APPENDIX A

WATERSHED ANALYSIS OF VERNAL POOLS

June 23, 2004

4087040804.05

Mr. William Collins
Directorate of Environmental Natural Resources
P.O. Box 5004
Monterey, CA 93944-5004

Watershed Analysis of Vernal Pools in the Contra Costa Goldfields Critical Habitat

Dear Mr. Collins;

MACTEC Engineering and Consulting, Inc. (MACTEC) is pleased to submit to you the watershed analysis of vernal pools located in the area designated as critical habitat for Contra Costa goldfields at the Former Fort Ord. The information in this report presents the methods used to define the watersheds for vernal pools that contain the primary constituent elements necessary to support Contra Costa goldfields.

Background

Four populations of Contra Costa goldfields were identified on approximately five acres of vernal pool habitat on the Former Fort Ord in 1998. These populations occur within vernal pools or "mima mound" topography outside the Impact Area. Two of the four populations are located within Site OE-10B and have been monitored by the Army since 1999 to determine whether unexploded ordnance removal has affected these populations.

A large portion of the designated critical habitat unit is located in the Impact Area and comprises approximately 8,000 acres dominated by maritime chaparral with small inclusions of grasslands, coast live oak woodlands, and vernal pools. The Impact Area was used by the military since 1917 to train soldiers in the use of weapons such as handguns, rifles, machineguns, grenades, mortars, artillery, and rockets.

On August 6, 2003, the U.S. Fish and Wildlife Service (Service) designated 6,874 acres of Former Fort Ord as critical habitat for Contra Costa goldfields (*Lasthenia conjugens* [*68 FR 46648*]). The Service identified the following two primary constituent elements (habitat features considered essential to the conservation of Contra Costa goldfields):

1) Vernal pools, swales, moist flats, and other ephemeral wetlands and depressions of appropriate sizes and depths including adjacent upland margins of these depressions that sustain Contra Costa goldfields germination, growth, and reproduction.

2) The associated watershed(s) and hydrologic features that contribute to the filling and drying of the vernal pool or ephemeral wetland, and that maintain suitable periods of pool inundation, water quality, and soil moisture for Contra Costa goldfields germination, growth, and reproduction, and dispersal, but not necessarily every year. Vernal pool watersheds and hydrologic features were considered based on the sites topography and climate. Soil type and depth, hardpan or clay pan type and extent were also considered.

Although the Service has designated a significant portion of the Impact Area as Contra Costa goldfields Critical Habitat, Contra Costa goldfields have not been found in the Impact Area.

Watershed Analysis Methods

Automated vernal pool watershed delineations within Former Fort Ord required several layers of digital terrain data including 2-foot vector contour intervals, a digital elevation model, and color aerial orthophotographs in conjunction with ESRI's Hydrologic Modeling Extension for ArcMap. As part of the delineation, area, slope, elevation, flow distances, flow accumulations, and soil type supported these automated computations.

For this analysis, 41 vernal pools were identified within the Former Fort Ord study area for watershed delineation. Plate 1 shows the pool locations and their watersheds. The first step in automatically delineating vernal pool watersheds within the Contra Costa critical habitat region was to convert the 2-foot vector contour lines to a raster data set, or grid, which served as the model's digital elevation model, or DEM. This DEM is a floating point digital raster data set with an X and Y cell size of 50 feet. Given time and the contour data provided, this is the finest grid that could be developed. From these data, the upslope area contributing to a point (or pool) and the downlsope path where water would flow, as well as watershed areas, were calculated using ESRI's Hydrologic Modeling Extension.

Flow across a surface will always be in the steepest downslope direction. Once this direction of flow from each cell is known, it is possible to determine how many cells flow into any given cell. This information, in conjunction with soil type, can then be used to define watershed boundaries and stream networks.

The flow direction step in delineating watersheds takes the raster surface as input and outputs a raster showing the direction of flow out of each cell. There are eight valid output directions in a grid, relating to the eight adjacent cells into which flow could travel. The direction of flow is determined by finding the direction of the steepest descent, or maximum drop, from each cell, and is calculated as:

Maximum drop = change in z value / distance.

Distance is measured from each cell center. For example, if the cell size is 1, the distance between two orthogonal cells is 1, and the distance between two diagonal cells is 1.4142135, or the square root of 2. If the descent to all adjacent cells is the same, the grid size is reduced until the steepest descent is found. Once the steepest descent is determined, the output cell is coded with the appropriate value representing the direction (1 = East, 2 = South-East, 4 = South, 8 = South-West, 16 = West, 32 = North-West, 64 = North, and 128 = North-East).

The next step in delineating the watershed was to calculate accumulated surface flow as the weight of all cells flowing into each downslope cell in the output raster (grid). A raster weight of 1 was applied to each cell, so that the values of the each cell in the output raster are the same number of cells that flow into each cell. Cells with a high flow accumulation were then used to identify potential stream channels, and cells with a flow accumulation of zero were assumed to be local topographic highs and used to identify ridges.

The final step is to automatically delineate the vernal pool watersheds, or contributing area, based on the previously computed surface flow direction and flow accumulation raster data sets. A watershed is considered to be the entire upland area that contributes flow to a given location. In this particular case, that given location is a vernal pool.

The size of the watershed returned can be determined by either a flow accumulation threshold (response producing value), pour points, or a shapefile. Because soil type plays a key role in the water level regime of vernal pools, the appropriate method for automatically delineating these watersheds is the flow accumulation threshold method. This method allows for flexibility in the size of the output watershed based on supporting soil group. The logic applied here is that soils supporting larger surface flows (i.e. higher clay content) into the pool will have a larger threshold, or larger sphere of influence, and those soils having a smaller influence (i.e. lower clay content) on surface flow to the pool will have a smaller threshold, or smaller sphere of influence. To that end, each soil group was weighted, based on the following physical properties, and subsequently assigned a relative cell threshold: hydrologic group, clay content, available water capacity, and frequency of flooding.

The following seven soil groups occur in conjunction with vernal pools within the area determined to be Contra Costa goldfields habitat (Cook, 1978):

AeC (Antioch very fine sandy loam, 2 to 9 percent slopes),

AkD (Arnold loamy sand, 9 to 15 percent slopes),

Ar (Arnold-Santa Ynez Complex),

BbC (Baywood sand, 2 to 15 percent slopes),

OaD (Ocean loamy sand, 2 to 15 percent slopes),

ShE (Santa Ynez fine sandy loam, 15 to 30 percent slopes), and

Xd (Xerorthents, dissected).

These seven soil groups were assigned a relative cell threshold between 100 and 500, in increments of 50, based on the weight of their physical soil properties. That pools' cell threshold number was then used in the .AsGrid calculation (see below) to determine the watershed output extent for each vernal pool supported by that particular soil group. For example, soil group ShE was assigned a cell threshold of 100 because this soil group provides the least amount of surface runoff into the pool. Soil groups assigned a cell threshold of 500 fell outside the Contra Costa Goldfield critical habitat area and therefore do not appear on any table and are not discussed in this memo.

The following table lists each soil group and its relative cell threshold:

Soil Group	Threshold Value
ShE	100
OaD	150
BbC	250
Ar and AkD	300
Xd	350
AeC	450

The following code shows the process of automatically delineating watersheds from elevation data sets:

```
calculate flow direction:
flowDirGrid = elevGrid.FlowDirection(FALSE):
calculate flow accumulation:
flowAccGrid = flowDirGrid.FlowAccumulation(NIL):
extract streams from flow accumulation:
streamGrid = (flowAccGrid < 100.AsGrid).SetNull(1.AsGrid):
delineate stream links:
streamLinkGrid = streamGrid.StreamLink(flowDirGrid):
delineate watersheds for each stream link:
watershedGrid = flowDirGrid.Watershed(streamLinkGrid)
```

The watersheds that resulted from this process were then captured as raster images and manually edited based on the original high-resolution color aerial orthophotos and the 2-foot vector contour intervals. Without weighting each soil group and applying that weighted value to the flow accumulation threshold in the .AsGrid function, each returned watershed would be based on the same cell threshold and therefore would not reflect the impact soils group have on watershed area.

Plate 1 shows vernal pools and their respective watersheds within the area the Service considers critical habitat for Contra Costa goldfields at Fort Ord. Vernal pools constitute roughly 60 acres of this critical habitat region, while their watersheds, which influence the water level regime of the pool, constitute approximately 1,444 acres of upland habitat.

The life cycle of the Contra Costa goldfield, like many species of vernal pool vegetation, depends on the duration, timing, and source of inundation of the pool. While upland portions of the watersheds do not typically support Contra Costa goldfields, they are critical in supporting the seasonal fluctuations of vernal pool water levels. If the upland portions of these watersheds are impacted by cleanup or caretaker actions, the vernal pools' ability to fill or dry may also be impacted

Sincerely,

MACTEC Engineering and Consulting, Inc.

Daniel Craig, RG
Principal Hydrogeologist

Charlotte L. Hedlund
Senior Staff Hydrogeologist

DC/CLH/mlb:mb60763-FO

Attachment: Reference List

CC: Thomas Graham
Edward Ticken

Reference List

Butterwick, M., 1998. *The Hydrogeomorphic Approach and Its Use in Vernal Pool Functional Assessment*. Pages 50-55 in: C.W. Witham, Editor. Ecology, Conservation, and Management of Vernal Pool Ecosystems: Proceedings from a 1996 Conference, 19-21 June, 1996, Sacramento, CA. California Native Plant Society. Sacramento, CA. 285 pp.

Cook, T. D., 1978. *Soil Survey of Monterey County, California*. USDA Soil Conservation Service in cooperation with the University of California Agricultural Experiment Station. U.S. Government Printing Office, Washington, DC.

Hanes, T. and L. Stromberg, 1998. *Hydrology of Vernal Pools on Non-Volcanic Soils in the Sacramento Valley*. Pages 38-49 *in:* C.W. Witham, Editor. Ecology, Conservation, and Management of Vernal Pool Ecosystems: Proceedings from a 1996 Conference, 19-21 June, 1996, Sacramento, CA. California Native Plant Society. Sacramento, CA. 285 pp.

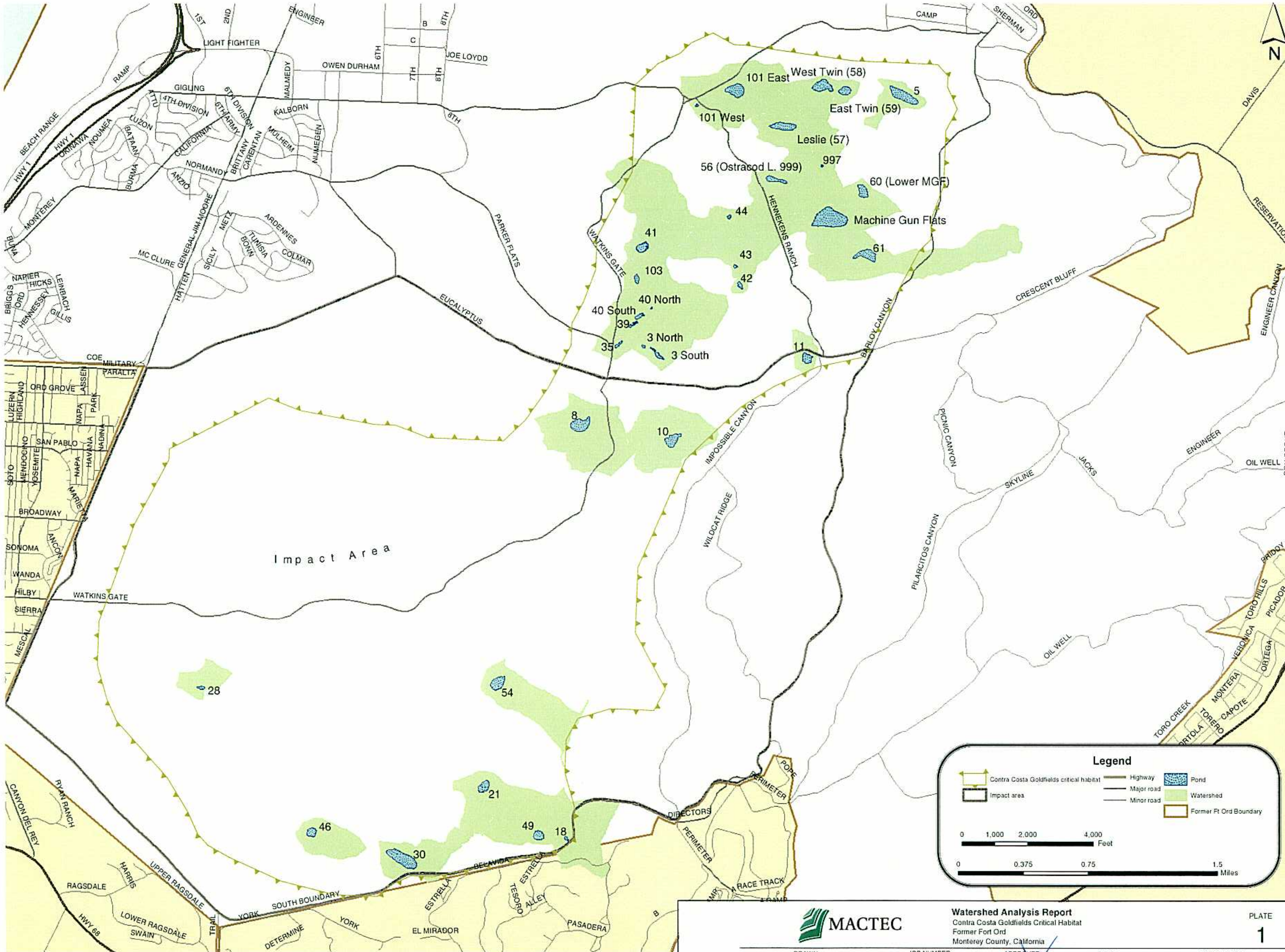
Keeley, J.E. and P.H. Zedler, 1998. *Characterization and Global Distribution of Vernal Pools*. Pages 1-14 in: C.W. Witham, Editor. Ecology, Conservation, and Management of Vernal Pool Ecosystems: Proceedings from a 1996 Conference, 19-21 June, 1996, Sacramento, CA. California Native Plant Society. Sacramento, CA. 285 pp.

Maidment, D.R., Djokic, D., 2000. *Hydrologic and Hydraulic Modeling Support with Geographic Information Systems*. ESRI Press, Redlands, CA.

United States Army Corps of Engineers, Sacramento District, 1992. *Flora and Fauna Baseline Study of Fort Ord, California*. December. With technical assistance from Jones and Stokes Associates (JSA-90-214), Sacramento, California.

U.S. Fish and Wildlife Service, 2003. *Endangered and Threatened Wildlife and Plants; Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon: Final Rule.* (Federal Register/Vol. 68, No 151*)*. August 6.

WI-2002-01: Report: Smith, D.P., Curry, R., Kozlowski, D., Williams, R., Watson, F., Turrini-Smith, L.A., and Newman, W., 2002, Watershed and Riparian Assessment Report: Bureau of Land Management Lands: Former Fort Ord, Monterey County, California: Central Coast Watershed Studies, Report No. WI-2002-01 (February, 2002), 75 pp., includes Arcview GIS Project, and PDF web document.



Fort Ord GIS - CCG_critical_habitat.mxd

MACTEC

Watershed Analysis Report
Contra Costa Goldfields Critical Habitat
Former Fort Ord
Monterey County, California

PLATE 1

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
JCF	4087040804 05		06/04	

DISTRIBUTION

2004 Annual Monitoring Report
Biological Baseline Studies and Follow-up Monitoring
Former Fort Ord
Monterey, California

April 5, 2005

Copy No. ___

Copy 1 - 7:	Mr. David Eisen Department of the Army Corps of Engineers Sacramento District 1325 J Street Sacramento, California 95814-2922
Copy 8 - 12:	MACTEC files

Quality Control Reviewer

Edward J. Ticken

Edward J. Ticken
Senior Principal Environmental Scientist

P:\Secretarial\MBarker\FtOrd\MB61176.doc