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# Agricultural Outlook Forum 2008

Crystal City, VA

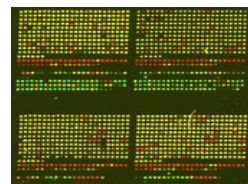
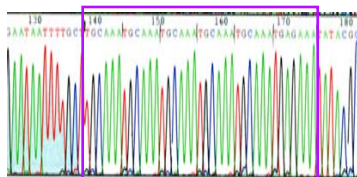
*FOOD RISK & SECURITY TRACK*

*Protecting the Food Supply Through Food Safety and Defense*

## “Preventing *E. coli* Contamination of Food”

Robert E. Mandrell, Ph.D.

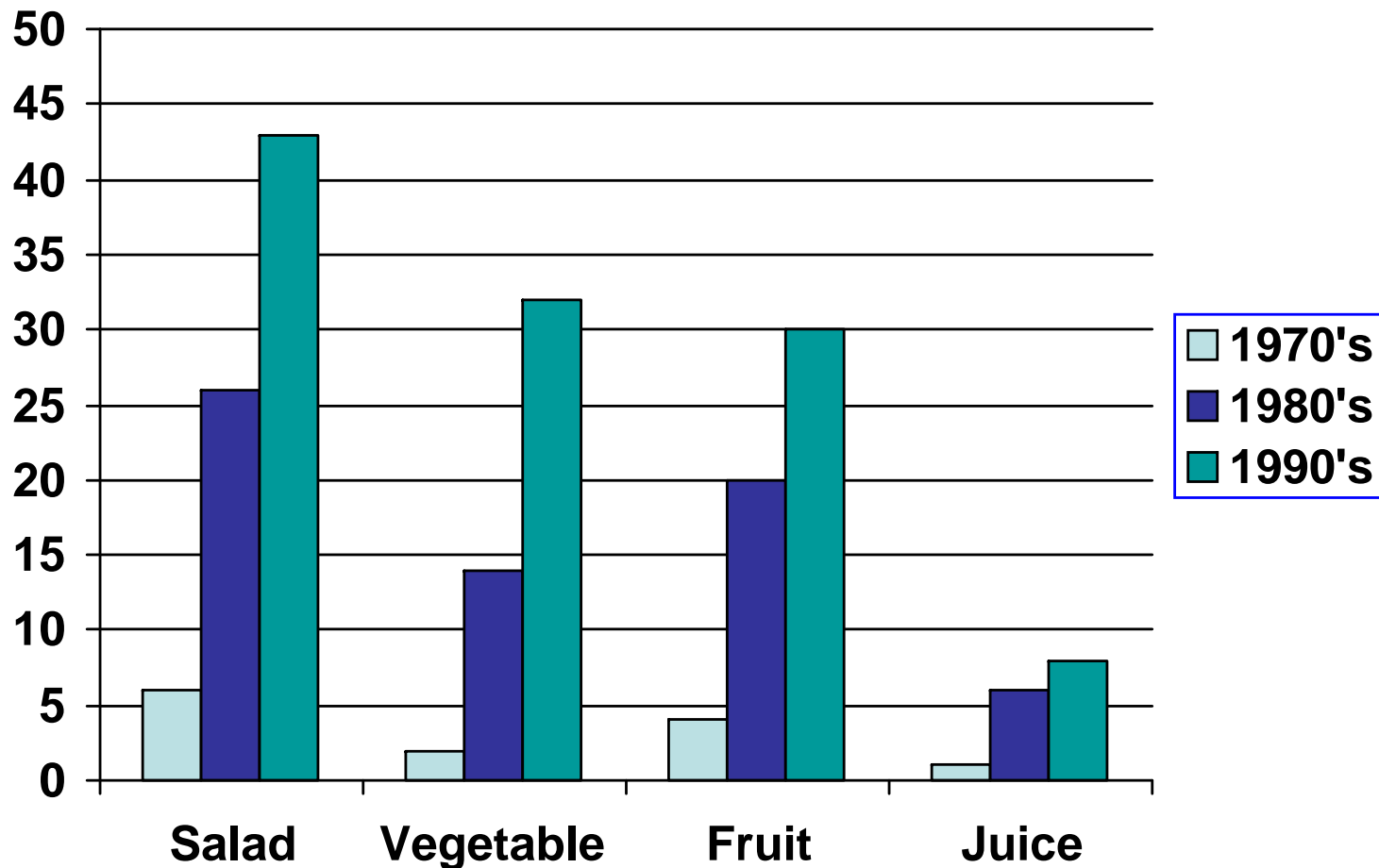
Research Leader, Produce Safety and Microbiology Research Unit  
USDA, Agricultural Research Service, Western Regional Research Center  
800 Buchanan Street, Albany, CA 94710



# Topics covered

- *E. coli* O157:H7 outbreaks associated with leafy vegetables.
- Central California Coast
  - Environment
  - Incidence in watersheds
  - Spinach outbreak, Sep-Oct, 2006.
- Potential risk factors and solutions.

# Foodborne outbreaks related to fresh produce, 1973-1997



Ref.: R. Tauxe. 2005. CDC.

# Most common single-food linked to outbreaks,

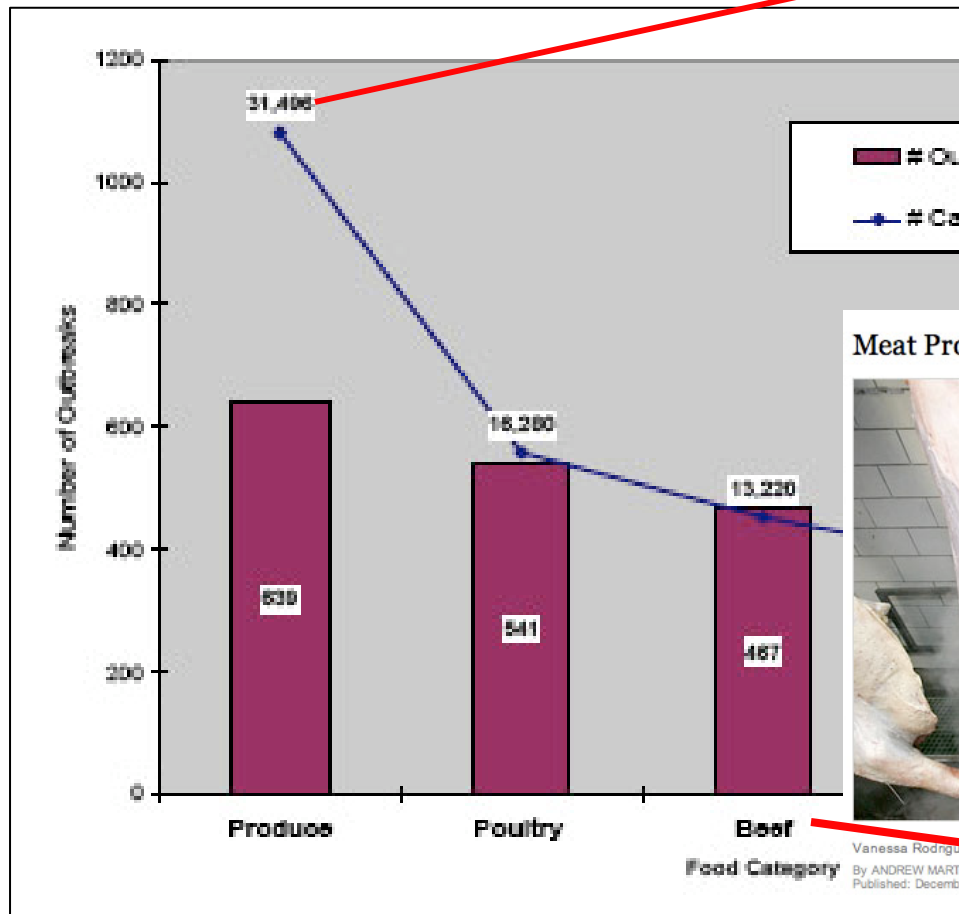
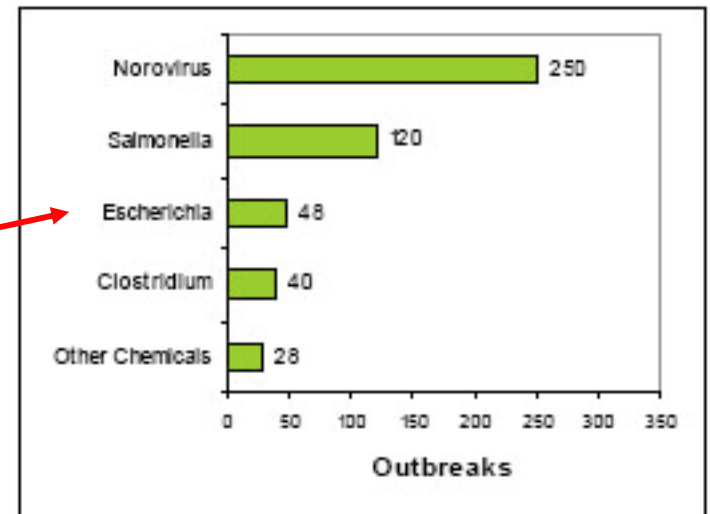


Figure 8. Leading Produce Pathogens



Meat Processors Look for Ways to Keep Ground Beef Safe



Vanessa Rodriguez... carcasses before processing  
By ANDREW MARTIN  
Published: December 6, 2007

Kent Sievers for The New York Times

NY Times, Dec 6, 2006

Ref.: Outbreak alert! 2006. CSPI.

From 1995 to 2006,  
There have been ~22 outbreaks  
***E. coli* O157:H7** in the US  
associated with lettuce and other  
leafy vegetables

## ***E. coli* O157:H7 outbreaks associated with leafy vegetables, 1995-2006**

Outbr.#	Month	Year	Location	No. Ill	Known/Suspected Vehicle	Region of Source
1	Jul	1995	MT	74	Romaine lettuce	MT, WA
2	Sep	1995	ID	20	Romaine lettuce	Unknown
3	Oct	1995	OH	11	Lettuce	Unknown
<b>4</b>	<b>May</b>	<b>1996</b>	<b>IL, CT</b>	<b>61</b>	<b>Mesclun mix lettuce</b>	<b>Salinas Valley, CA</b>
5	Jun	1996	NY	7	Mesclun lettuce	Unknown
6	May	1998	CA	2	Salad	Unknown
7	Sep	1998	MD	4	Lettuce	Unknown
<b>8</b>	<b>Sep</b>	<b>1999</b>	<b>CA</b>	<b>8</b>	<b>Romaine lettuce</b>	<b>Salinas Valley, CA</b>
<b>9</b>	<b>Sep</b>	<b>1999</b>	<b>WA</b>	<b>6</b>	<b>Romaine lettuce</b>	<b>Salinas Valley, CA</b>
10	Oct	1999	OH, IN	47	Lettuce	Unknown
<b>11</b>	<b>Oct</b>	<b>1999</b>	<b>OR</b>	<b>3</b>	<b>Romaine hearts</b>	<b>Salinas Valley, CA</b>
<b>12</b>	<b>Oct</b>	<b>1999</b>	<b>PA</b>	<b>41</b>	<b>Romaine lettuce</b>	<b>Salinas Valley, CA</b>
<b>13</b>	<b>Jul</b>	<b>2002</b>	<b>WA (Spokane)</b>	<b>29</b>	<b>Romaine lettuce</b>	<b>Salinas Valley, CA</b>
14	Nov	2002	IL, WI, MN, SD, UT	24	Lettuce	San Joaquin Valley, CA
<b>15</b>	<b>Sep</b>	<b>2003</b>	<b>CA (Pat &amp; Oscars)</b>	<b>57</b>	<b>Romaine/iceberg lettuce</b>	<b>Salinas Valley, CA</b>
16	Sep	2003	ND	5	Lettuce mix w. romaine	Unknown
<b>17</b>	<b>Oct</b>	<b>2003</b>	<b>CA (Sequoias)</b>	<b>16</b>	<b>Spinach</b>	<b>Salinas Valley, CA</b>
<b>18</b>	<b>Nov</b>	<b>2004</b>	<b>NJ</b>	<b>6</b>	<b>Lettuce</b>	<b>Salinas Valley, CA</b>
<b>19</b>	<b>Sep</b>	<b>2005</b>	<b>MN</b>	<b>11</b>	<b>Romaine mix w. veg.</b>	<b>Salinas Valley, CA</b>
<b>20</b>	<b>Aug-Sep</b>	<b>2006</b>	<b>26 states</b>	<b>&gt;200</b>	<b>Baby spinach, bagged</b>	<b>San Juan Valley, CA</b>
21	Nov	2006	NJ, NY, PA, DE	71	Iceberg lettuce (TB)	Central Valley, CA
22	Nov-Dec	2006	MN, IA, WI	81	Iceberg lettuce (TJ)	Central Valley, CA

Many in the US are  
wondering...

What's going on?

Has something changed?





Opening line of "East of Eden", by John Steinbeck:

"The Salinas Valley is in Northern California. It is a long swale between two ranges of mountains, and the Salinas River winds and twists up the center until it falls at last into Monterey Bay."



# Leafy Vegetable Production



- California-Arizona
  - **Salinas/Santa Maria valleys**
    - Temp: cool, to warm, to cool
    - Rainfall: 12-15 in, between Nov to Mar/Apr
    - **2-3 crops per year**
  - San Benito County
  - Huron (Central Valley)
  - Imperial Valley/Yuma, AZ (winter)
- **70-80% of the US supply**

Low incidence in the environment may  
be amplified and/or spread  
- How long does it survive in the  
environment?

One theory is that expansion of bagged  
salad industry may lead to an increase in  
cross-contamination of more product =  
more cases of *E. coli* O157:H7



# *E. coli* O157:H7 in the Environment

Islam et al, 2004, J Food Protection	<ul style="list-style-type: none"><li>• 154 to 217 d in soil amended with spiked compost</li><li>• 77 d on lettuce, 177 d on parsley</li></ul>
Mukherjee et al, 2006, J Appl Microbiol	<ul style="list-style-type: none"><li>• Child illness due to:<ul style="list-style-type: none"><li>- O157:H7 in garden soil fertilized with cow manure</li><li>- This “naturally occurring” strain survived &gt;69 days</li></ul></li></ul>

## *E. coli* O157:H7 in the Environment

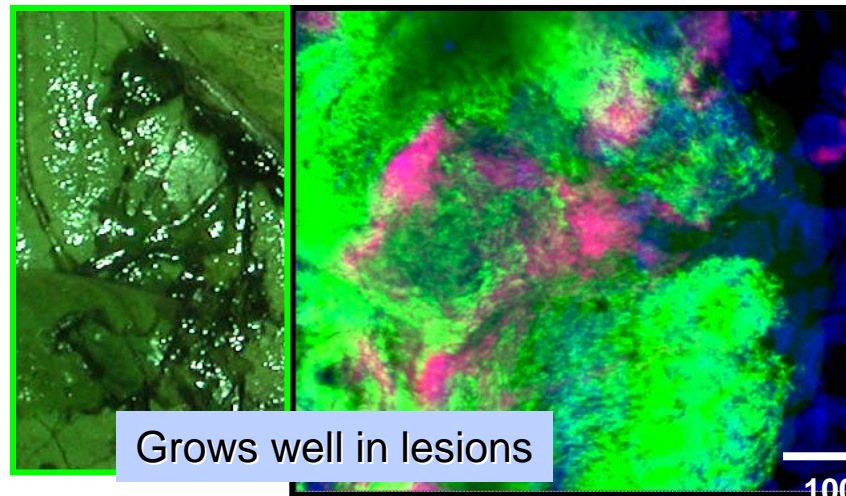
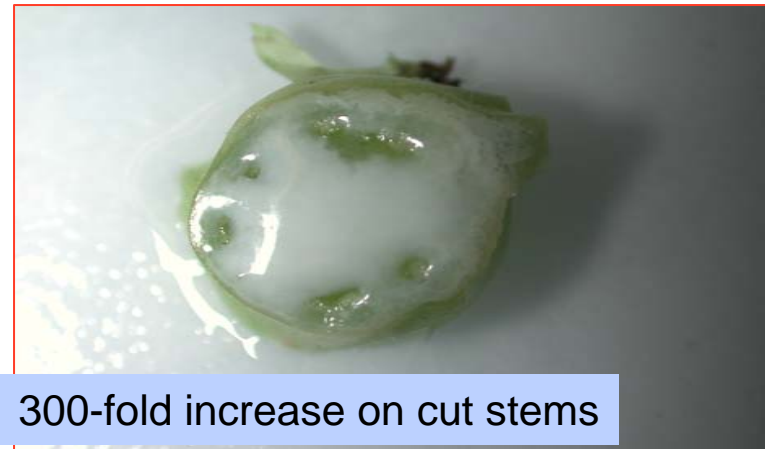
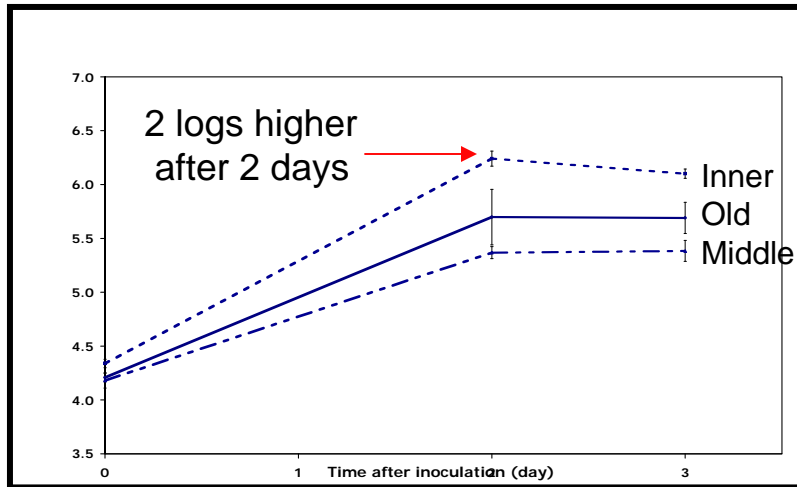
Elder et al, 2000, <i>Proc. Nat. Acad. Sci.</i>	<ul style="list-style-type: none"><li>• 28% in feces of cattle at slaughter</li><li>• ~50% on hides</li></ul>
LeJeune et al., 2006, <i>J. Clin. Microbiol.</i>	<ul style="list-style-type: none"><li>• Most cattle have &lt;100 CFU/g feces</li><li>• Some, &gt;10,000 CFU/g feces = “Super Shedders”</li><li>• These high shedders may be most important epidemiologically</li></ul>

What happens if enteric pathogens get on plants?

Do human pathogens survive and grow on or in produce?

# *E. coli* O157:H7 colonization of Romaine lettuce plants (growth chamber)

*M. Brandl, Appl. Environ. Microbiol. In press*



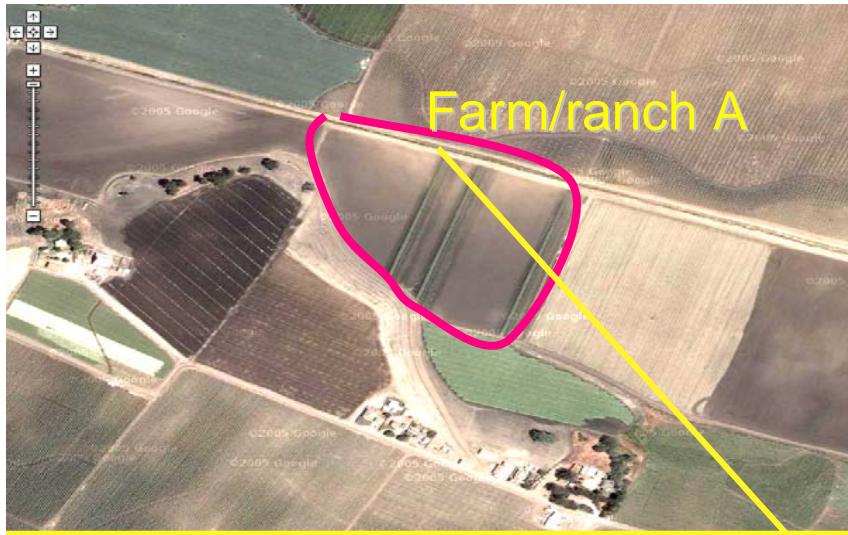
*Erwinia* (green) and  
*E. coli* O157 (pink)

Grows well in lesions

“Is the pathogen in the production environment?”

Identifying sources and transport of pathogens may assist in understanding how pre-harvest contamination of produce occurs

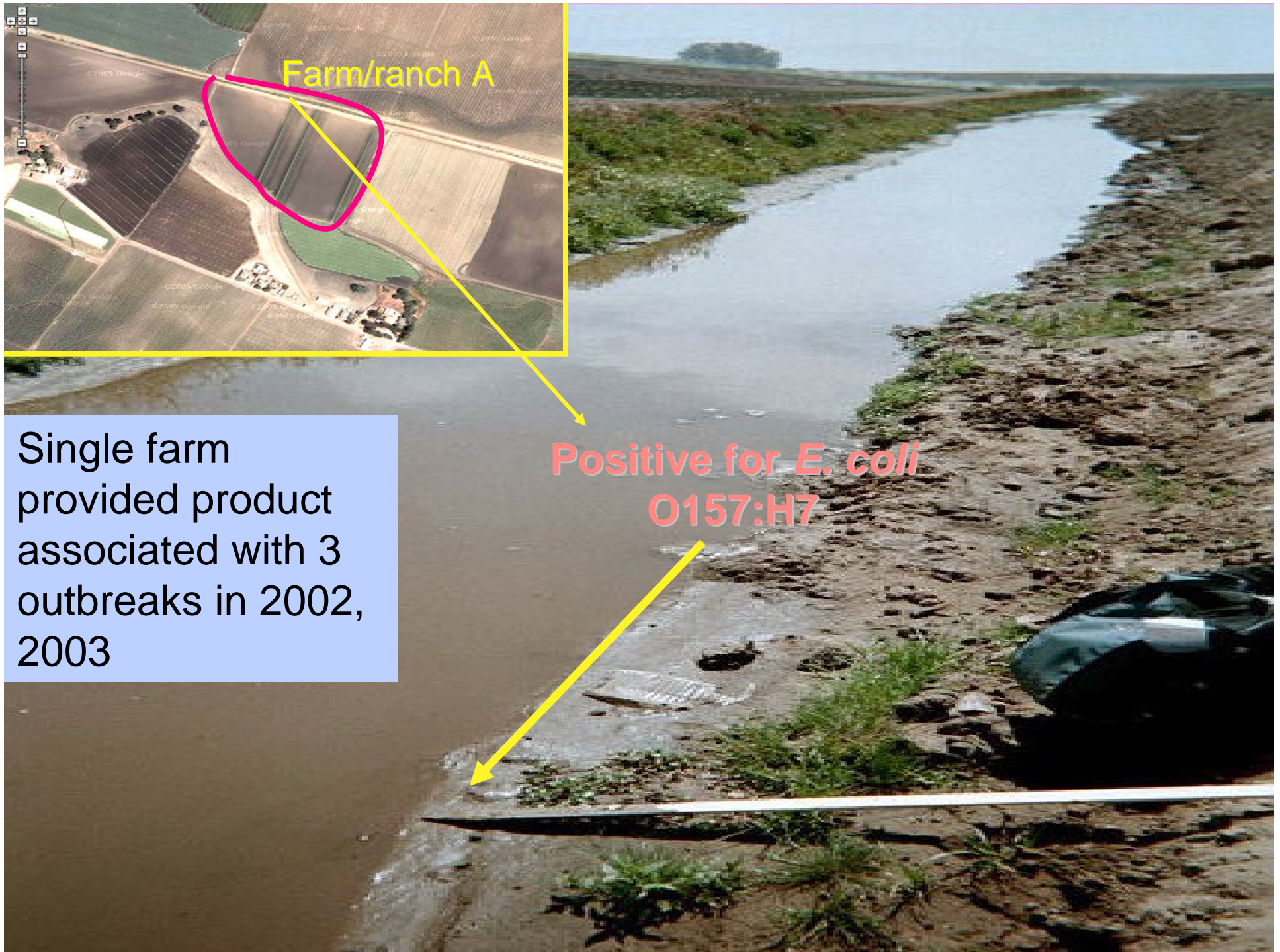




Farm/ranch A

Single farm  
provided product  
associated with 3  
outbreaks in 2002,  
2003

Positive for *E. coli*  
O157:H7



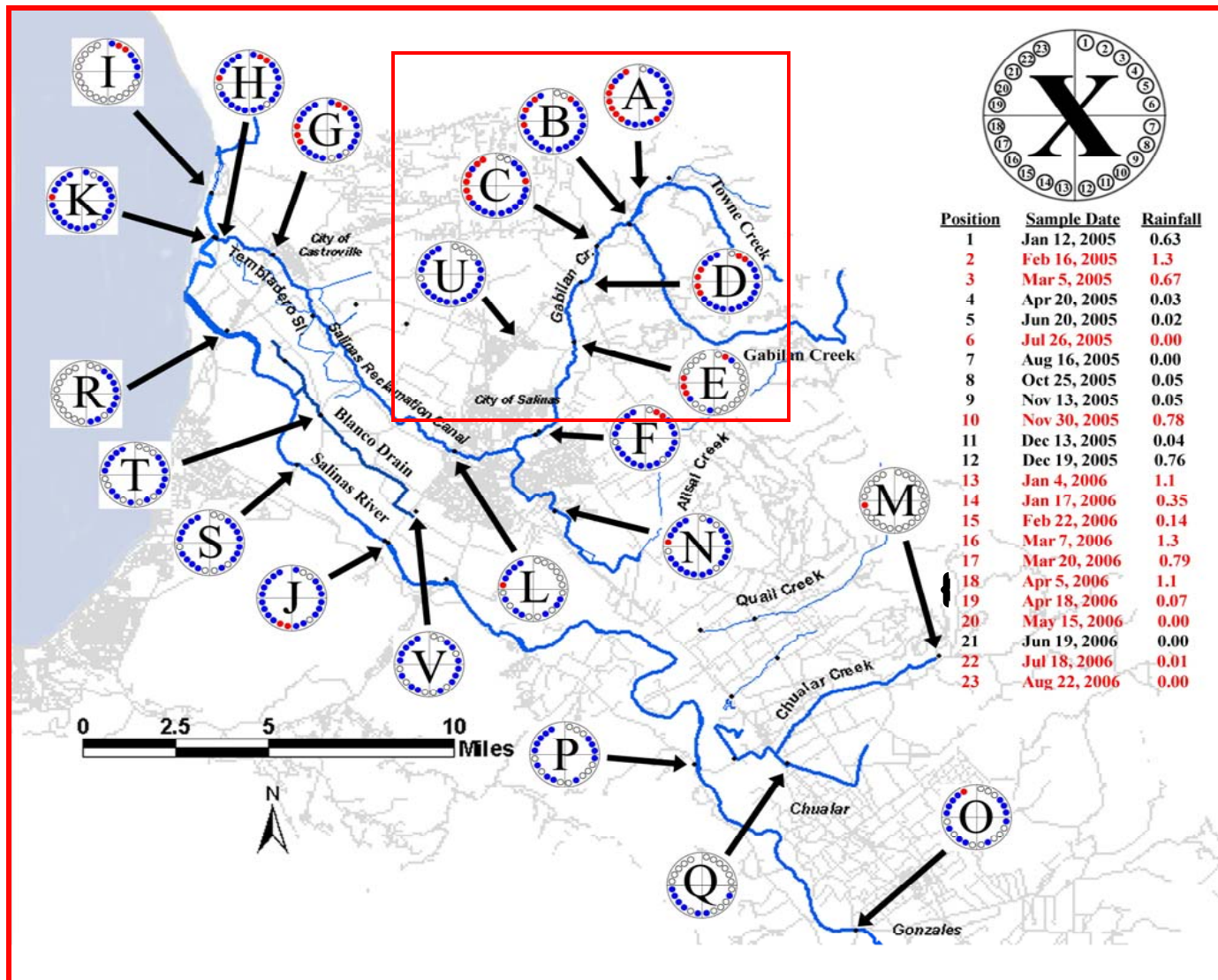
## *E.coli* O157:H7: Salinas Valley Watershed

- Study was expanded in coordination with CDPH and CCRWQCB (TMDL surveys)
- Jan-2005 to Sept-2006 (19 mo.)
- ~ 1200 samples analyzed for *E. coli* O157:H7

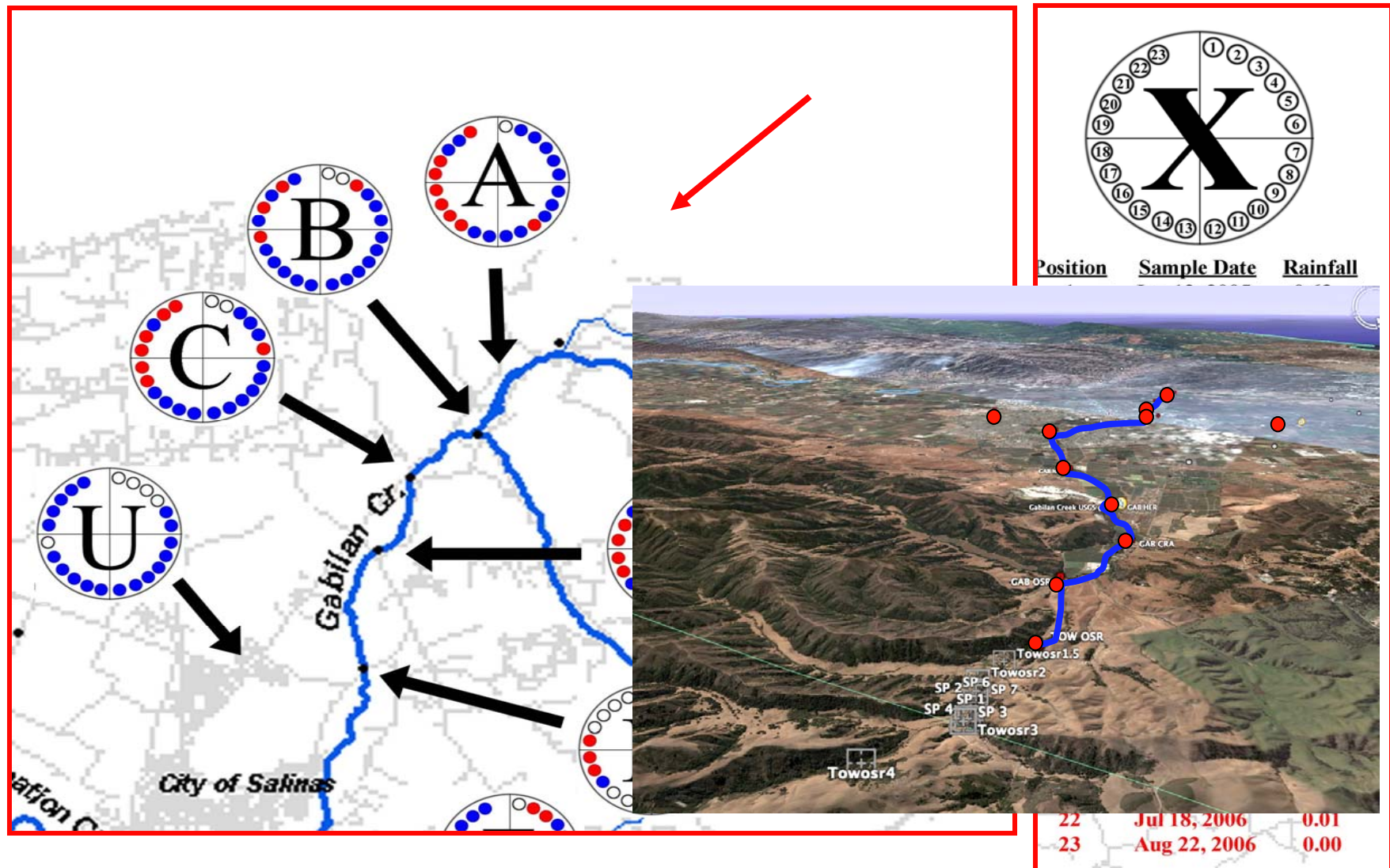




# Summary of results of isolation of *E.coli* O157:H7 from the Salinas Valley Watershed

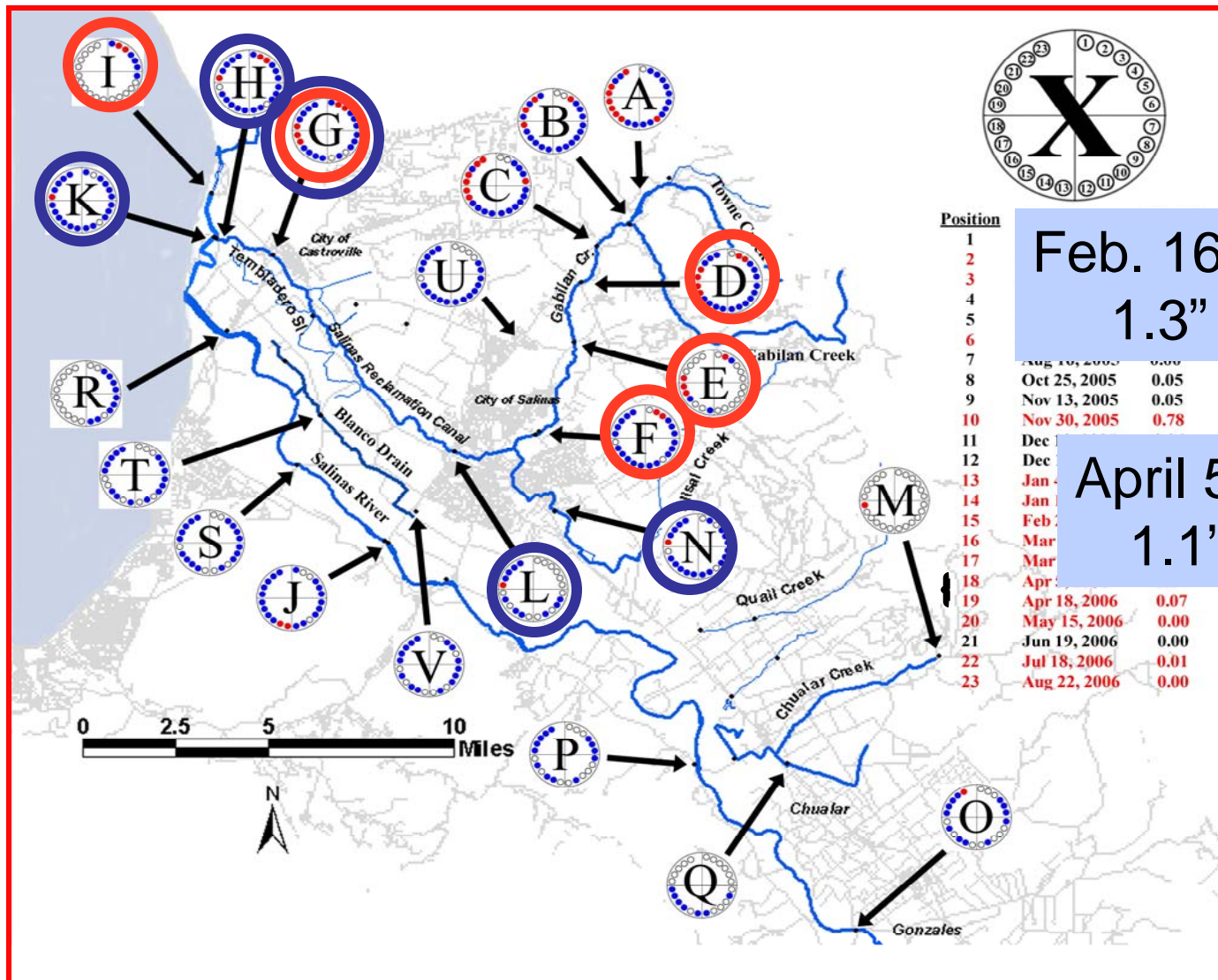


# Selected region of the watershed with frequent isolation of *EcO157*





- Feb. 16, 2005 samples: MLVA 2 strains
- April 18, 2006 samples: MLVA 100 strains



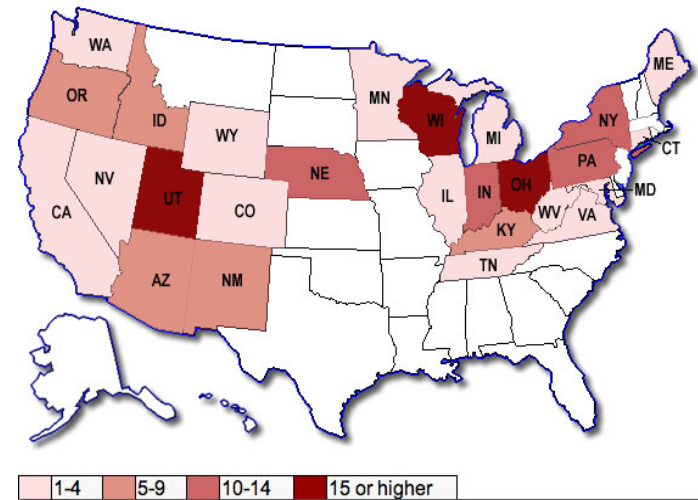
**Salinas Valley watershed  
sampling ended in Sept., 2006**

**Then...**

**The Spinach Outbreak** of  
Aug/Sep 2006

# Multi-State Outbreak of *E. coli* O157:H7 Infections From Fresh Spinach, October 6, 2006

- >200 illnesses
- 51% were hospitalized
- 16% developed hemolytic uremic syndrome
- 3 deaths



FDA-CFSAN, Oct. 6, 2006

- *E. coli* O157 was isolated from **13 packages** of spinach supplied by patients living in **10 states**
- Multi-agency (FDA, CDHS, USDA-ARS) investigation of the 4 farms and adjacent ranches was initiated: **>1500 samples tested**

# *E. coli* O157:H7 outbreak associated with consumption of spinach, 2006

(Addendum to CDPH-FDA “*E. coli* O157:H7 Spinach Report” May 7, 2007)

Farm	Samples	<i>E. coli</i> O157:H7 (% of total)
A	351	45/351 (13.5%); 28/45 match outbreak strain (62%)*
B	102	10/102 (9.8%); 0 match
C	132	1/132 (0.8%); 0 match
D	45	1/45 (2.2%); 0 match
Total	630	57/630 (9.0%)

\* Cattle (15), wild pig (8), water (4), dirt/soil (1).



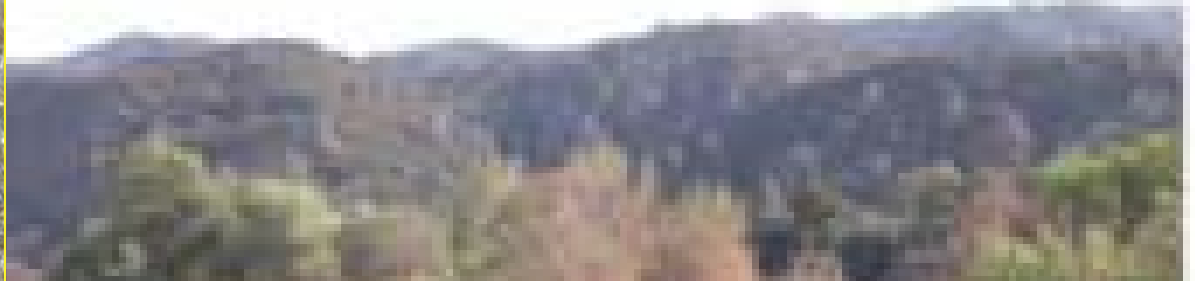


Table 2. Unique alphanumeric MLVA types of *Escherichia coli* O157:H7 isolated from environmental samples collected at ranch A and an upstream watershed, California, September–November 2006\*

Sample type	No. samples	No. isolates	MLVA type
Reference (human stool, bagged spinach)	NA	NA	<b>E</b>
Cattle feces	26	34	<b>A, C, E, F, I, J, L, M, P, Q, R, S, T, W, X, Z</b>
Feral swine feces	11	14	<b>A, B, C, E, L, O, P, X, 5, 6</b>
Feral swine colonic feces (necropsy)	2	10	<b>A, C, D, G, H, K, L, U, V, Y</b>
Sediment (river)	2	8	<b>A, C, L, M, N, W, 3</b>
Soil (cattle pasture)	1	1	<b>A</b>
Surface water	3	6	<b>A, C, L, P, 4</b>
Surface water Moore swab†	2	3	<b>1, 2</b>

\*MLVA, multilocus variable number tandem repeat analysis; NA, not applicable. Samples indistinguishable from the major spinach-related outbreak strain by pulsed-field gel electrophoresis (*Xba*I-*Bln*I PulseNet profile EXHX01.0124-EXHA26.0015) are shown in **boldface**.

†Isolates collected from surface water (river) ≈32 km upstream of ranch A.

# How do pathogens get to produce from watersheds?

- Wild animals
  - Which animals?
- Flooding
- Irrigation
  - Wells (defective, shallow)
  - Surface water
- Fertilizer/compost
- ??



# Prevention of *E. coli* on Food

- Pre-harvest approaches
  - Maintain water quality
  - Minimize exposure of produce to wild animals, flooding, dust
  - Treat livestock: vaccines, feed, novel antimicrobials
  - Observe/inspect, common sense
- Post-harvest approaches
  - Sampling and testing product, processing water
  - Effective “kill step” (new sanitizers, irradiation)
- No major outbreaks in 2007 associated with leafy vegetables!



New fencing for feral swine

# Acknowledgements

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