,000 to \$30,000		
2	Flaherty - Carrion	3381	151	12
Construction cost range:		\$25,000 to \$40,000		
14	Boshoven	930	128	13
Construction cost range:		\$25,000 to \$30,000		
15	Rowell	716	115	14
Construction cost range:		\$25,000 to \$35,000		
11	Guglielmoni	772	105	15
Construction cost range:		\$0		
4	Doud	1186	86	16
Construction cost range:		\$0		
Total construction range:		\$620,000 to \$880,000		

The above costs reflect rough estimates for the range of expenses that are likely to be required to implement the recommended construction activities for each property. These activities include all recommended actions following the initial spray treatment for control of invasive species. The costs **do not** reflect estimates for invasive control, as this program will be administered on a watershed basis and will not be broken down by individual reach. There may also be some additional costs for initial access improvements for spray vehicle access. The estimates assume approval by permitting agencies and no further requirements for technical engineering specifications. However, additional engineering input may be required for more severe surface drainage issues

described in this report. No estimate for cost of administration, permit documentation, bid meetings, or monitoring has been made.

The estimates in the table above include costs for rock and boulder materials, culverts, drop-inlet boxes, flapper valves, grading of inset floodplains, bank shaping, rock structure construction, access ramp enhancement, revetment placement, machinery rentals, fuel, and all other associated construction costs. On properties that include rock structure construction, the cost estimate is roughly split 50/50 between delivered material cost and operational cost to construct the rock/boulder structures.

The cost estimates are based on conceptual design and are subject to change dependent upon final approved design specifications and contractor bids. Estimates for riparian revegetation planning and implementation, long-term maintenance, and monitoring require further research and consultation with specialists to develop a comprehensive plan. Estimates for grading and hauling tasks should be refined when details regarding disposal sites for excess fill material can be verified. Once the above variables are known, StreamWise suggests on-site meetings with potential contractors to further clarify the budget estimates and project specifications.

StreamWise looks forward to working with the local landowners, Solano County Water Agency, Lower Putah Creek Coordinating Committee, the resource agencies, and other stakeholders to address the sediment source and riparian resource issues in the Pleasants Creek watershed.

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APPENDIX A
Site Specific Survey Data
Assessment Worksheets

APPENDIX B
Rosgen Cross-Vane Design Specifications

APPENDIX C
Rock Structure, Crossing, and Bench
Features
Design Diagrams

APPENDIX D

Site Maps

Map #1 - Martin/Bureau Reclamation/Flaherty/Carrion

Map #2 - Shurnas/Murdoch/Doud/Beall

Map #3 - Hudson

Map #4 - Nichols/Gates/Bertagnoli/et al

Map #5 - Hoskins/Guglielmoni

Map #6 - Campbell/Rochen/Boshoven/Rowell/Milner