Selenium Concentrations in the Las Vegas Wash and Its tributary Waters

Xiaoping Zhou, Ph.D.

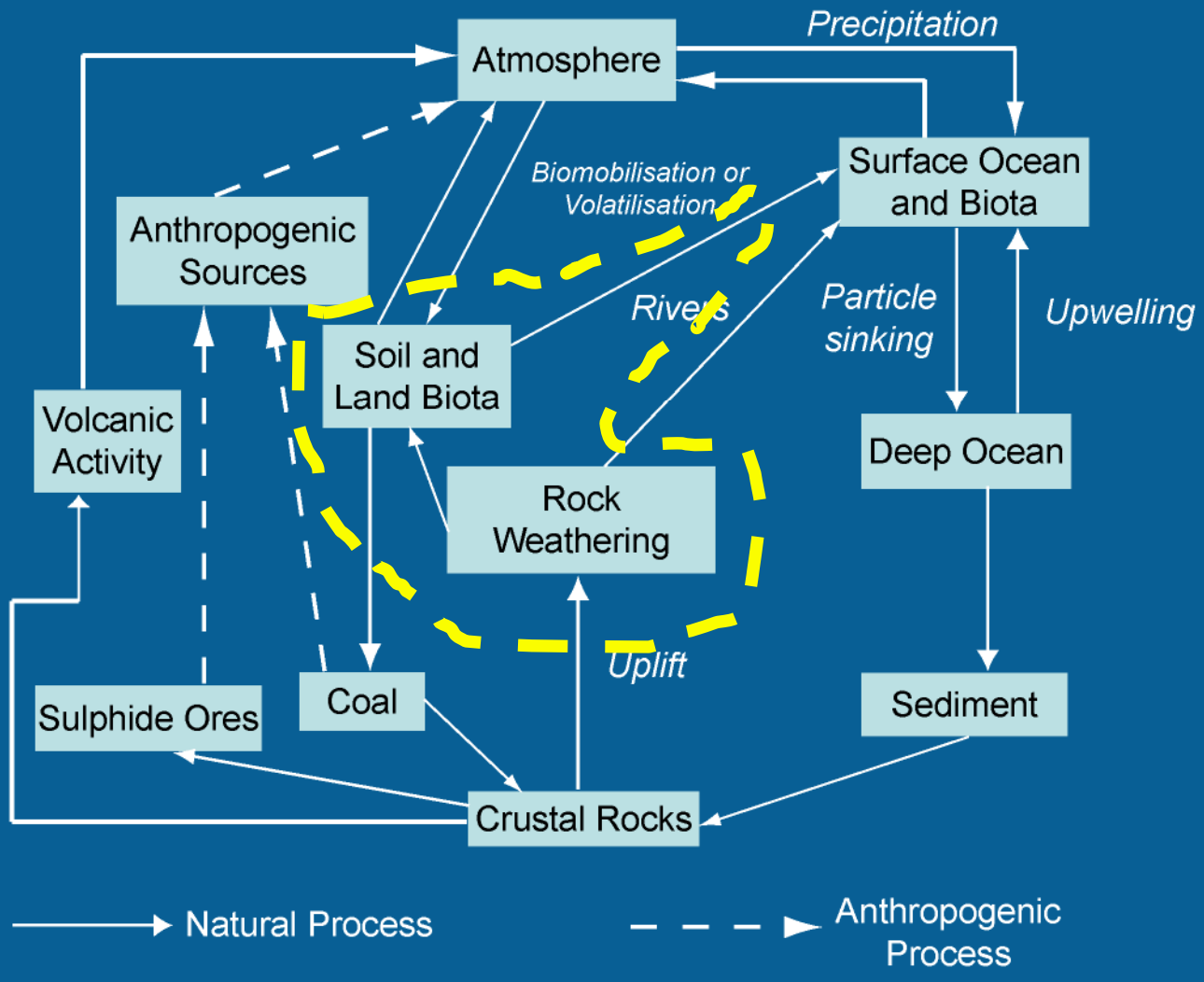
Southern Nevada Water Authority

May 20, 2008

Aquatic Criteria for Selenium

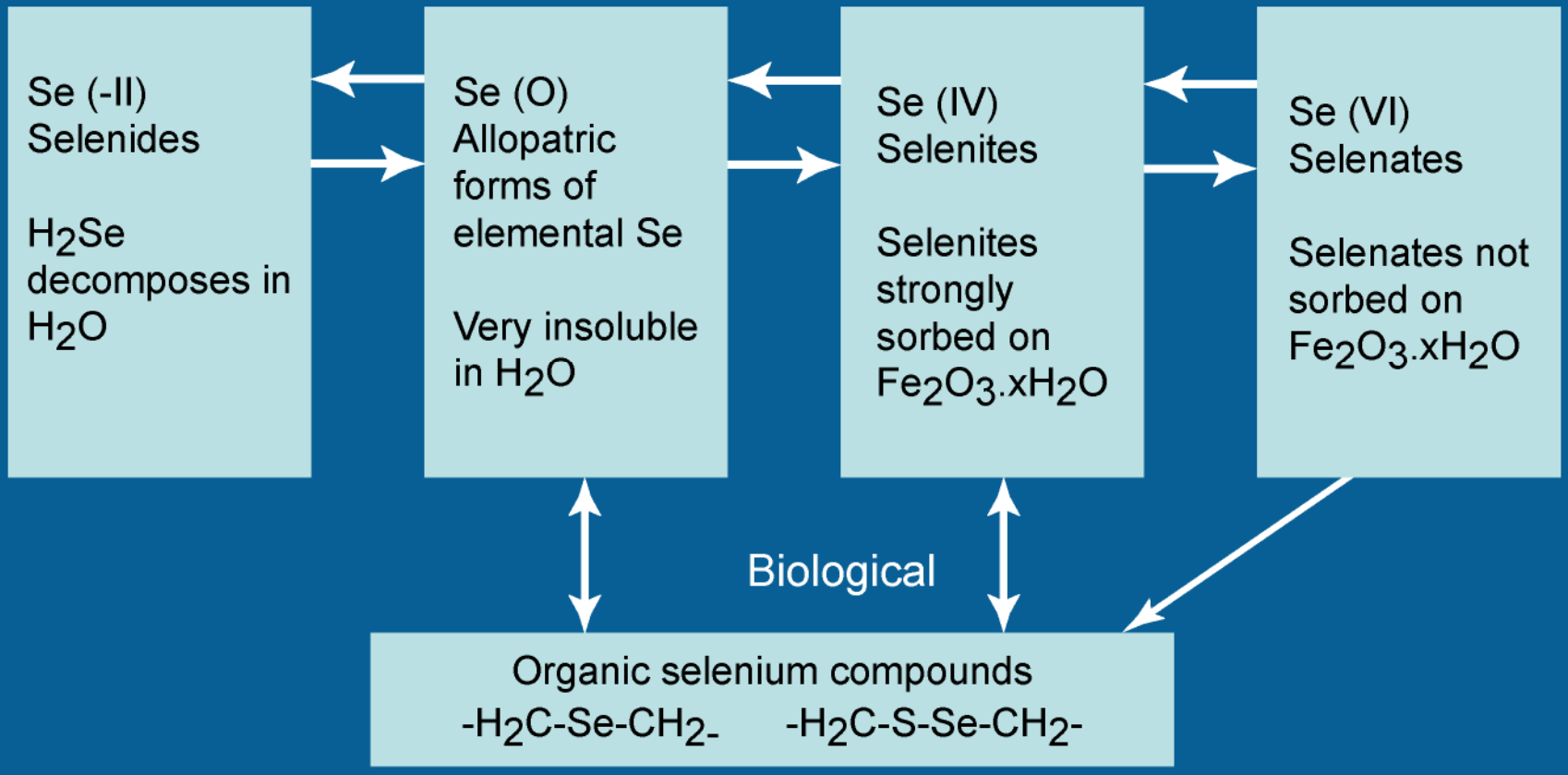
- **Freshwater Acute: 20 µg/L**
- **Freshwater Chronic: 5 µg/L**
- **Presently under reevaluation by EPA**

Selenium cycle



MacGregor et al., 1998

Selenium oxidation states



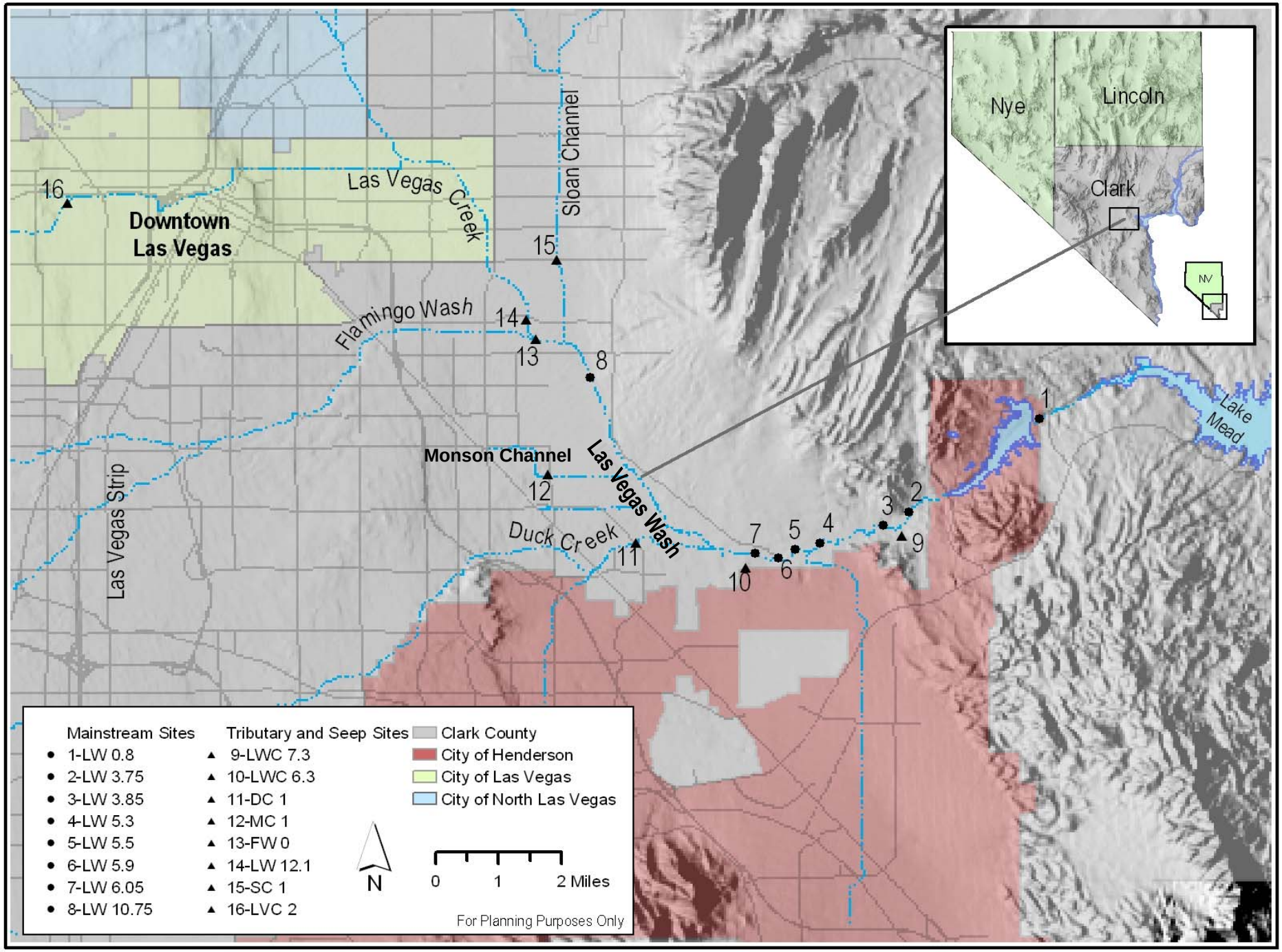
MacGregor et al., 1998

Selenium Sample Programs

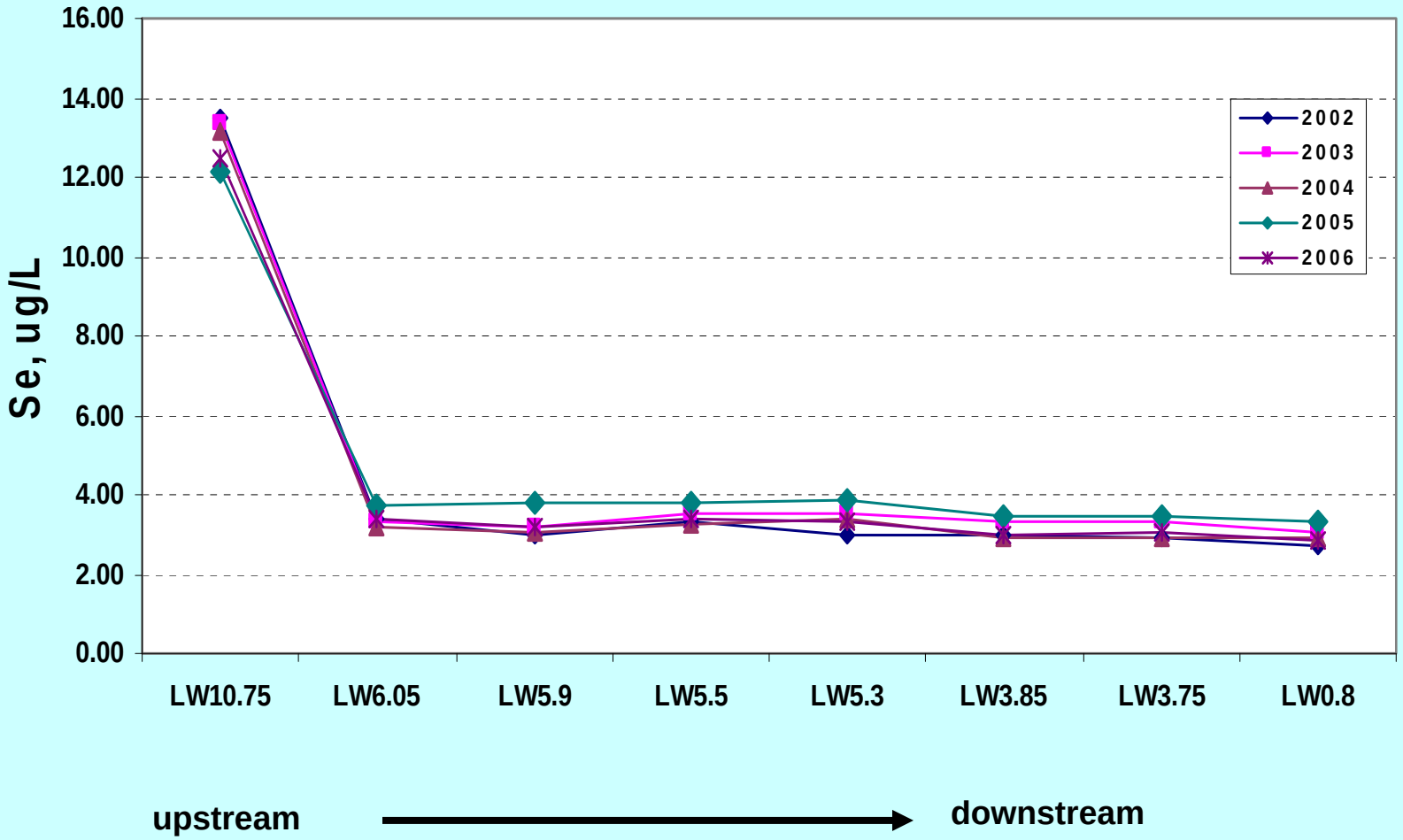
- **Sample sites:**
  - 8 sites in the Wash
  - 6 tributaries & 2 seeps
- **Sample frequency:**
  - monthly in the Wash
  - Quarterly in tributaries and seeps
- **Sample duration:**
  - 1/2002 – present
- **Sample collection:**
  - ultraclean bottles
  - acidification with HNO_3
  - cooled to 4^0C

Selenium Analysis

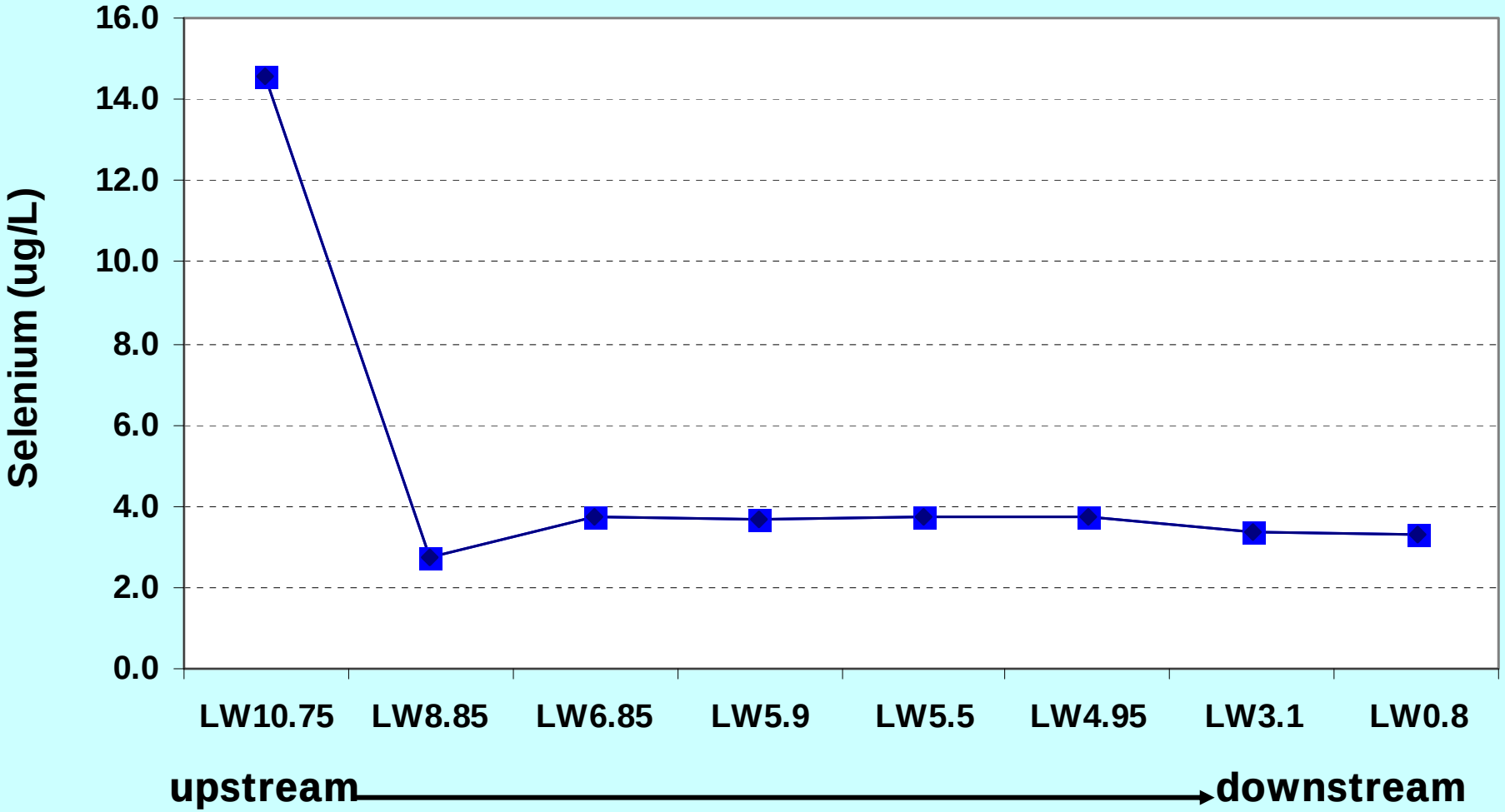
- **Analytical Methods:**
  - **HG-AFS method at Frontier**
  - **Fluorometric method at SDSU**
- **Detection Limits:**
  - **1 µg/L at Frontier**
  - **0.004 µg/L at SDSU**


Nye
Lincoln
Clark
NV
Las Vegas Creek
Sloan Channel
Downtown
Las Vegas
Flamingo Wash
Monson Channel
Las Vegas Wash
Duck Creek
Las Vegas Strip
Lake
Mead
16
15
14
13
8
12
11
10
9
7
6
5
4
3
2
1
Mainstream Sites
1-LW 0.8
2-LW 3.75
3-LW 3.85
4-LW 5.3
5-LW 5.5
6-LW 5.9
7-LW 6.05
8-LW 10.75
Tributary and Seep Sites
9-LWC 7.3
10-LWC 6.3
11-DC 1
12-MC 1
13-FW 0
14-LW 12.1
15-SC 1
16-LVC 2
Clark County
City of Henderson
City of Las Vegas
City of North Las Vegas
N
0
1
2 Miles
For Planning Purposes Only

Annual Average Selenium Concentrations in the Wash



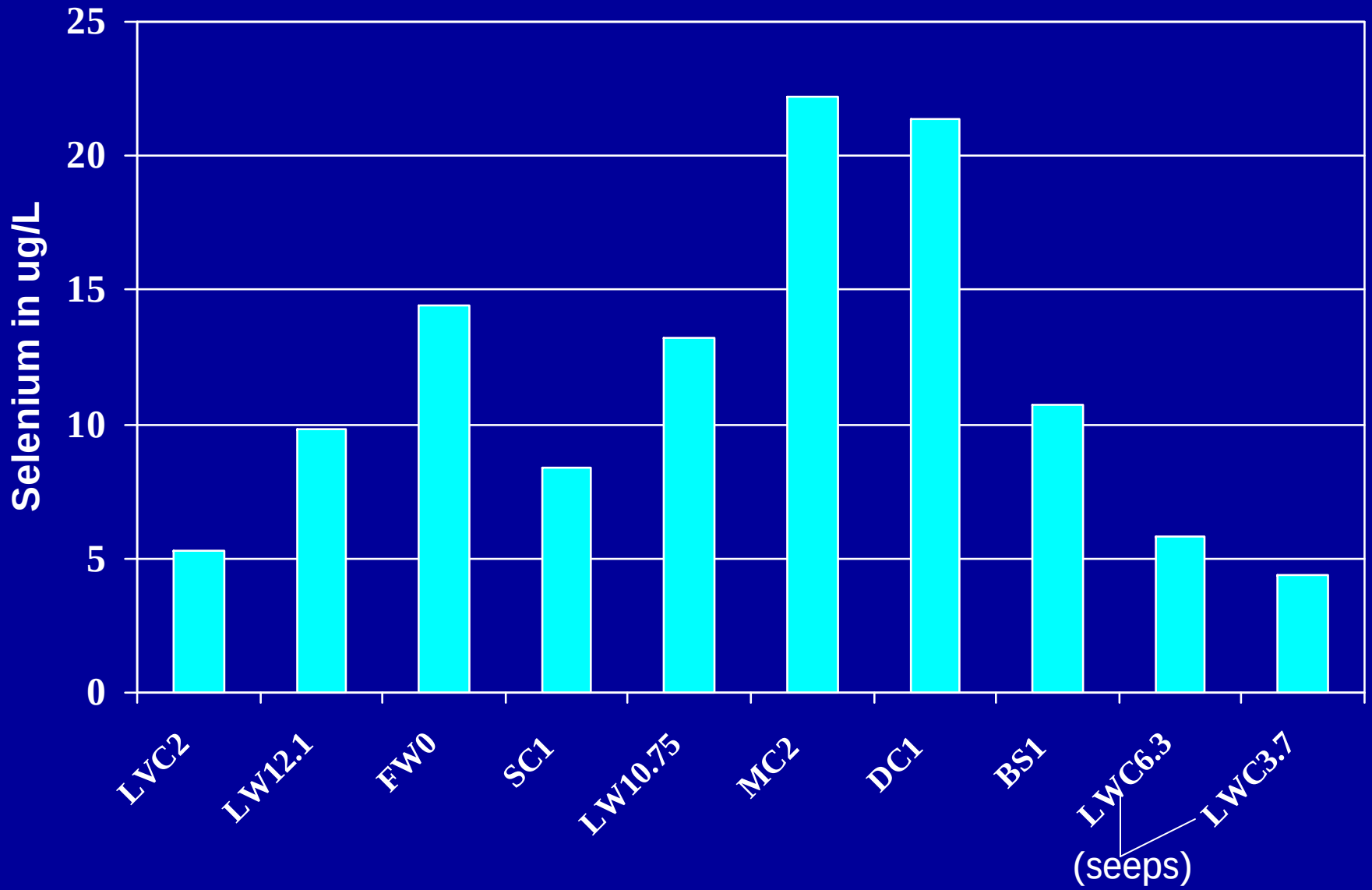
Average Selenium Concentrations in 2007



Selenium in the Mainstream Wash

- **Consistent levels from 2003-2008, (<4 µg/L)**
- **High selenium levels from tributary flows greatly diluted by wastewater effluent.**

Average Selenium Concentration for the Tributaries and Seeps to the Wash (2002-07)

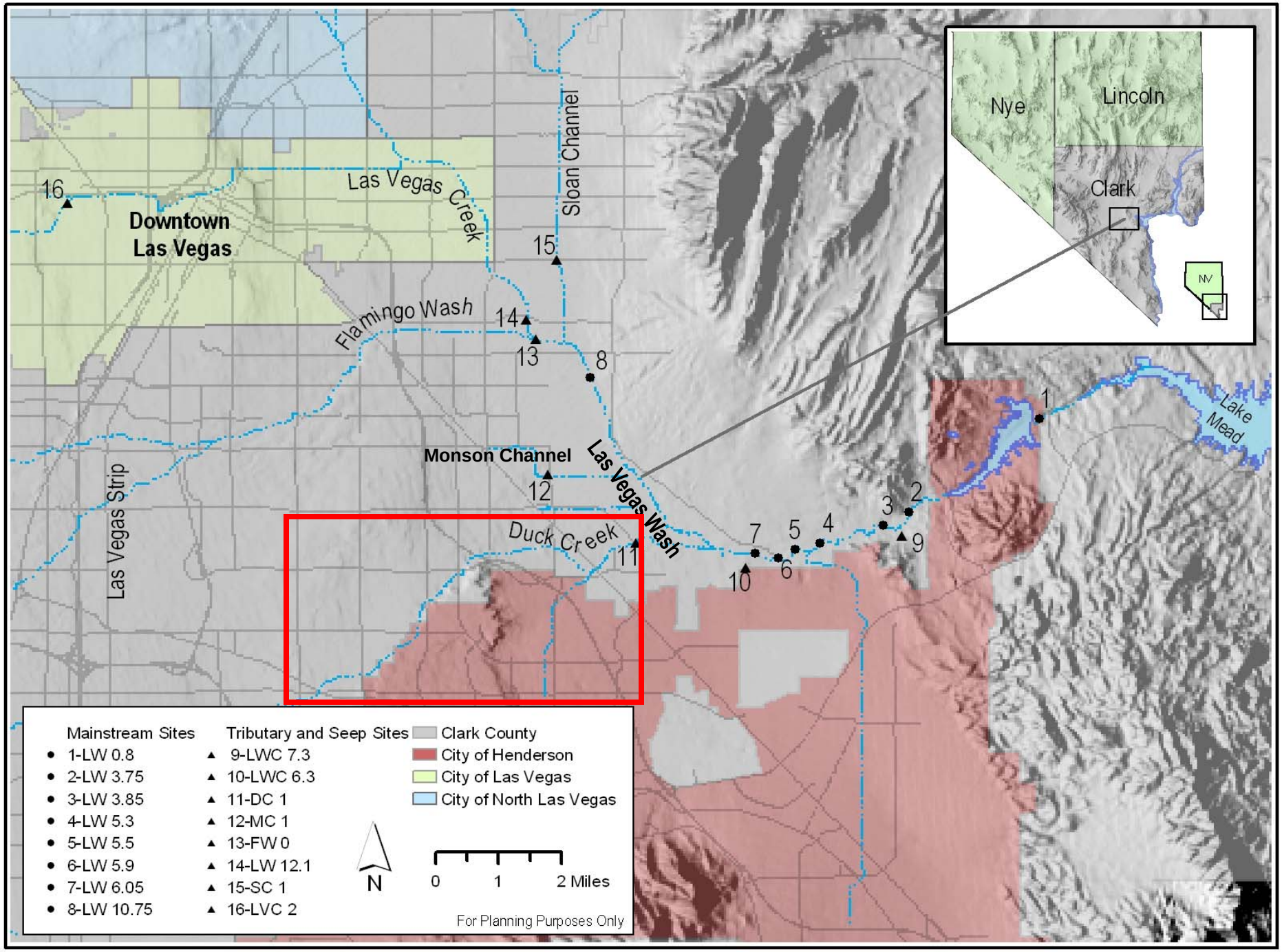


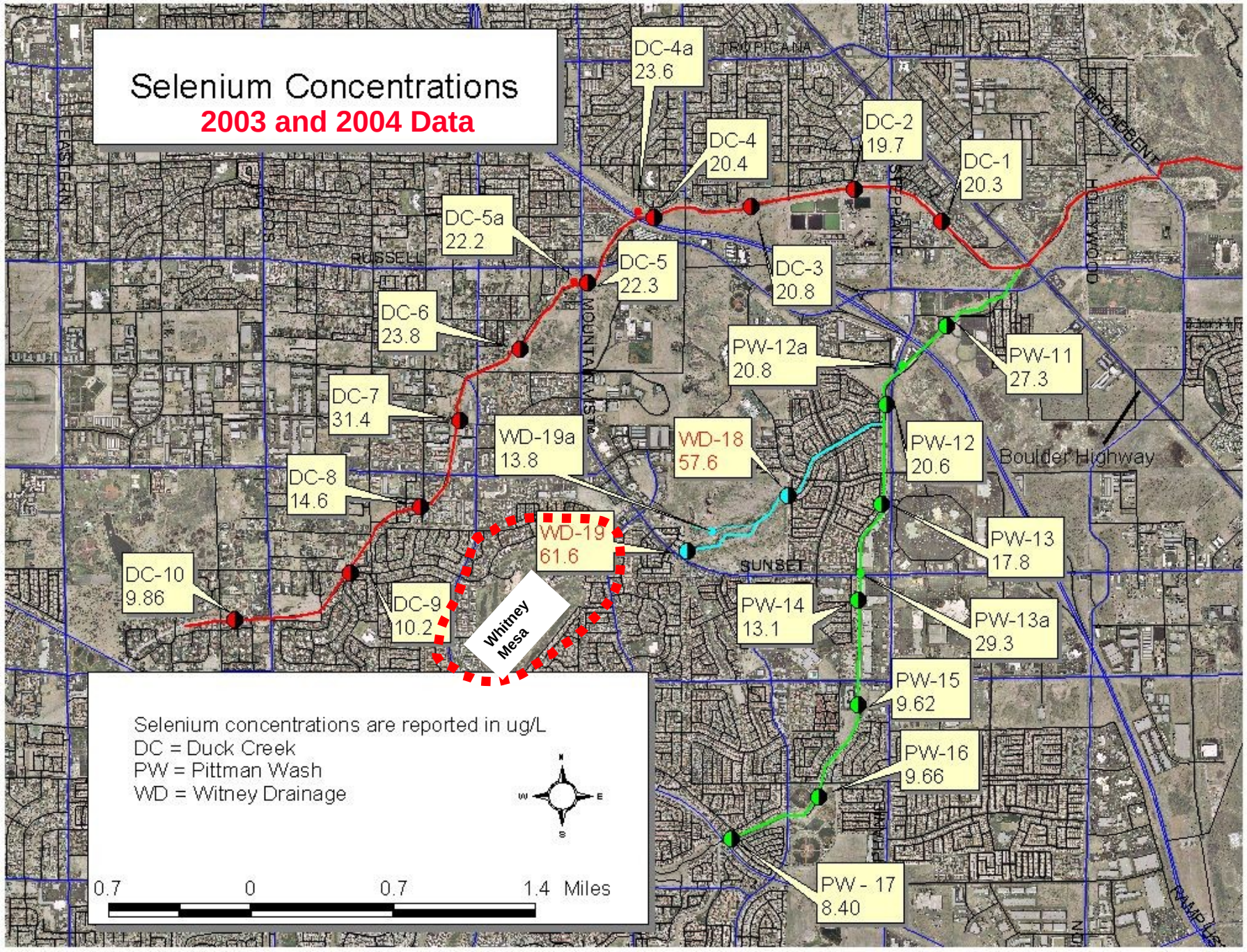
Selenium in Tributaries

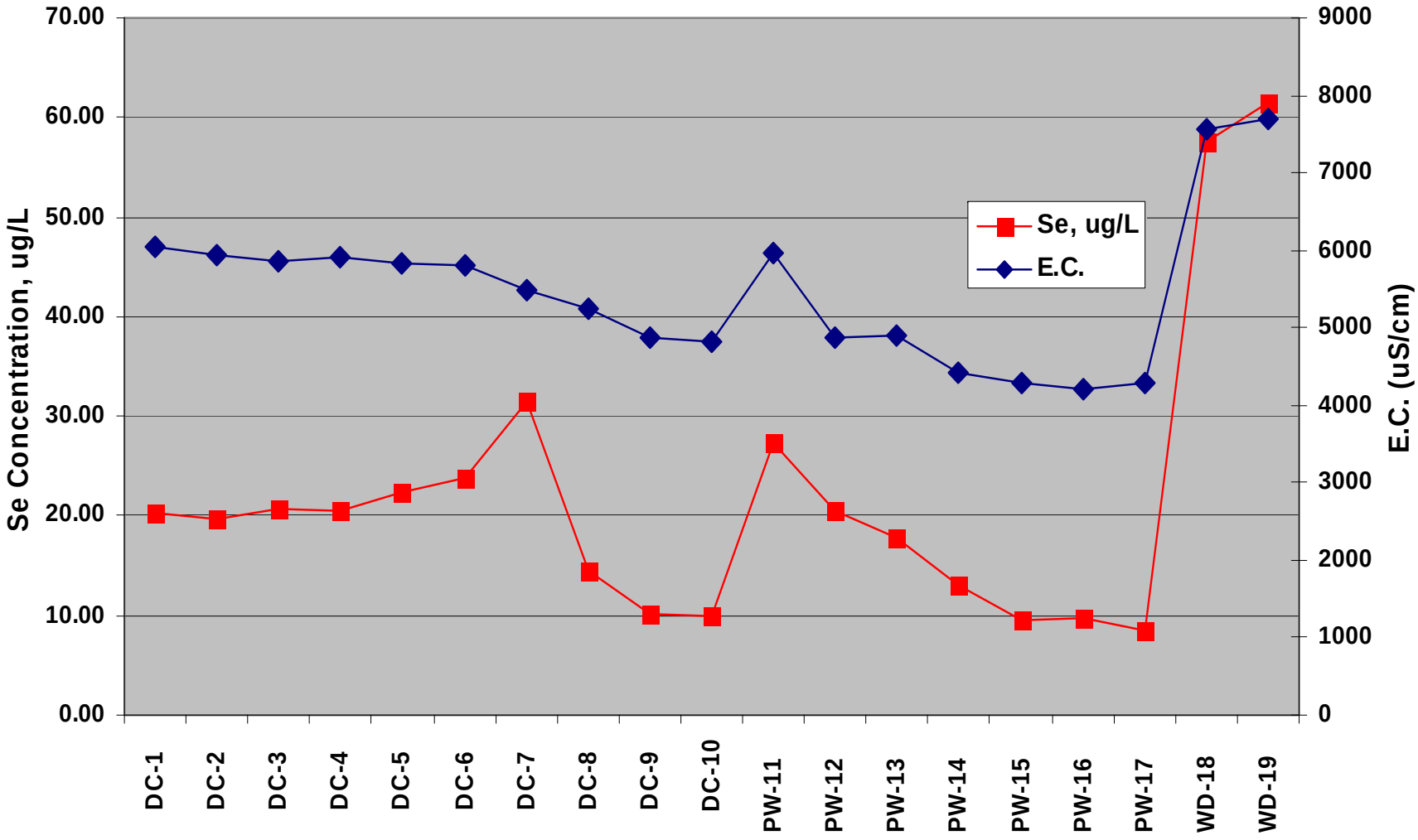
- Highest concentration from shallow groundwater and urban runoff
- Tributaries with high average selenium concentrations are Monson Channel (22.2 µg/L) and Duck Creek (21.4 µg/L)
- Average selenium level at LW10.75 is 13.2 µg/L

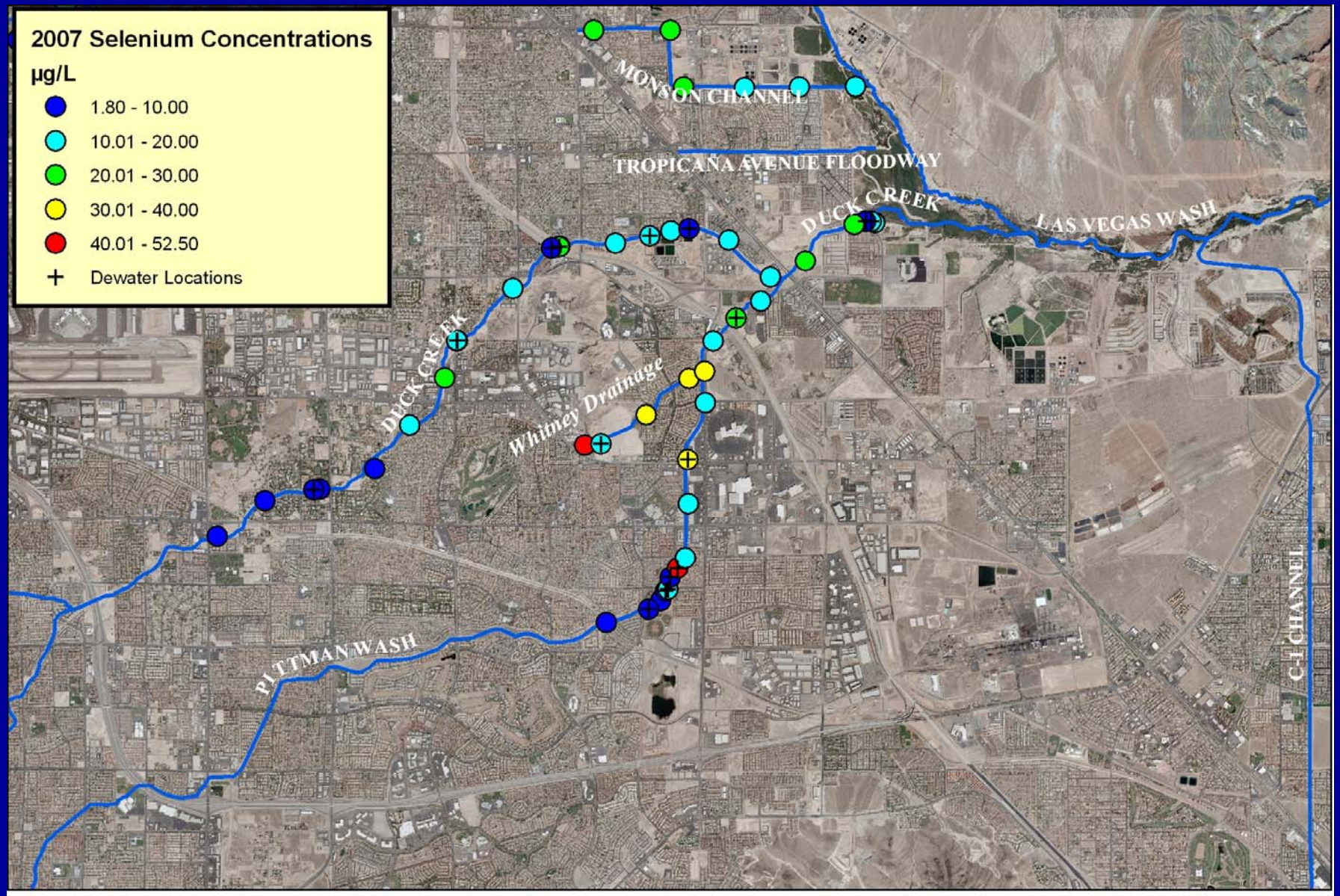
Extensive Selenium Sampling from Tributaries

- Purpose: Locate Se sources (Hot Spots)
- Sample Year: 2003, 2004, 2007, 2008
- One sample every ½ mile
- Plus samples from dewater pipes
- More than 200 samples collected
- Analyzed for Se (µg/L) by SDSU Lab.

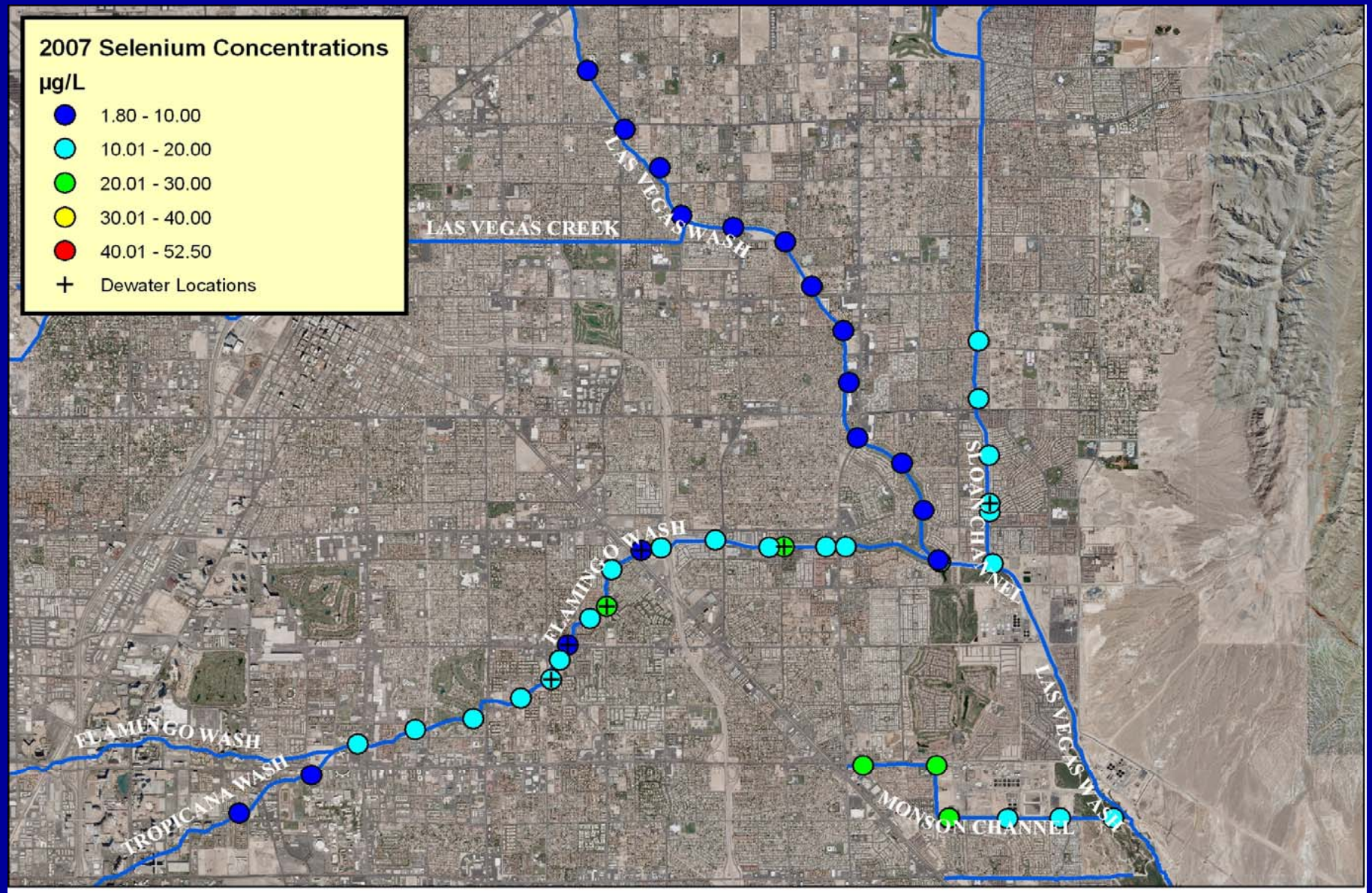

Nye
Lincoln
Clark
NV
Downtown
Las Vegas
Las Vegas Creek
Sloan Channel
Flamingo Wash
Monson Channel
Las Vegas Wash
Las Vegas Strip
Duck Creek
Lake
Mead
16
15
14
13
8
12
11
10
9
7
6
5
4
3
2
1
Mainstream Sites
1-LW 0.8
2-LW 3.75
3-LW 3.85
4-LW 5.3
5-LW 5.5
6-LW 5.9
7-LW 6.05
8-LW 10.75
Tributary and Seep Sites
9-LWC 7.3
10-LWC 6.3
11-DC 1
12-MC 1
13-FW 0
14-LW 12.1
15-SC 1
16-LVC 2
Clark County
City of Henderson
City of Las Vegas
City of North Las Vegas
N
0
1
2 Miles
For Planning Purposes Only


Selenium Concentrations
2003 and 2004 Data
DC-4a
23.6
DC-4
20.4
DC-2
19.7
DC-1
20.3
DC-5a
22.2
DC-5
22.3
DC-3
20.8
DC-6
23.8
PW-12a
20.8
PW-11
27.3
DC-7
31.4
WD-19a
13.8
WD-18
57.6
PW-12
20.6
DC-8
14.6
WD-19
61.6
PW-13
17.8
DC-10
9.86
DC-9
10.2
PW-14
13.1
PW-13a
29.3
PW-15
9.62
PW-16
9.66
PW - 17
8.40
Whitney Mesa
Boulder Highway
TROPICANA
BROADBENT
RUSSELL
SUNSET
Selenium concentrations are reported in ug/L
DC = Duck Creek
PW = Pittman Wash
WD = Witney Drainage
0.7
0
0.7
1.4 Miles

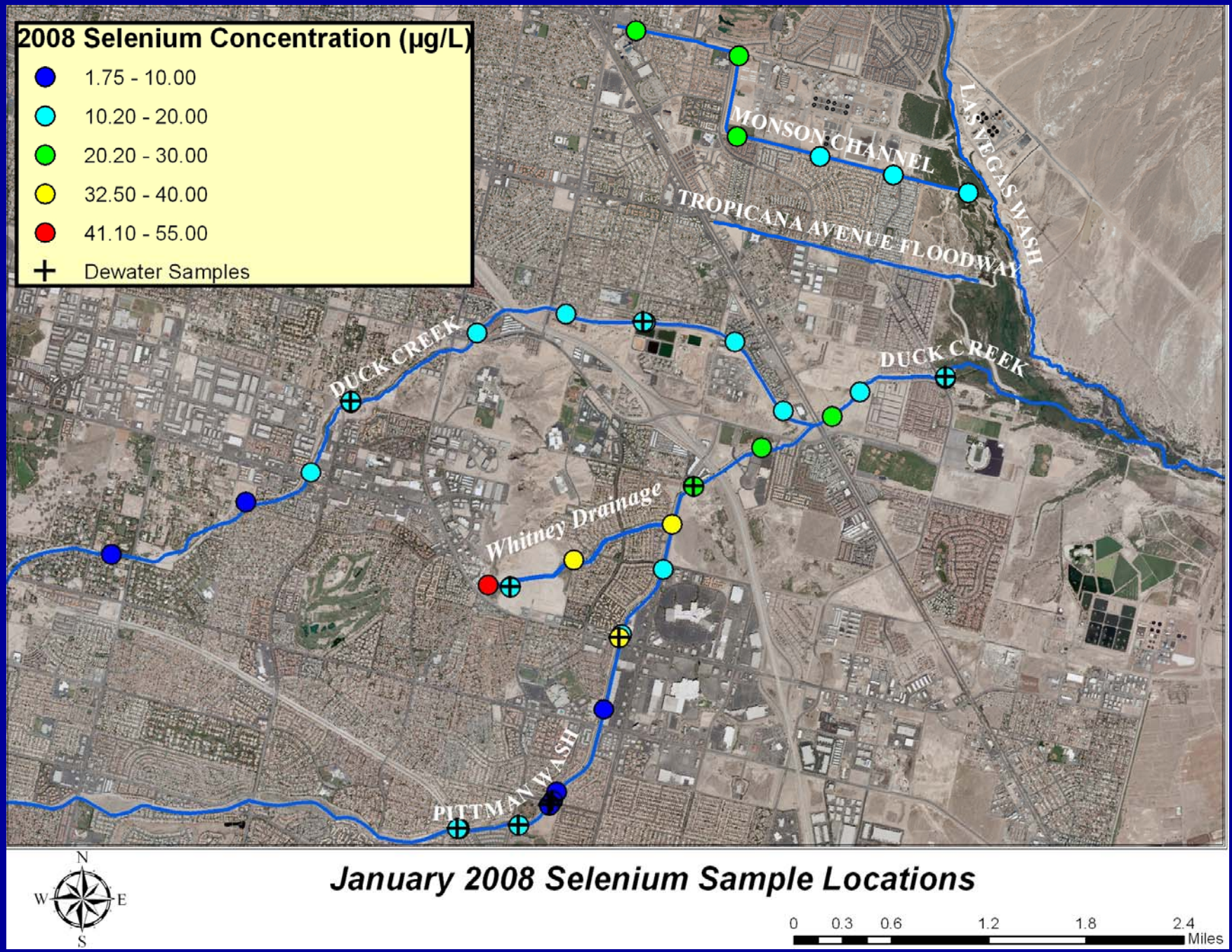

Se Concentrations and other parameters from DC, PW, and WD
Se Concentration, ug/L
E.C. (uS/cm)
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Se, ug/L
E.C.
DC-1
DC-2
DC-3
DC-4
DC-5
DC-6
DC-7
DC-8
DC-9
DC-10
PW-11
PW-12
PW-13
PW-14
PW-15
PW-16
PW-17
WD-18
WD-19



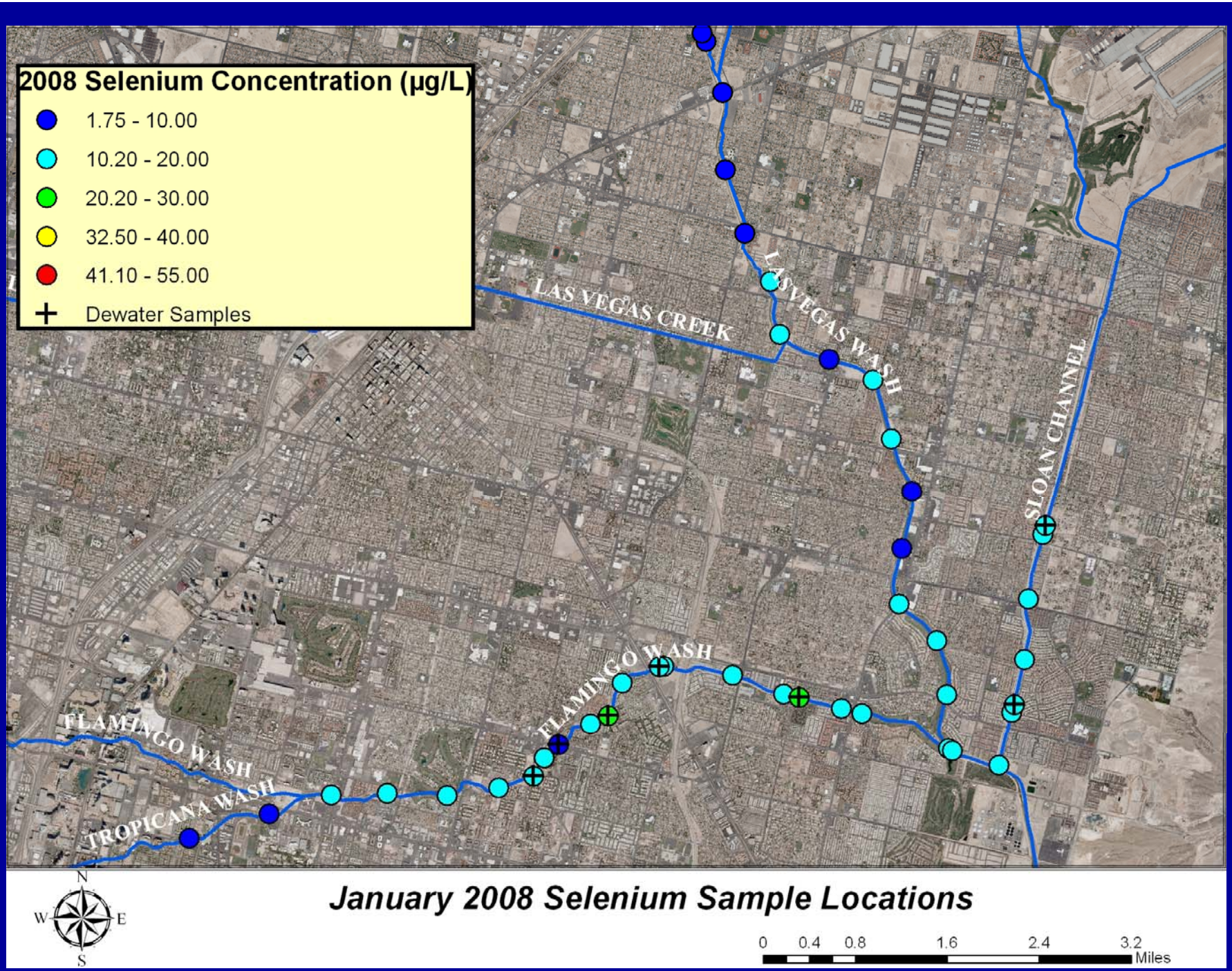
Fall 2007 Tributary Sampling Locations



Fall 2007 Tributary Sampling Locations



January 2008 Selenium Sample Locations



January 2008 Selenium Sample Locations

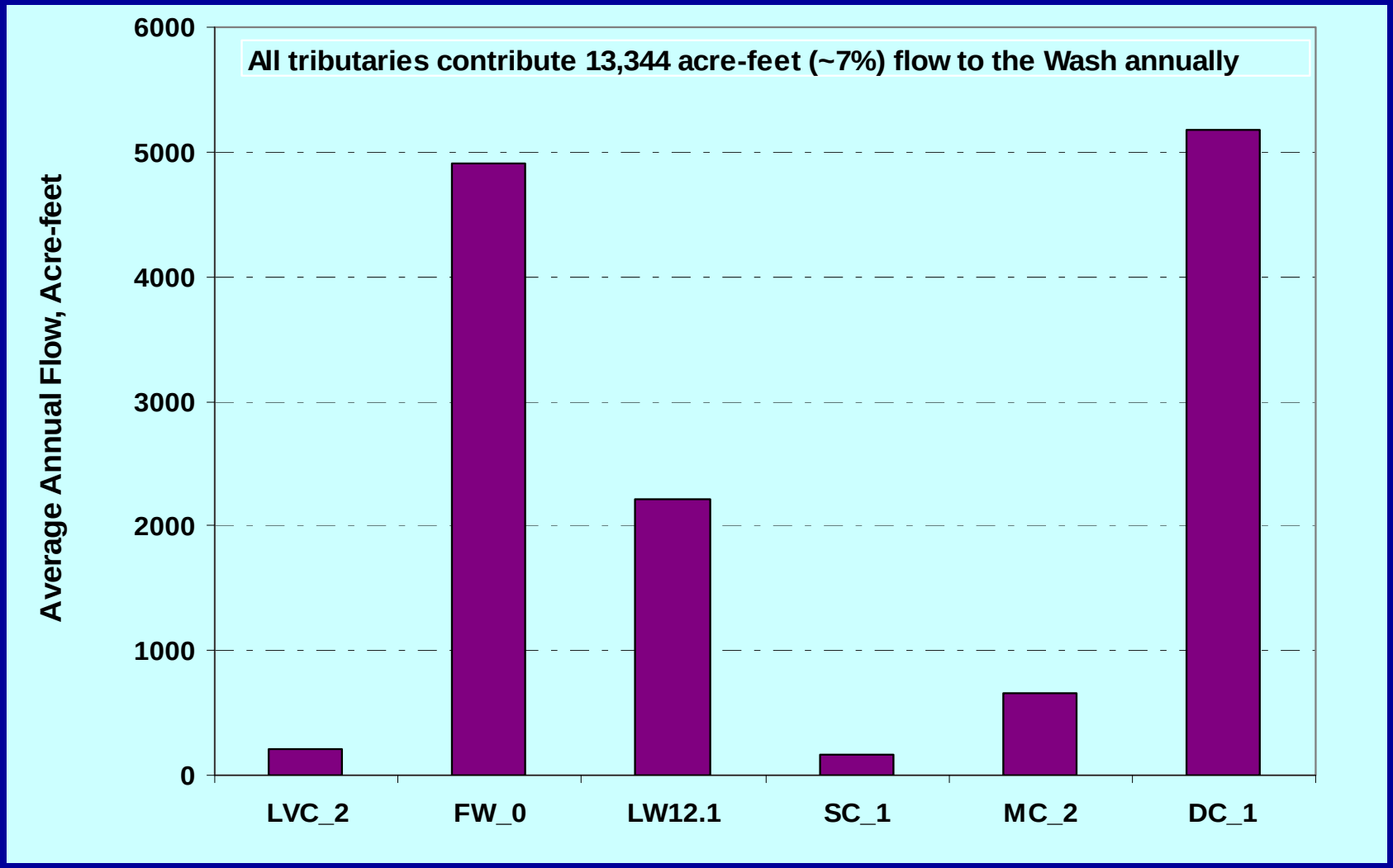
Se Speciation of Tributary and Wash Water

		IC-ICPMS Results			ICPMS Mass Balance
Sample ID	Preservative	Selenate	Selenocyanate	Selenite	Total Selenium
LW 10.75	Unpreserved	15.51	<1.0	<1.0	13.50
LW 10.75	Unpreserved	14.16	<1.0	<1.0	14.18
MC_1	Unpreserved	22.05	<1.0	<1.0	22.33
DC_1	Unpreserved	14.51	<1.0	<1.0	16.19
WD	Unpreserved	41.56	<1.0	<1.0	46.56
WD-Dup	Unpreserved	46.87	<1.0	<1.0	45.85
LW 0.8	Unpreserved	3.59	<1.0	<1.0	4.96
LW 10.75	Preserved- 0.1% (v/v)HCl	15.29	<1.0	<1.0	13.50
MC_1	Preserved- 0.1% (v/v)HCl	20.49	<1.0	<1.0	20.11
MC_1	Preserved- 0.1% (v/v)HCl	19.03	<1.0	<1.0	20.26
DC_1	Preserved- 0.1% (v/v)HCl	13.75	<1.0	<1.0	14.92
WD	Preserved- 0.1% (v/v)HCl	46.71	<1.0	<1.0	43.53
WD-Dup	Preserved- 0.1% (v/v)HCl	37.59	<1.0	<1.0	41.38
LW 0.8	Preserved- 0.1% (v/v)HCl	3.00	<1.0	<1.0	3.37

Flow Rate Determinations

- From 6 tributaries to the Wash:
  - 18.6 cfs (12 MGD)
  - ~13,000 AF/yr
  - ~7% of the total flow of the Wash
- From the Wash to Lake Mead:
  - ~255 cfs (165 MGD)

Average Annual Flow (AF) from Six Tributaries to the Las Vegas Wash



Yearly Se Mass Loading Rate (lbs/yr)

= Se Concentration (μg/L) x 10^{-3}

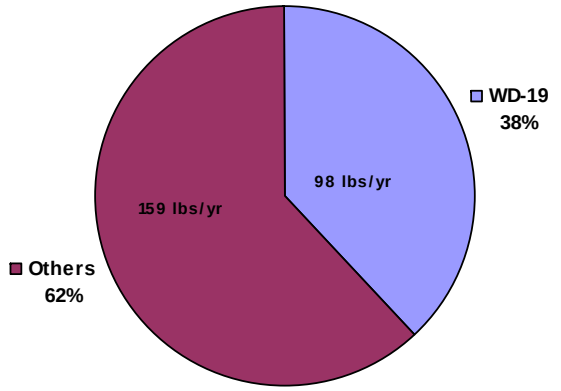
x Flow Rate (cfs) x 0.6463

x 8.34 x 365 (days/yr)

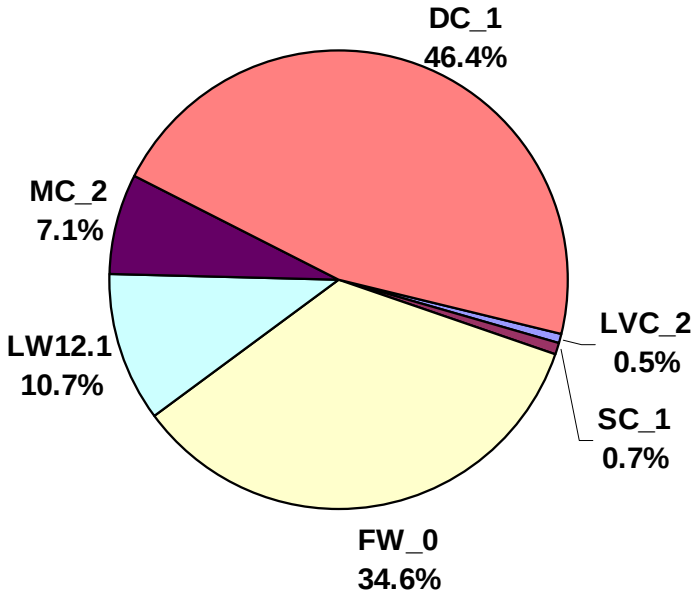
Relative Percentage of Yearly Se Mass Loading

(Based on 2002-07 Data)

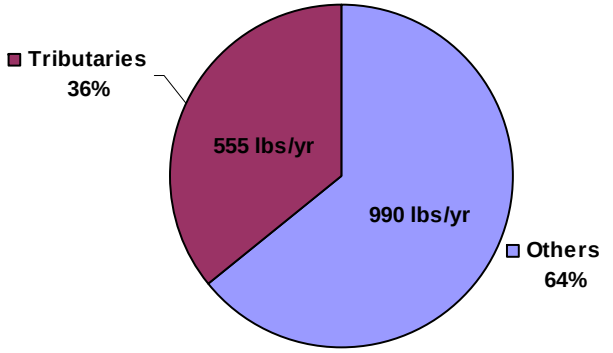
Total yearly Se loading from Duck Creek to the Wash = 257 lbs/yr



Total yearly Se loading from six trubutaries to the Wash = 555 lbs/yr



Total yearly Se loading from the Wash to Lake Mead = 1545 lbs/yr

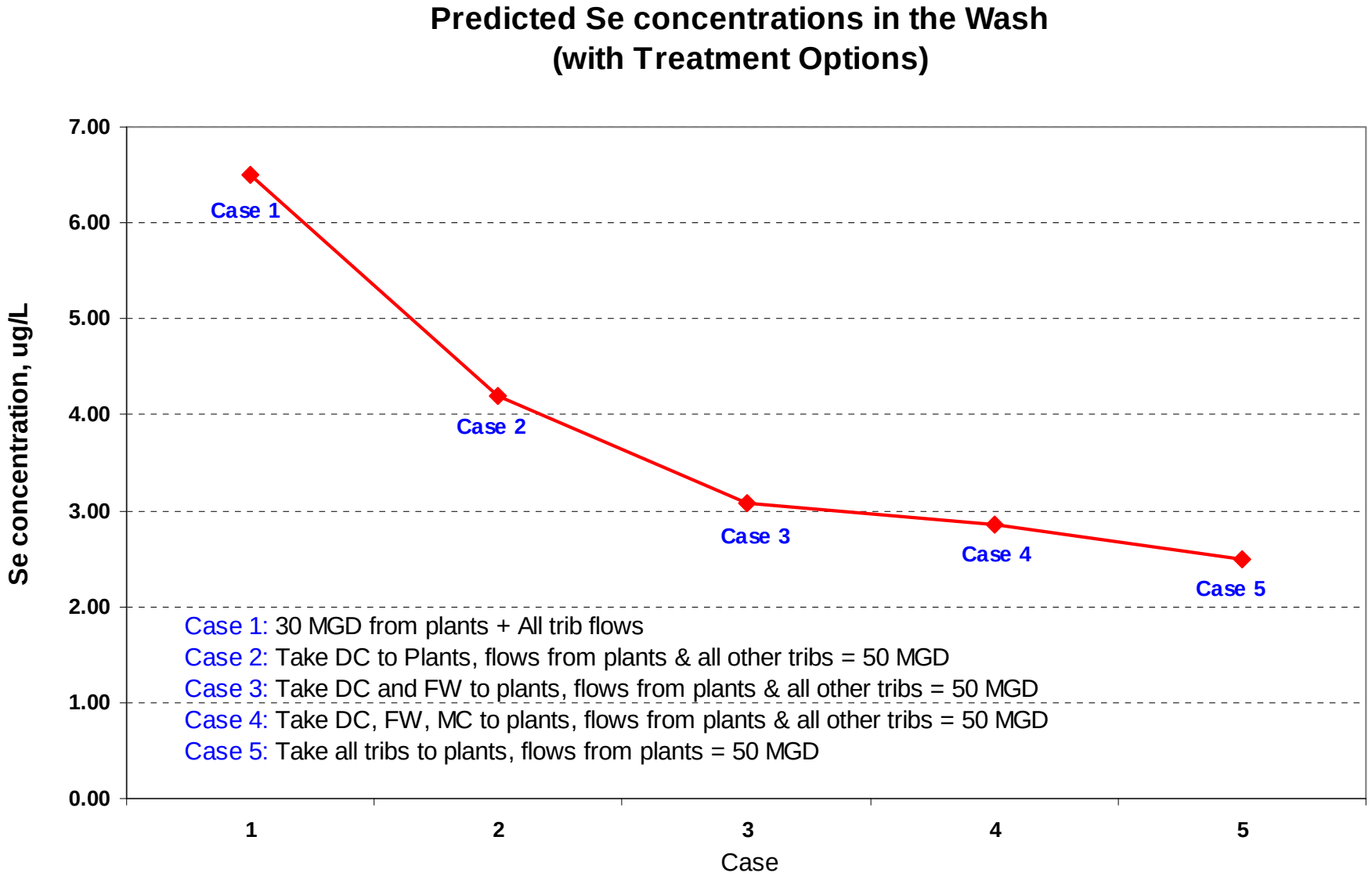


Summary

- **Se in the mainstream Wash: < 4 µg/L**
- **Se from most tributaries: > 5 µg/L**
- **Hot spot: DC (WD) (40 - 62 µg/L)**
- **Se Mass Loading Calculations:**
  - **From Wash to Lake Mead: 1545 lbs/yr**
  - **Tributaries / Wash: 36%**
  - **Duck Creek / Tributaries: 46.4%**
  - **Whitney Drainage / Duck Creek: 38%**

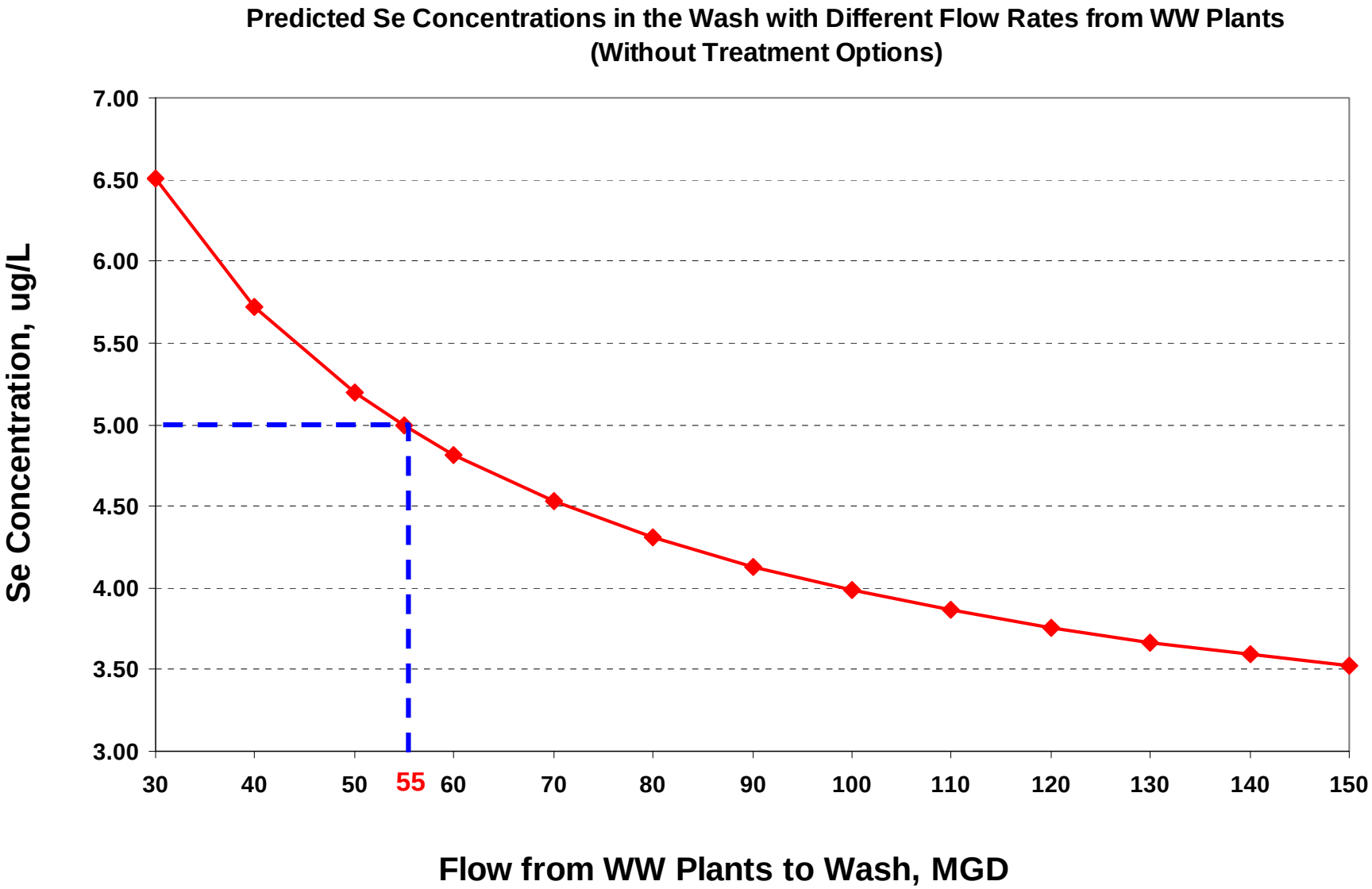
Predicted Se concentrations in the Wash (with Treatment Options)

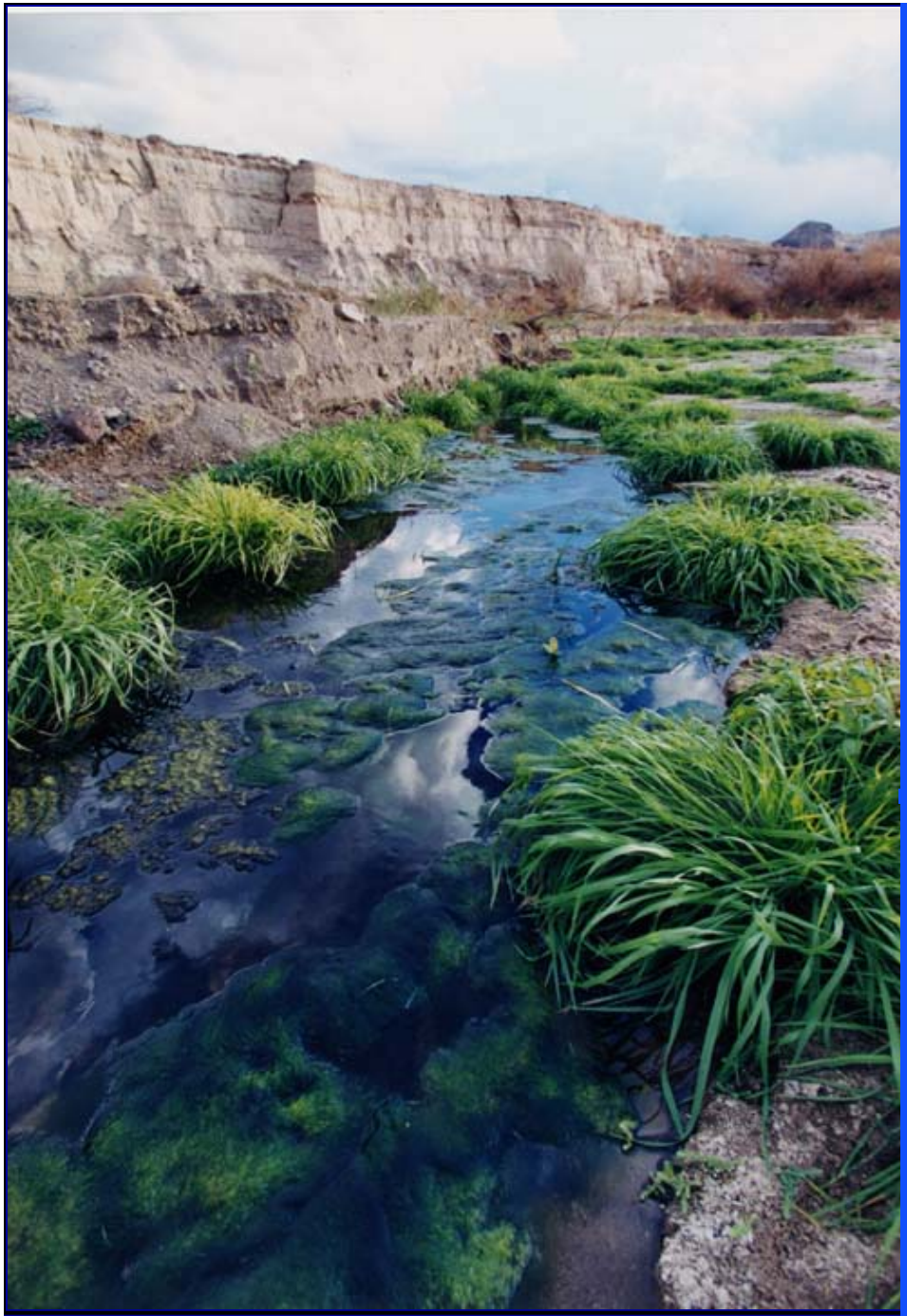
	LVC_2	SC_1	FW_0	LW12.1	MC_2	DC_1	3 Plants		
Average Flow Rate (cfs)	0.3	0.2	6.8	3.1	0.9	6.1	232.0		
Average Flow Rate (MGD)	0.2	0.2	4.4	2.0	0.6	4.0	150		
Average Se Concentration (ug/L)	4.8	7.3	15.2	10.7	22.4	22.8	2.5		
Se loading rate (lbs/day)	0.01	0.01	0.56	0.18	0.11	0.75	3.13		
Total Se loading to Lake Mead (lbs/day)				**4.74**					
Flow to the Wash	**Tributary flow (MGD)**	**3 plant influent (MGD)**	**Se in effluent (ug/L)**	**Flow from plant to Wash (MGD)**	**Se in the Wash (ug/L)**	**Flow from plant to Lake Mead (MGD)**	**Loading from plant to Lake (lbs/day)**	**Loading from wash to Lake (lbs/day)**	**Total Se loading to Lake (lbs/day)**
Case 1. 30 MGD from plants + Tribs	11.3	150	2.50	30.0	**6.50**	120.0	2.50	2.24	4.74
Case 2. Take DC to the plant	7.3	154	2.50	42.7	**4.20**	111.2	2.32	1.75	4.07
case 3. Take DC and FW to the Plant	2.9	158	2.50	47.1	**3.08**	111.2	2.32	1.28	3.60
Case 4. Take DC, FW, and MC to the Plant	2.3	159	2.50	47.7	**2.85**	111.2	2.32	1.19	3.51
Case 5. Take all tributaries to the Plant	0.0	161	2.50	50.0	**2.50**	111.2	2.32	1.04	3.36


Predicted Se concentrations in the Wash
(with Treatment Options)
Se concentration, ug/L
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Case 1
Case 2
Case 3
Case 4
Case 5
Case 1: 30 MGD from plants + All trib flows
Case 2: Take DC to Plants, flows from plants & all other tribs = 50 MGD
Case 3: Take DC and FW to plants, flows from plants & all other tribs = 50 MGD
Case 4: Take DC, FW, MC to plants, flows from plants & all other tribs = 50 MGD
Case 5: Take all tribs to plants, flows from plants = 50 MGD
1
2
3
4
5
Case

Predicted Se Concentrations in the Wash with Different Flow Rates from WW Plants (Without Treatment Options)

	LVC_2	SC_1	FW_0	LW12.1	MC_2	DC_1	3 Plants		
Average Flow Rate (cfs)	0.3	0.2	6.8	3.1	0.9	6.1	232.0		
Average Flow Rate (MGD)	0.2	0.2	4.4	2.0	0.6	4.0	150		
Average Se Concentration (ug/L)	4.8	7.3	15.2	10.7	22.4	22.8	2.5		
Se loading rate (lbs/day)	0.01	0.01	0.56	0.18	0.11	0.75	3.13		
Total Se loading to Lake Mead (lbs/day)				**4.74**					
Flow to the Wash, MGD	**Tributary flow (MGD)**	**3 plant influent (MGD)**	**Se in effluent (ug/L)**	**Flow from plant to Wash (MGD)**	**Se in the Wash (ug/L)**	**Flow from plant to Lake Mead (MGD)**	**Loading from plant to Lake (lbs/day)**	**Loading from wash to Lake (lbs/day)**	**Total Se loading to Lake (lbs/day)**
30+Tribs	11.3	150	2.50	30.0	**6.50**	119.9	2.50	2.24	4.74
40+Tribs	11.3	150	2.50	40.0	**5.72**	110.0	2.29	2.45	4.74
50+Tribs	11.3	150	2.50	50.0	**5.20**	100.0	2.09	2.65	4.74
55+Tribs	11.3	150	2.50	55.0	**4.99**	95.0	1.98	2.76	4.74
60+Tribs	11.3	150	2.50	60.0	**4.82**	90.0	1.88	2.86	4.74
70+Tribs	11.3	150	2.50	70.0	**4.53**	80.0	1.67	3.07	4.74
80+Tribs	11.3	150	2.50	80.0	**4.31**	70.0	1.46	3.28	4.74
90+Tribs	11.3	150	2.50	90.0	**4.13**	60.0	1.25	3.49	4.74
100+Tribs	11.3	150	2.50	100.0	**3.98**	50.0	1.04	3.70	4.74
110+Tribs	11.3	150	2.50	110.0	**3.86**	40.0	0.83	3.91	4.74
120+Tribs	11.3	150	2.50	120.0	**3.76**	30.0	0.63	4.11	4.74
130+Tribs	11.3	150	2.50	130.0	**3.67**	20.0	0.42	4.32	4.74
140+Tribs	11.3	150	2.50	140.0	**3.59**	10.0	0.21	4.53	4.74
150+Tribs	11.3	150	2.50	150.0	**3.52**	0.0	0.00	4.74	4.74


Predicted Se Concentrations in the Wash with Different Flow Rates from WW Plants
(Without Treatment Options)
Se Concentration, ug/L
7.00
6.50
6.00
5.50
5.00
4.50
4.00
3.50
3.00
30
40
50
55
60
70
80
90
100
110
120
130
140
150
Flow from WW Plants to Wash, MGD



Questions?