SUMMARY OF FINDINGS

❶ There will be permanent water table in the bed and banks of the stream. Shallow-rooted plants that grow quickly, including invasive grasses, could benefit.

❷ Areas with high canopy cover and many species of shallow-rooted native plants have lower coverage of invasive species.

❸ Avoiding discharge during dry seasons and allowing time between watering events can create a survival advantage for native drought-tolerant plants.

RECOMMENDATIONS

Use Caution After Disturbances
Disturbances could weaken native plants, alter soil conditions, and introduce new species. Adding water during or after these events could allow invasive plants to establish.

Don't Release High Nutrient Water
Increasing nutrients could favor invasive plants. This is not likely to be an additional issue for Boeing since water discharge permits typically put strict limits on nutrient content.

Restoration of Native Plants
Adding native plants and trees could increase resistance to invasive species. Boeing can create unfavorable habitat for non-native plants and reduce the potential risk of invasion by planting shallow-rooted plants and canopy creating shrubs and trees along specific areas of the stream.

Treated Water Release Schedule
Water should be released into the dry stream during historically wet months (November to March). Native plants are adapted to long periods of drought. Invasive grasses do not have these drought-tolerant traits. This will create a stressful environment for non-native grasses, allowing native plants to be better competitors and maintain a stream dominated by native vegetation.

ACKNOWLEDGEMENTS & REFERENCES

We would like to thank the Boeing staff at SSFL, Colleen Devlin (UCSB), Dr. James Frew (UCSB), Juan Carlos Villasenor Derbez, Zach Burke, the staff at NCEAS, and everyone else who took time to assist us. References: (1) Goldstein, L.J. and Suding, K.N. 2014. Applying competition theory to invasion: resource impacts indicate invasion mechanisms in California shrublands. Biol Invasions 16(1), pp. 191–203. (2) Brooks, M.L., Brown, C.S., Chambers, J.C., D'Antonio, C.M., Keeley, J.E. and Belnap, J. 2016. Exotic Annual Bromus Invasions: Comparisons Among Species and Ecoregions in the Western United States. In: Germino, M. J., Chambers, J. C., and Brown, C. S. eds. Exotic Brome-Grasses in Arid and Semiarid Ecosystems of the Western US. Cham: Springer International Publishing, pp. 11–60. (3) Eskelinen, A. and Harrison, S. 2014. Exotic plant invasions under enhanced rainfall are constrained by soil nutrients and competition. Ecology 95(3), pp. 682–692.

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BOEING

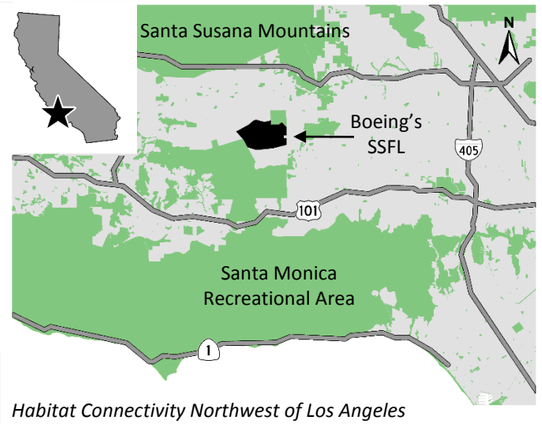
From Rocket Testing to Wilderness:

Investigating Water Management Strategies and Impacts at Santa Susana

ON THE WEB AT HTTP://ROCKETOUTFALL.GITHUB.IO SPRING 2017

History of the Santa Susana Site

Boeing's 2,850 acre site, the Santa Susana Field Laboratory (SSFL), lies in the arid hills of Simi Valley. The site was a testing campus for U.S space and energy technologies from 1947 to 2006. During early operations, industrial solvents such as trichloroethylene (TCE) infiltrated into the aquifer bedrock and contaminated the groundwater. The decommissioned site is currently undergoing multiple remediation projects, and Boeing hopes it can be turned into an open space for wilderness preservation.



Habitat Connectivity Northwest of Los Angeles

Groundwater Remediation Stalled

Boeing plans to pump and de-contaminate the groundwater, then release the clean water to a dry stream on-site. They need to understand how the stream's vegetation could respond to this new flow, and if the water could favor the growth of invasive species. The California Department of Fish and Wildlife will not issue a necessary permit until Boeing until investigates and reports on these issues.

Significance of Bren Project

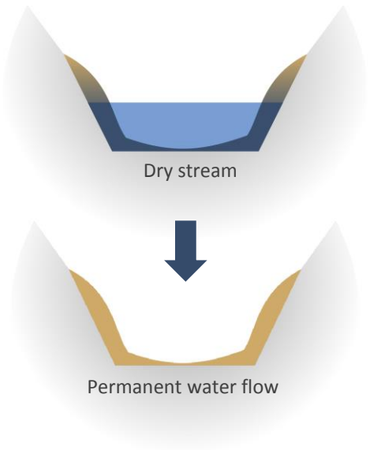
SSFL is one of few undeveloped areas connecting habitat in the region. Degradation in this area could have far-reaching effects. The results of this project will help Boeing prevent exposure to TCE while maintaining the integrity of this habitat link.

Project Objectives

- Define the extent of the discharged water's impact on the property.
- Assess the potential for colonization and growth of invasive plants.
- Develop management strategies to reduce growth of invasive plants.

CHANGES IN WATER FLOW AND VEGETATION DISTRIBUTION

How would the future water flow behave in the dry stream?



Current status: Dry stream

To analyze the extent of the introduced water, the Bren School working group surveyed the stream's physical characteristics to calculate the water height that would result from releasing 60 gallons per minute.

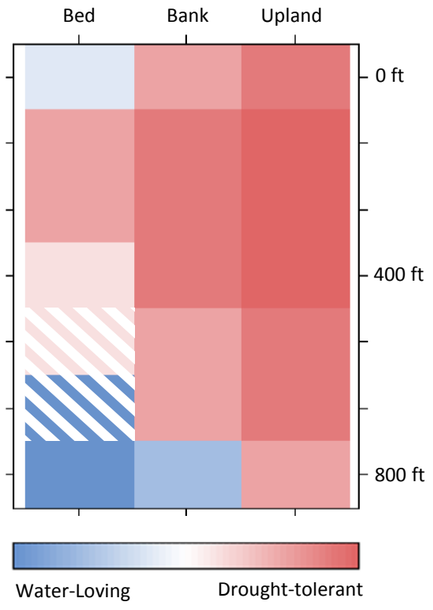
Future status: Permanent water flow

- ✓ The estimated water depth would vary along the stream from 3 cm to 17 cm.
- ✓ The water would not exceed the stream's capacity, and would flow downhill beyond the property boundary.
- ✓ There will be permanent water available to plants in the channel bed and banks during treated water discharge.

Will water alter the current vegetation distribution along the stream?

Water is one of the key determinants of vegetation composition in arid ecosystems. Currently at the dry stream, drought-tolerant species with low water requirement are predominant. At the lower end of the channel there is a wet zone that supports water-loving and wetland plants (noted by white stripes on the map to the right).

Current Plant Distribution in Channel
By water preference



What is expected after water discharge?

Permanent plant-available water will result in a more uniform distribution of water-loving plants in the bed and banks of the channel. Fast-growing species will respond first.

- ✓ Wetland plants will be present in the stream bed.
- ✓ Water-loving plants will be mostly present in stream banks
- ✓ Drought-tolerant plants will dominate the upland parts of the channel.


Chamise

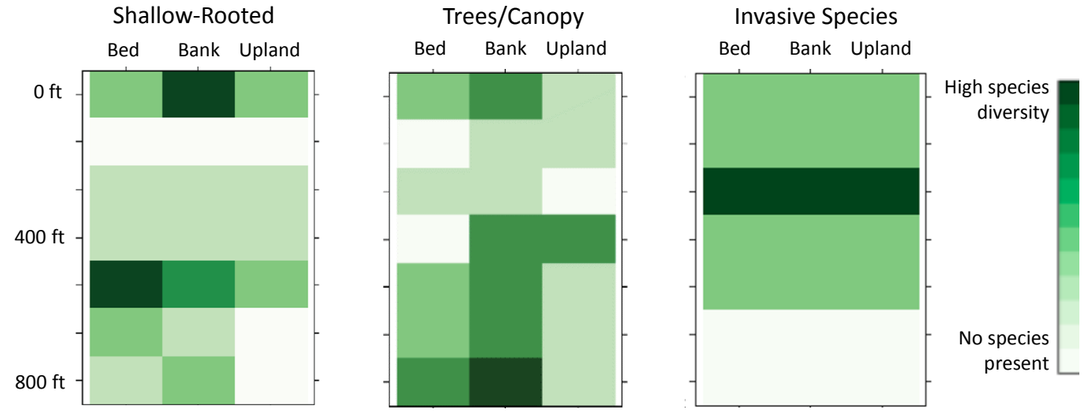

Western sycamore


Laurel sumac

POTENTIAL FOR INVASIVE VEGETATION COLONIZATION

Will creating permanent water favor the establishment of invasive species?

This environment can resist invasion by non-native vegetation in two ways: high canopy cover[2] and native plants outcompeting non-native plants for water in shallow soil. Currently along the stream areas with high canopy cover and diversity of shallow-rooted native plants have less invasive grasses, and vice versa. The degree of colonization by invasive grasses after the water is introduced will depend on the establishment of native additional canopy species (such as trees and shrubs) and native shallow-rooted species. These species can shade out non-native grasses and compete for plant-available water in the shallow soil layer.



MITIGATION OF POTENTIAL IMPACTS

Allow dry periods help native species thrive

Creating drought conditions will dry out the shallow soil layer where invasive grasses colonize. Native plants have adaptations to survive drought and will be able to better compete with invasive plants.[1]

Alternative water management

If Boeing needs to treat groundwater during a dry period, they'll need another place to release water. A viable substitute could avoid stream discharge entirely. However, a feasible alternative is not clear. Reinjecting treated water to the aquifer has also been met with permitting issues. Additionally, options that transport treated water off the property would open Boeing to litigation over poorly defined groundwater rights. Boeing could instead alternate discharge between two streams.