Groundwater at the Rocky Flats Site

Part 3

October 27, 2014

Rocky Flats Stewardship Council

U.S. DEPARTMENT OF ENERGY | Legacy Management

Agenda

- Summary of previous Part 1 and Part 2 groundwater presentations
- Part 3: Overview of groundwater treatment systems at Rocky Flats
- See slides from Part 2 presentation for previous briefing on treatment systems
- Part 3 provides additional depth

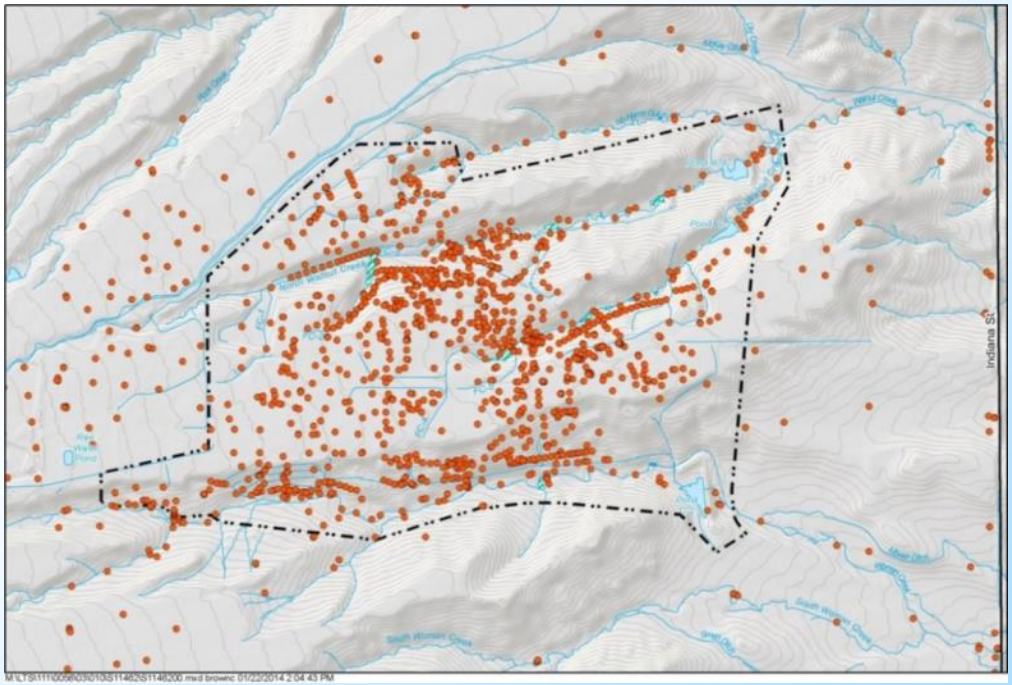
Summary of Groundwater Presentation, Part 1

- Geology
  - Predominantly low-permeability materials overlying lower-permeability claystone bedrock
  - Deeper units (regional aquifers) are separated by hundreds of feet of dense claystone
- Semiarid climate
  - 12 to 15 inches of precipitation per year
    - Only 1 to 2 inches recharges the groundwater, the rest is lost to evapotranspiration (ET)
- Groundwater
  - Movement controlled by bedrock surface
    - Similar to ground surface topography
  - Flow moves west to east, diverting toward drainages and discharging to surface water

➢ ***We monitor the groundwater to watch for threats to surface water***

Summary of Groundwater Presentation, Part 1 (continued)

- Upper hydrostratigraphic unit (UHSU) – shallow; past operations impacted groundwater in some areas
- Lower hydrostratigraphic unit (LHSU) – deeper; hydraulically isolated from UHSU
- Over 1,400 wells and hundreds of boreholes installed since the 1950s to characterize the site



Historic wells within and nearest the Central Operable Unit (COU)

Summary of Groundwater Presentation, Part 2

- Groundwater monitoring network design
  - Locations, frequencies, analytical suites defined via data, modeling, numerous stakeholder meetings
  - Target: Areas of known contamination
- Groundwater treated at four locations
- *Rocky Flats Legacy Management Agreement* (RFLMA) data evaluation protocols
  - Attachment 2 includes decision flowcharts

Rocky Flats Groundwater, Part 3: Treatment Systems

Some repeat from "Part 2" presentation, which also addressed treatment systems

- Treatment systems in the *Corrective Action Decision/Record of Decision for Rocky Flats* (CAD/ROD) were originally designed to **reduce contaminant load** reaching surface water
- RFLMA has more stringent requirements (effluent compared with Table 1 standards)
- These requirements and CERCLA 5-year review process (review, implement technological improvements as feasible/warranted) drive continuing efforts to improve systems
  - Example: zero-valent iron (ZVI) as volatile organic compound (VOC) treatment media – costly, wasteful
  - Moving from passive, gravity-driven ZVI-based treatment to active, solar-powered air stripping

RFLMA Depiction of Groundwater Conditions

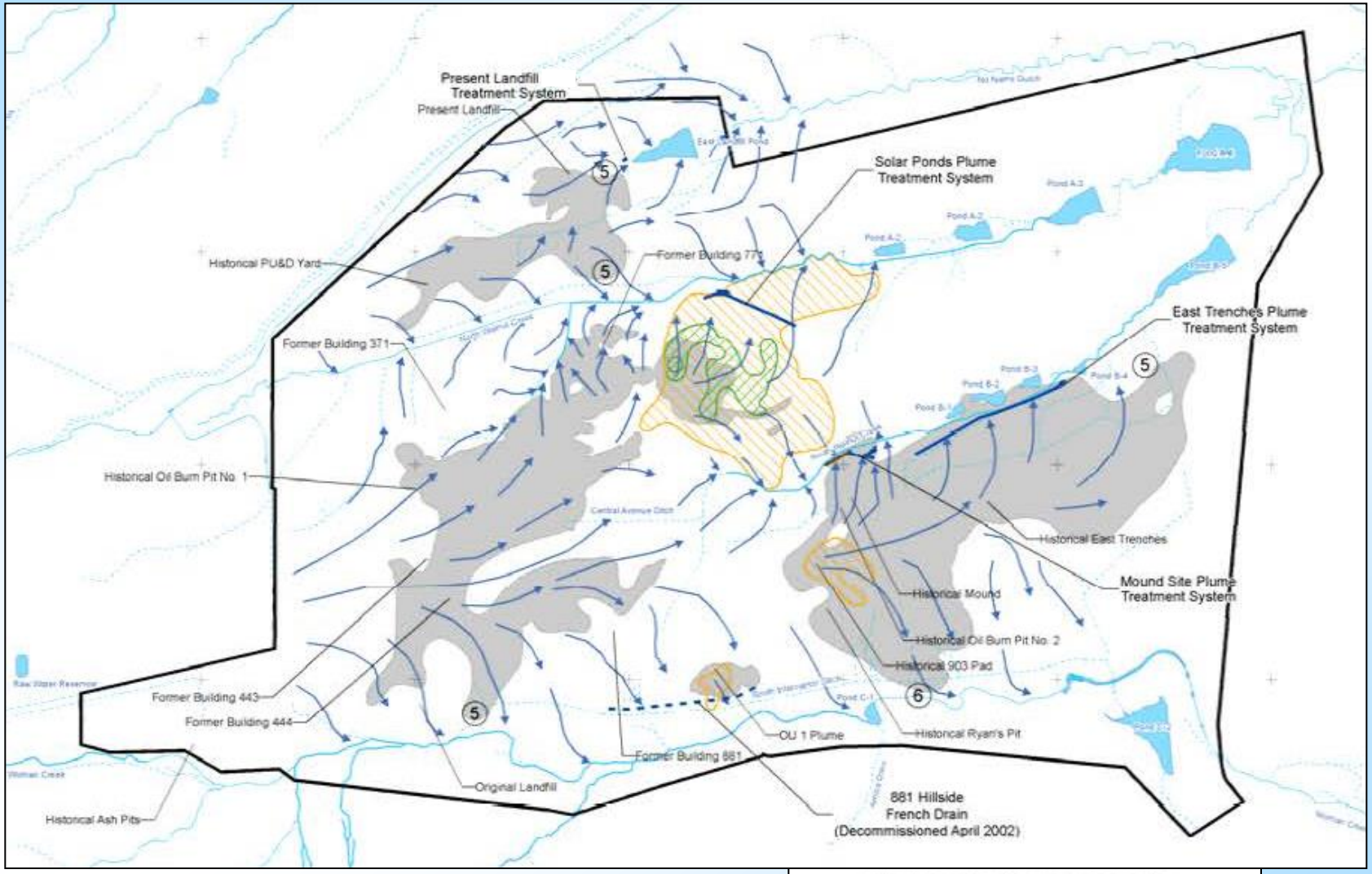


Figure 2. Composite Plume Map

December 2012
Attachment 2, Page 25

Modified after:

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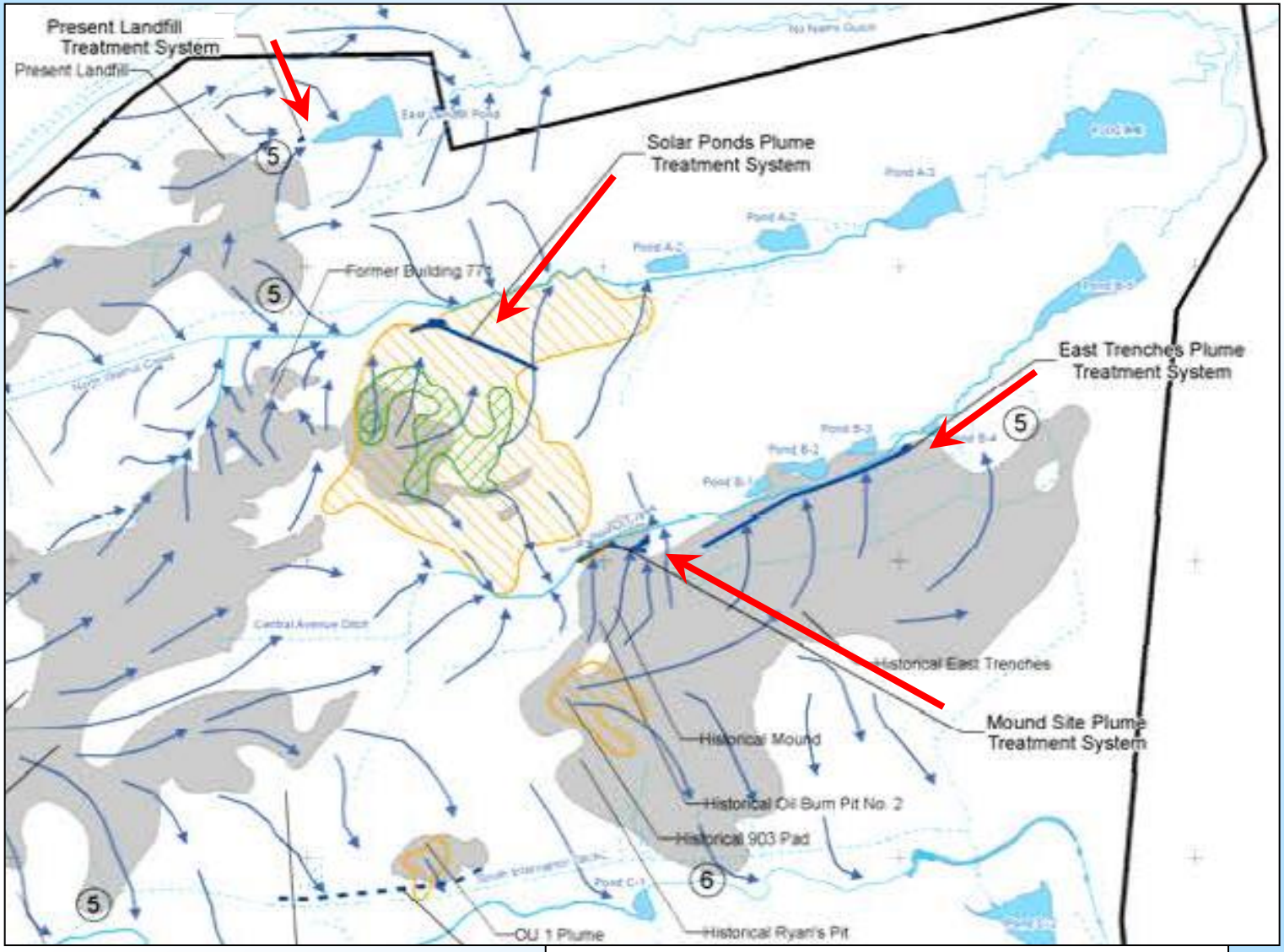
Groundwater Treatment Systems



Modified after RFLMA Attachment 2, Figure 2, December 2012, Page 25

Groundwater Treatment Systems

- Treatment system locations
  - Contaminated groundwater detected at or near surface water and fed by source area
  - Analytical data and modeling showed systems appropriate at four locations
    - Present Landfill Treatment System (PLFTS)
      - Designed to treat very low levels of VOCs by cascade aeration
    - Mound Site Plume Treatment System (MSPTS)
      - Former Seep SW059
      - Designed to treat VOCs by passing water through ZVI
    - East Trenches Plume Treatment System (ETPTS)
      - Designed to treat VOCs by passing water through ZVI
    - Solar Ponds Plume Treatment System (SPPTS)
      - Designed to treat nitrate and uranium by passing water through sawdust and ZVI
  - Each system includes groundwater intercept component

Groundwater Treatment Systems (continued)

- Except for PLFTS, systems have received upgrades since closure
- Each system treats very low flows of water
  - MSPTS approximately 0.75 gpm
  - ETPTS approximately 1.5 gpm
  - SPPTS approximately 1 gpm
  - PLFTS approximately 1 gpm

Comparisons:

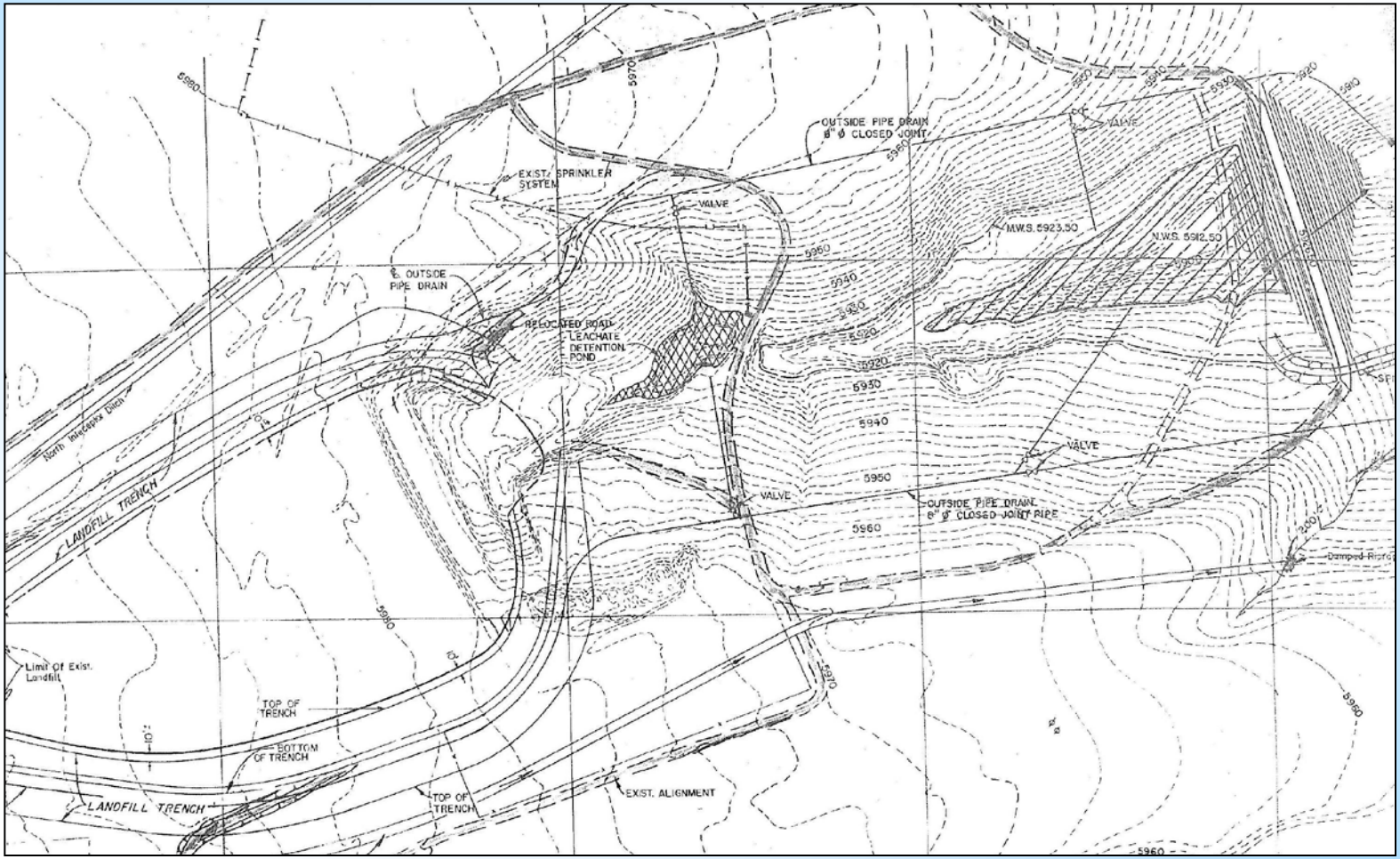
- Garden hose on “full blast” is often approximately 10 gpm
- Recommended minimum flow rate for a household-supply spring or well is typically at least 5 to 6 gpm
- All four treatment systems combined contribute less than 5% of the average flow measured at WALPOC

PLFTS

- Present Landfill (PLF) occupies “headwaters” of No Name Gulch
  - Seep developed on east face of PLF
  - Groundwater Intercept System (GWIS) intercepts groundwater flowing toward PLF
  - Water from GWIS and seep enters PLFTS
- PLFTS
  - Designed to treat very low levels of VOCs
  - Cascade aeration (concrete steps)
  - Very simple, gravity-driven, minimal maintenance

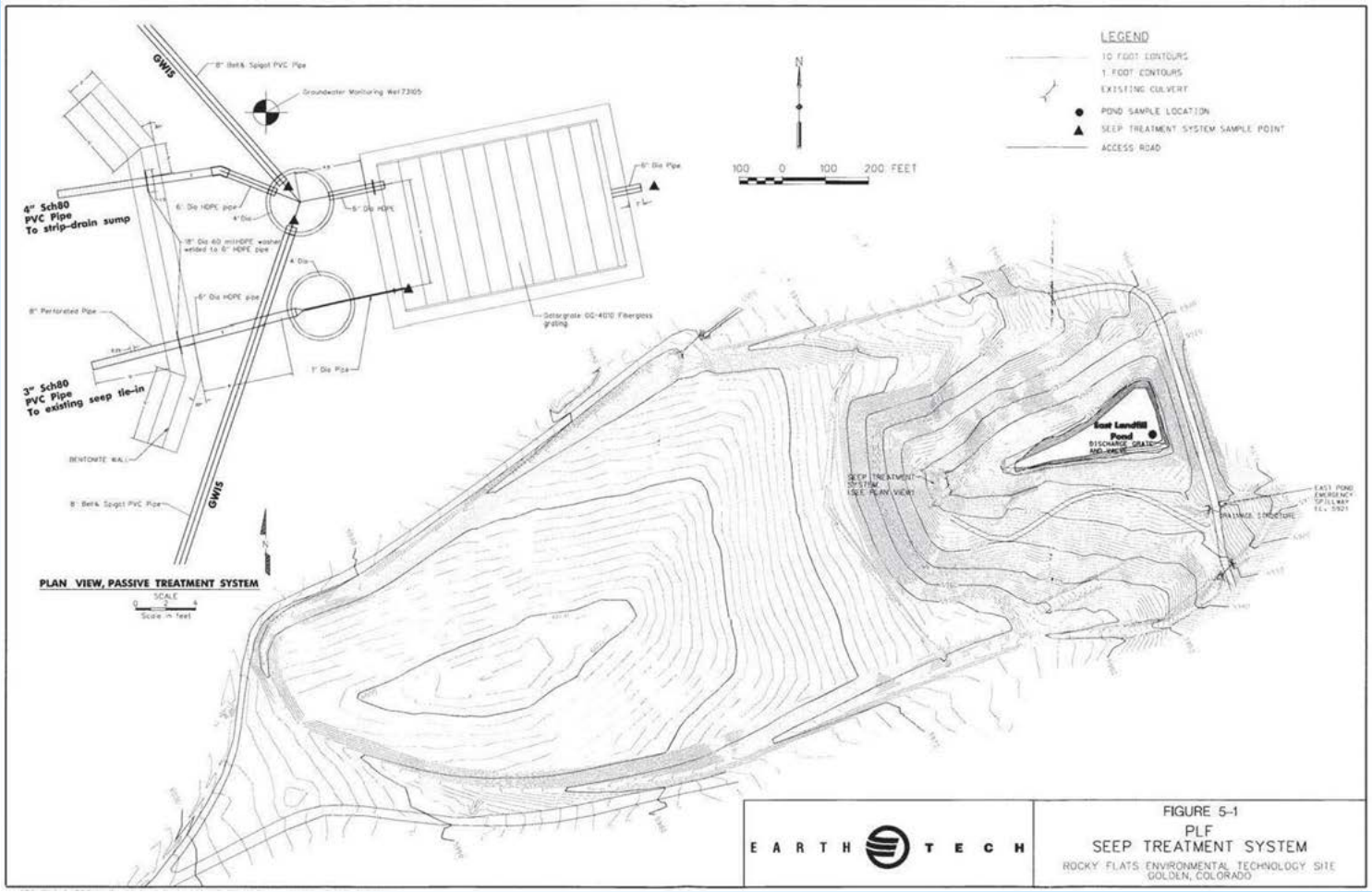
PLFTS (continued)

1974 drawing of then-smaller PLF with two ponds



PLFTS (continued)

From 2006 PLF Monitoring and Maintenance Plan

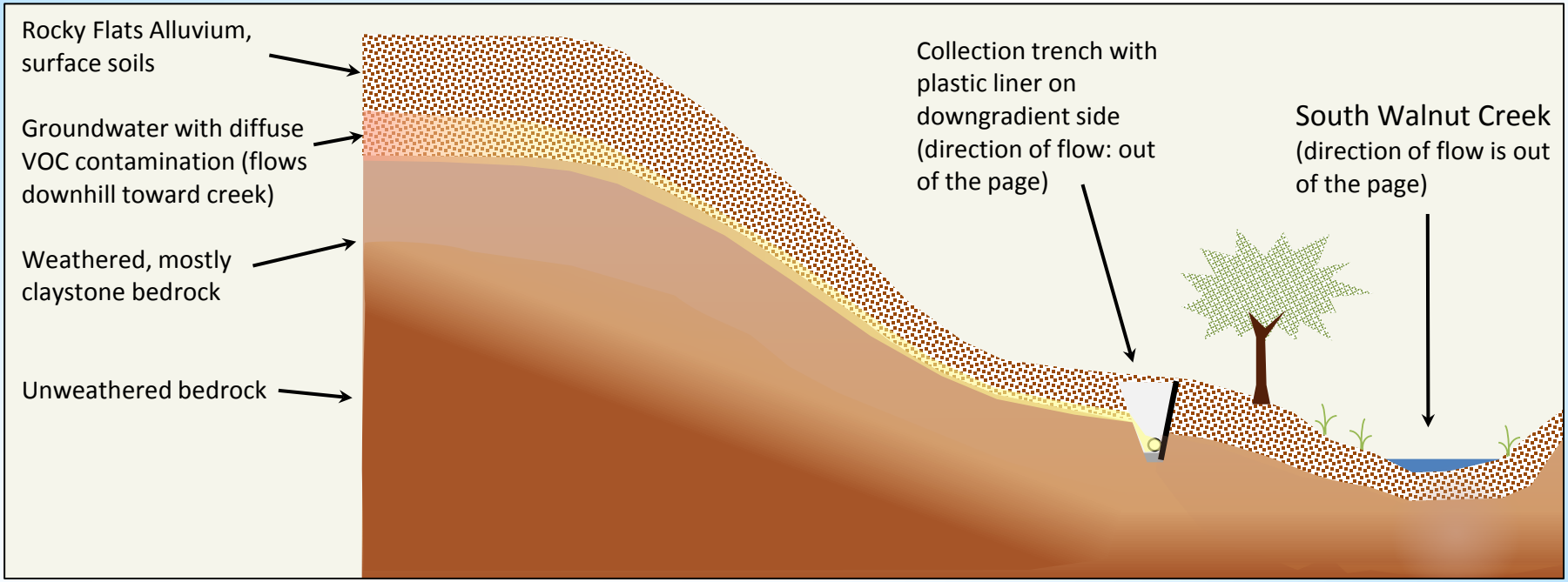


MSPTS, ETPTS, and SPPTS

- Designs are similar to one another
- Groundwater intercept trench feeds collected water to treatment cells
- Treated effluent is discharged to subsurface

MSPTS, ETPTS, and SPPTS (continued)

Conceptual drawing based on ETPTS



Groundwater Intercept Trench

(*a.k.a. collection trench*)

- Impermeable barrier along downgradient side
- Perforated pipe in bottom of trench
- Groundwater flows into trench, pipe routes it to treatment cells

Photos of ETPTS trench construction, 1999

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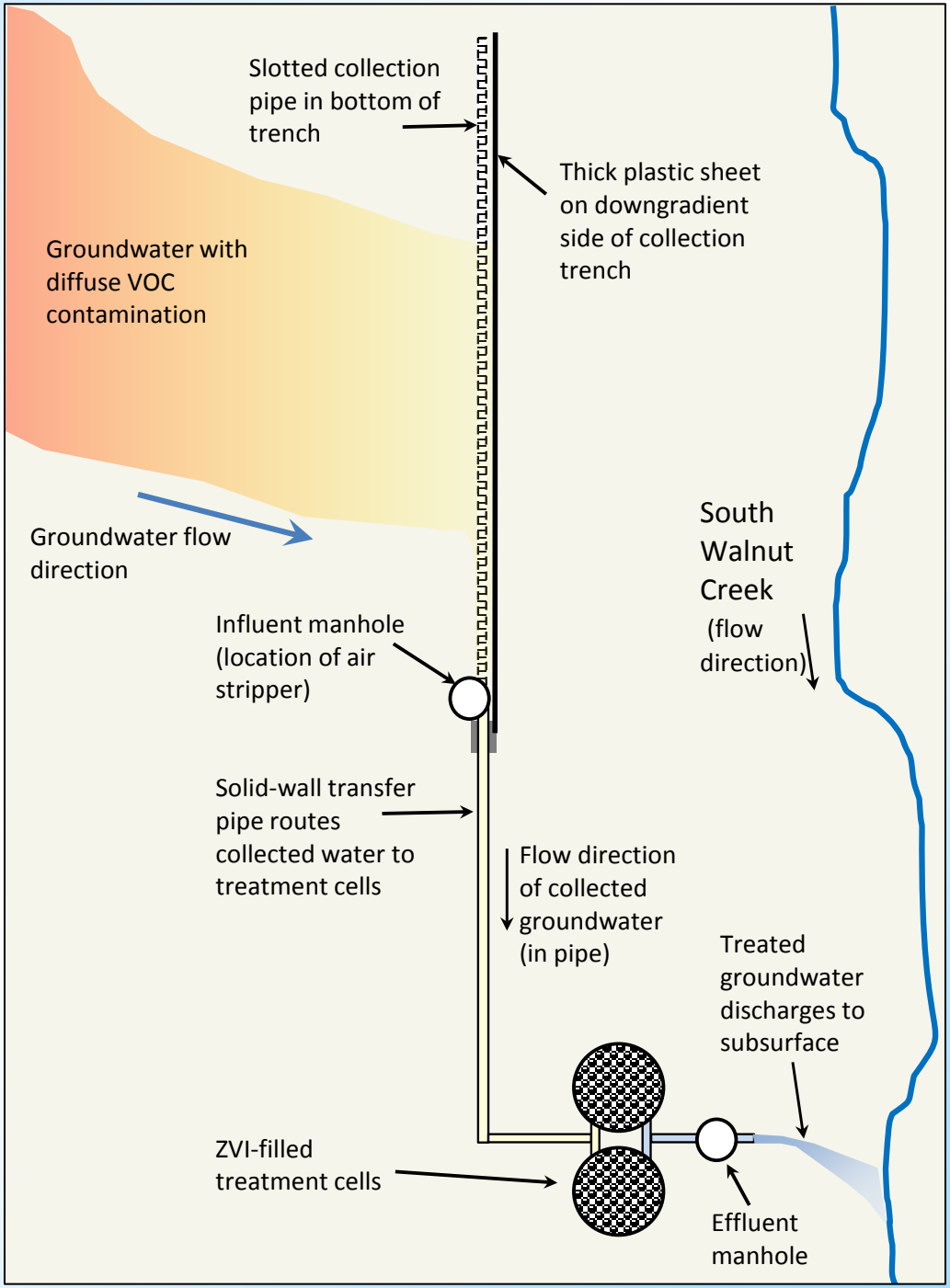
MSPTS, ETPTS, and SPPTS (continued)

Conceptual drawing based on ETPTS



MSPTS

- Pre-closure: Seep SW059 produced VOC-contaminated water
- Numerous wells installed to define groundwater contamination
- 1998: MSPTS installed to treat Mound Site Plume
  - 220-foot-long groundwater intercept trench, two ZVI-filled treatment cells
- 2005: Groundwater flow from Oil Burn Pit #2 (OBP#2) routed to MSPTS
  - Flows and contaminant loads increased
  - Residence times and treatment effectiveness decreased
- ZVI replaced twice since closure (2006, 2011)
- Air stripping added to “polish” **effluent** water quality
  - Tested in 2010–2011
  - Prototype installed in 2011
  - Larger-scale unit installed in 2013
  - Result: Significant reduction in recalcitrant VOCs in system effluent

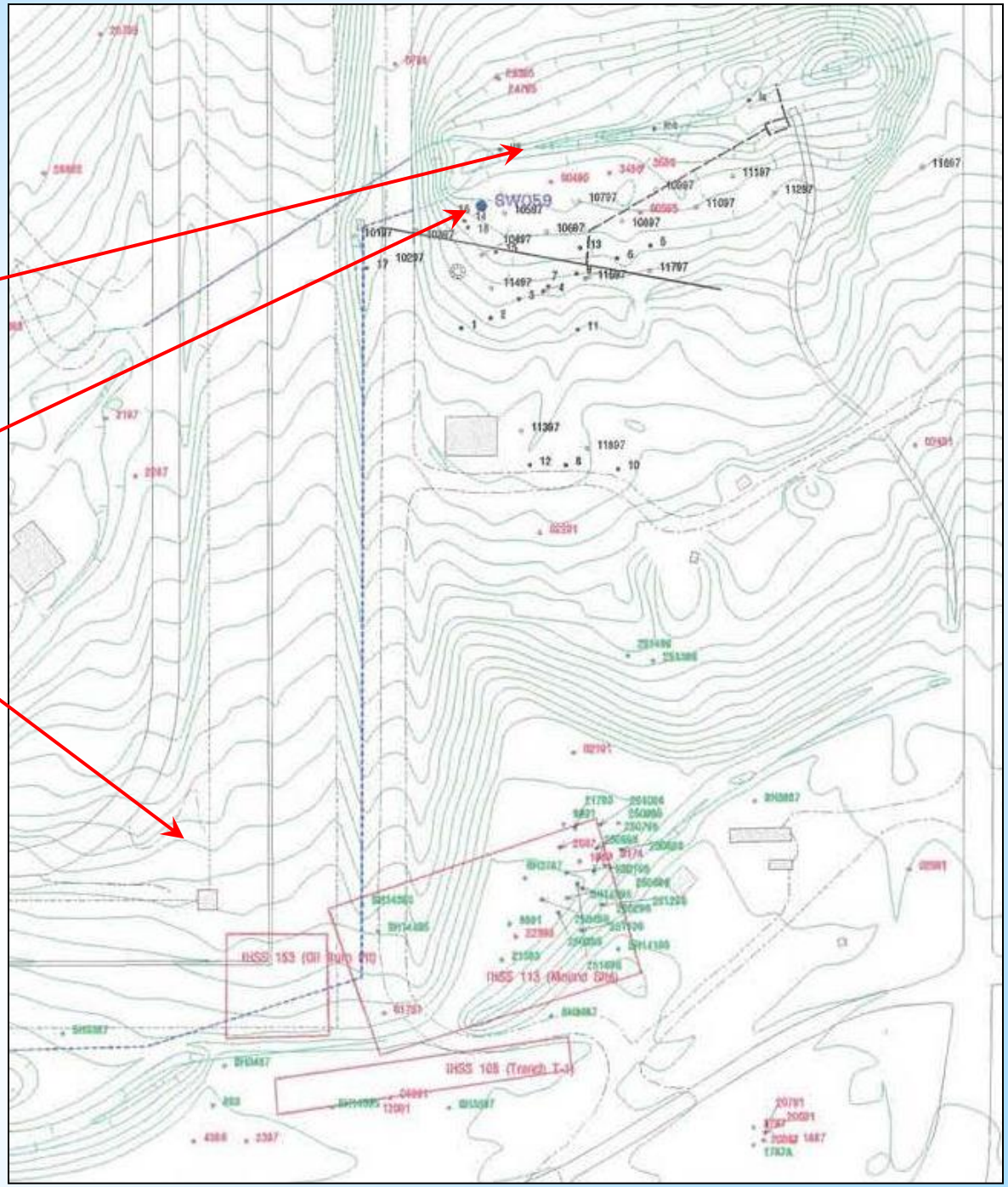
MSPTS (continued)

South Walnut Creek

Seep SW059

Mound and OBP#2 source areas

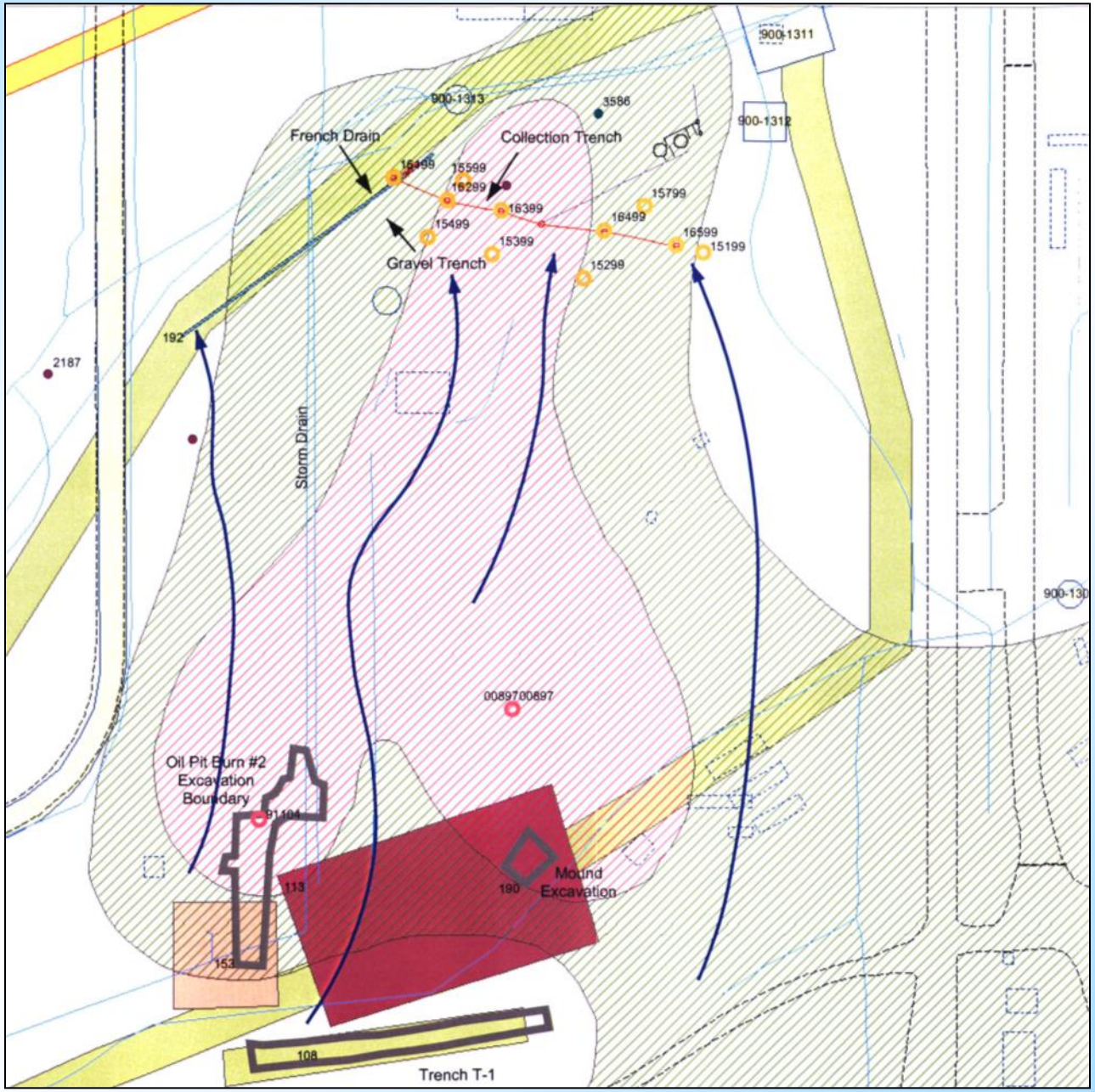
From 1997 Decision Document



MSPTS (continued)

Contaminant contributions from OBP#2 are substantial (pre-closure TCE shown at 2.5, 500 ug/L contour values)

From 2005 Groundwater IM/IRA

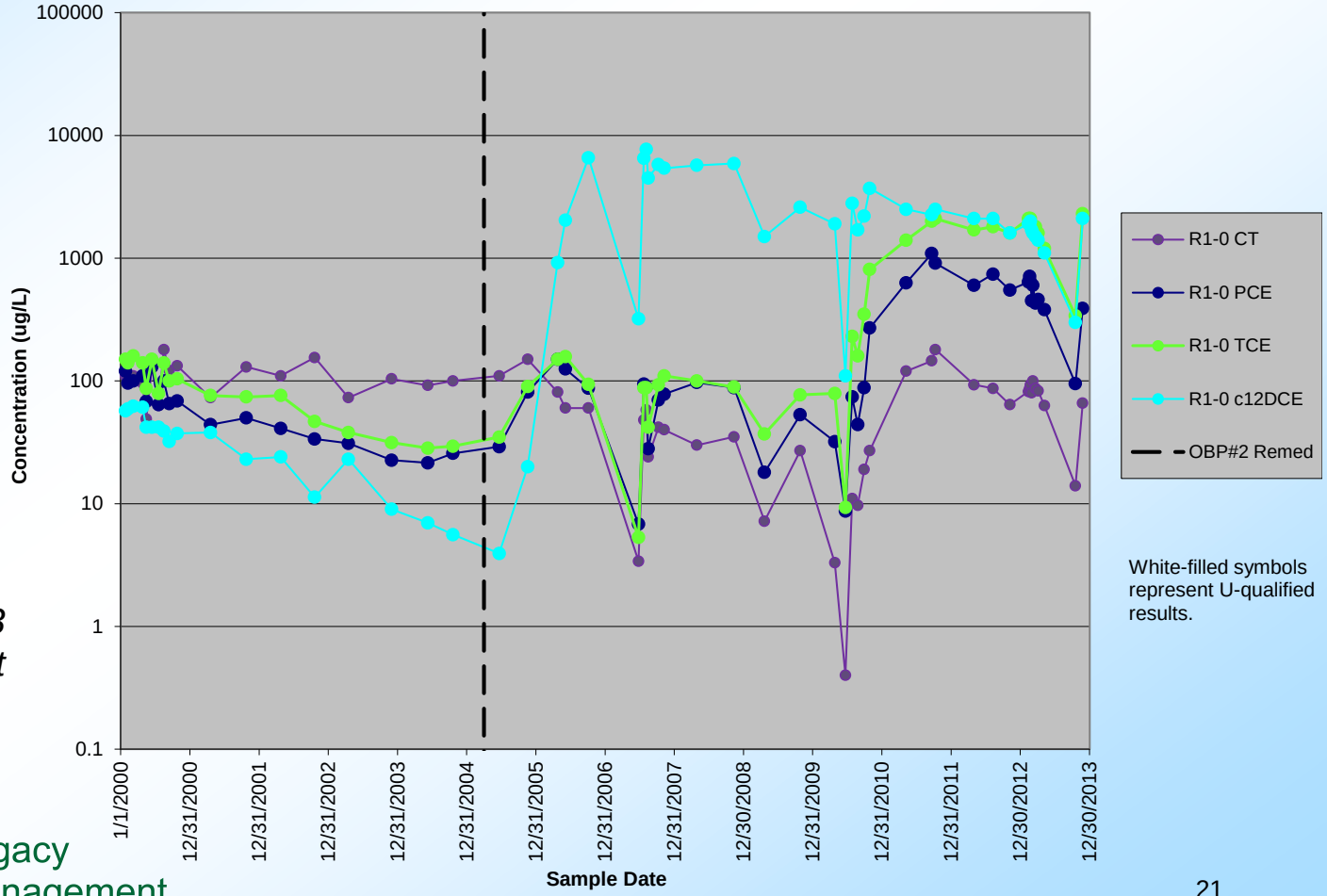


MSPTS (continued)

- Pre-closure flows (2000–2004) averaged 184,000 gallons per year; post-closure (2006–2013) averaged 406,000 gallons per year
- Increase is due to linking OBP#2 to MSPTS groundwater intercept trench

Influent data

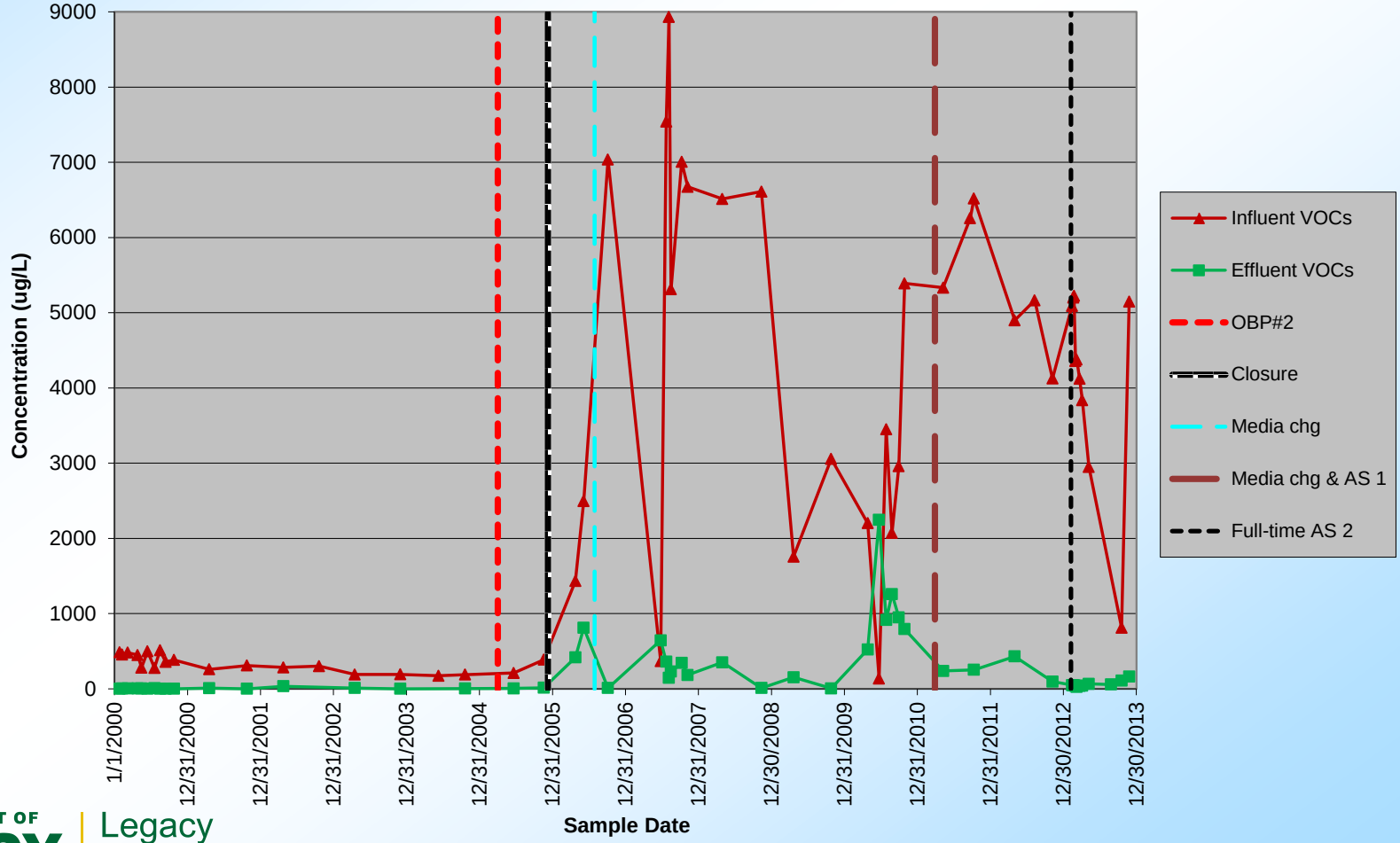
From 2013 Annual Report



White-filled symbols represent U-qualified results.

MSPTS (continued)

Chart of total VOCs, showing OBP#2 work, ZVI media replacement, air stripper activities



From 2013 Annual Report

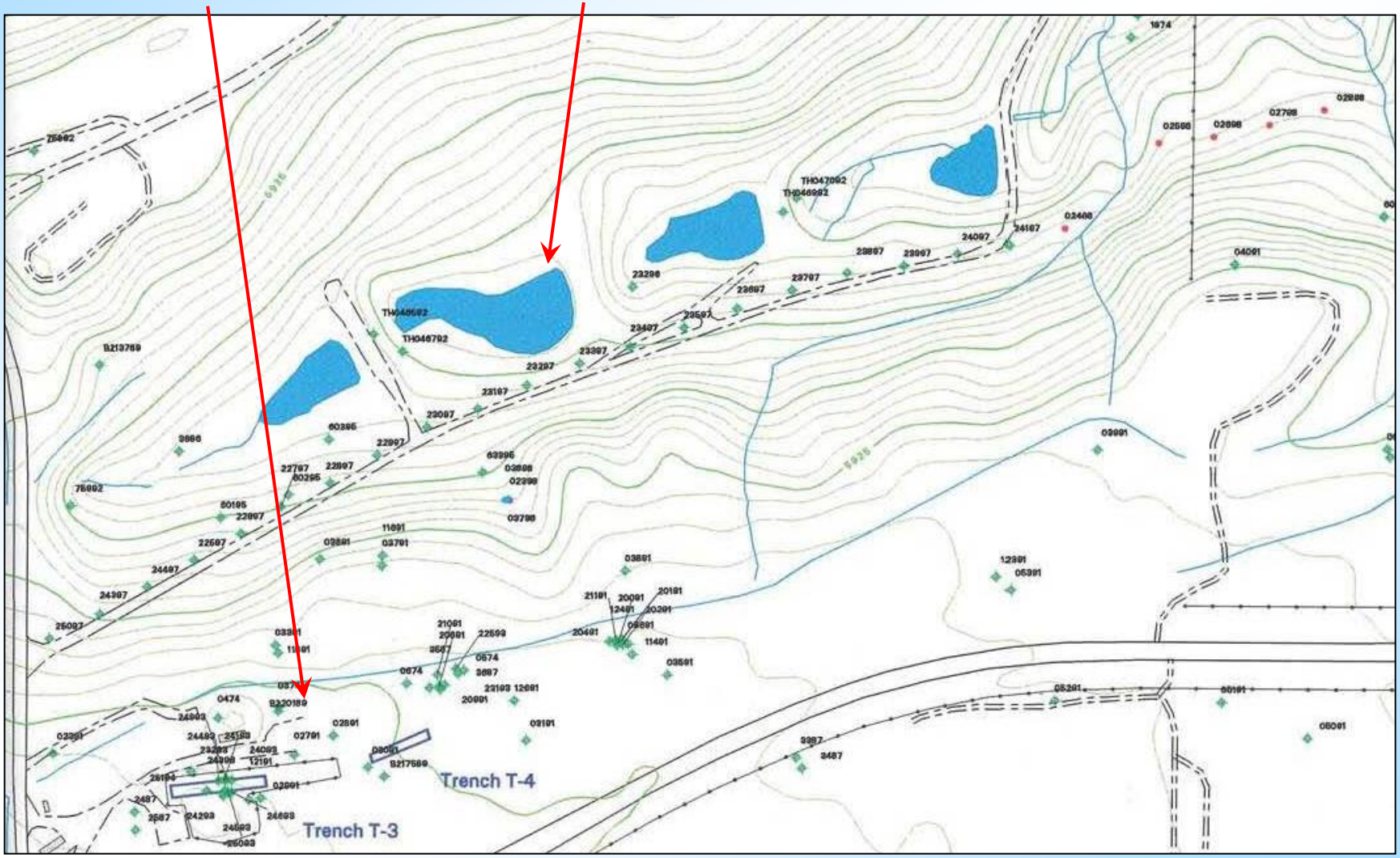
MSPTS (continued)

ETPTS

- Pre-closure: Wells in South Walnut Creek drainage produced contaminated groundwater, VOCs detected in surface water
- Numerous wells installed to define groundwater contamination
- 1999: ETPTS installed to intercept, treat East Trenches Plume as it migrates toward creek
  - 1,200-foot-long groundwater intercept trench, two ZVI-filled treatment cells
- ZVI changed several times (approximately every three to four years)
- Air stripping added to reduce **influent** contaminant concentrations (i.e., concentrations in water entering treatment cells)
  - Based on MSPTS prototype
  - Installed in 2013

ETPTS (continued)

Source area B-Ponds and South Walnut Creek

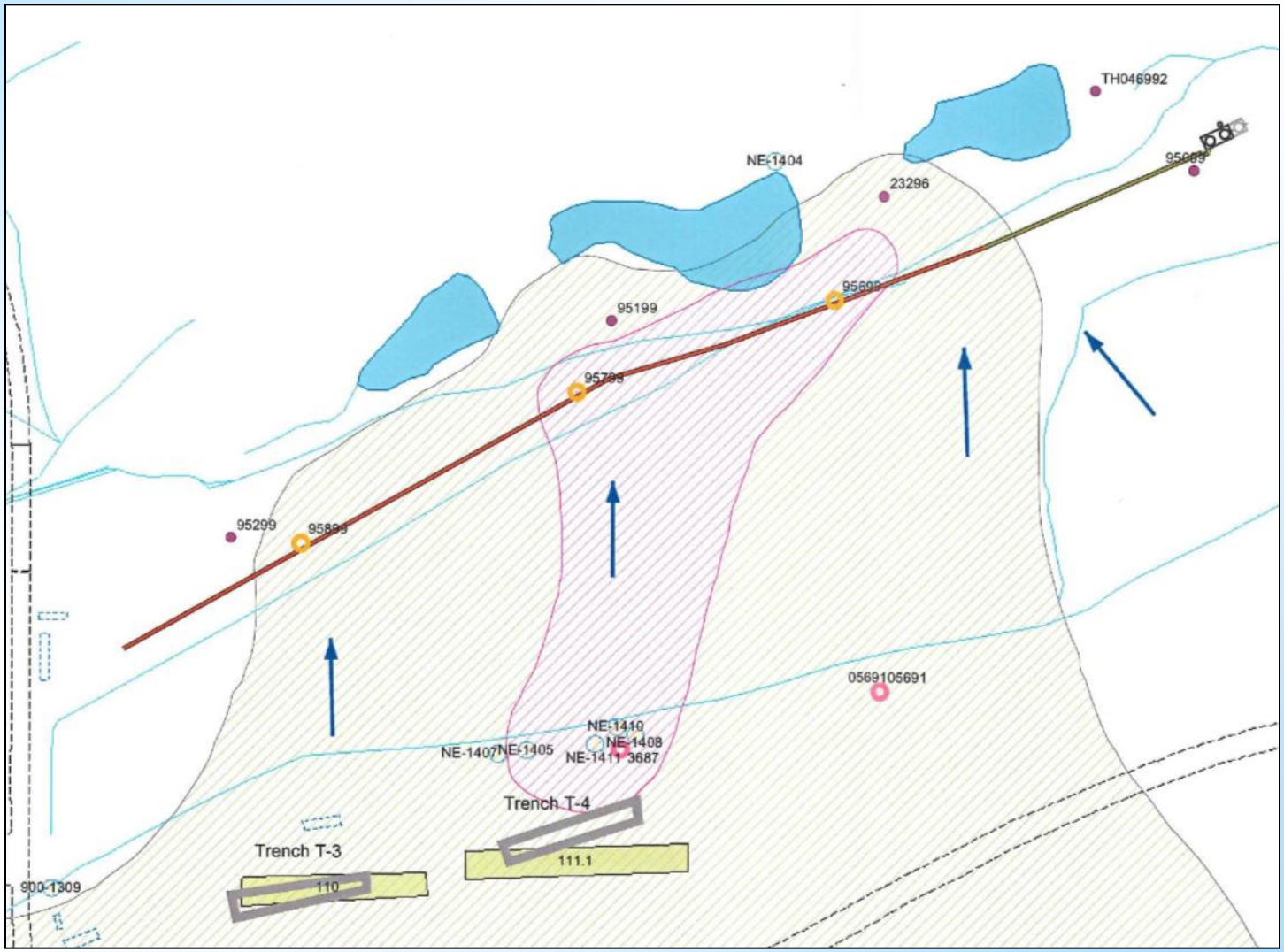


From 1999 Proposed Action Memorandum

ETPTS (continued)

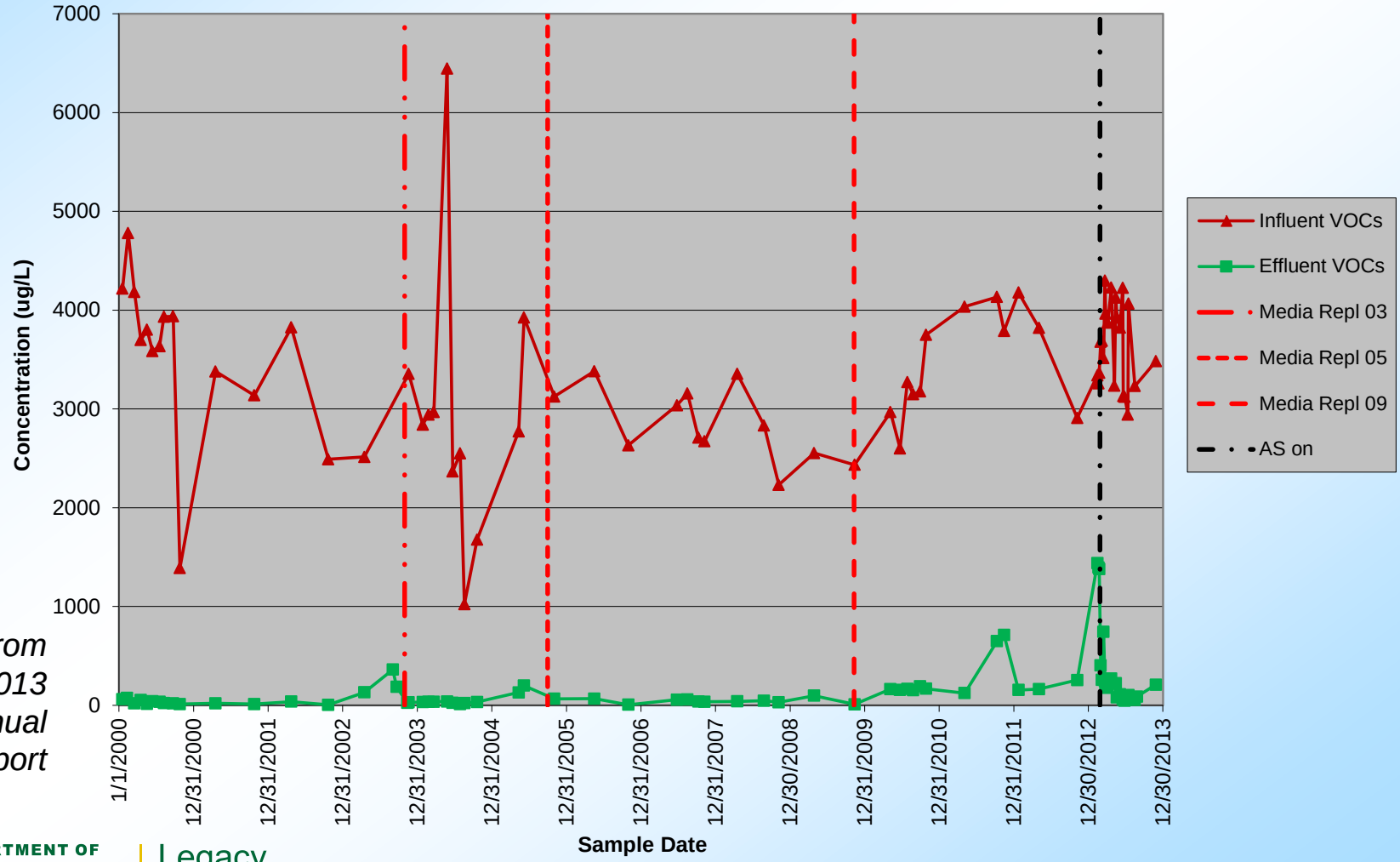
TCE (pre-closure) contour values are 2.5, 500 ug/L

From 2005 Groundwater IM/IRA



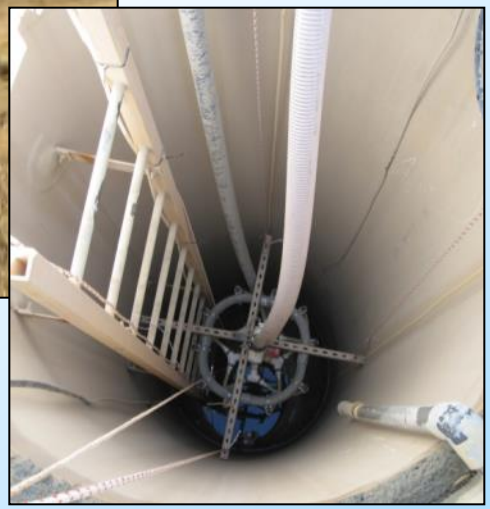
ETPTS (continued)

Chart of total VOCs showing media replacement, air stripper activities



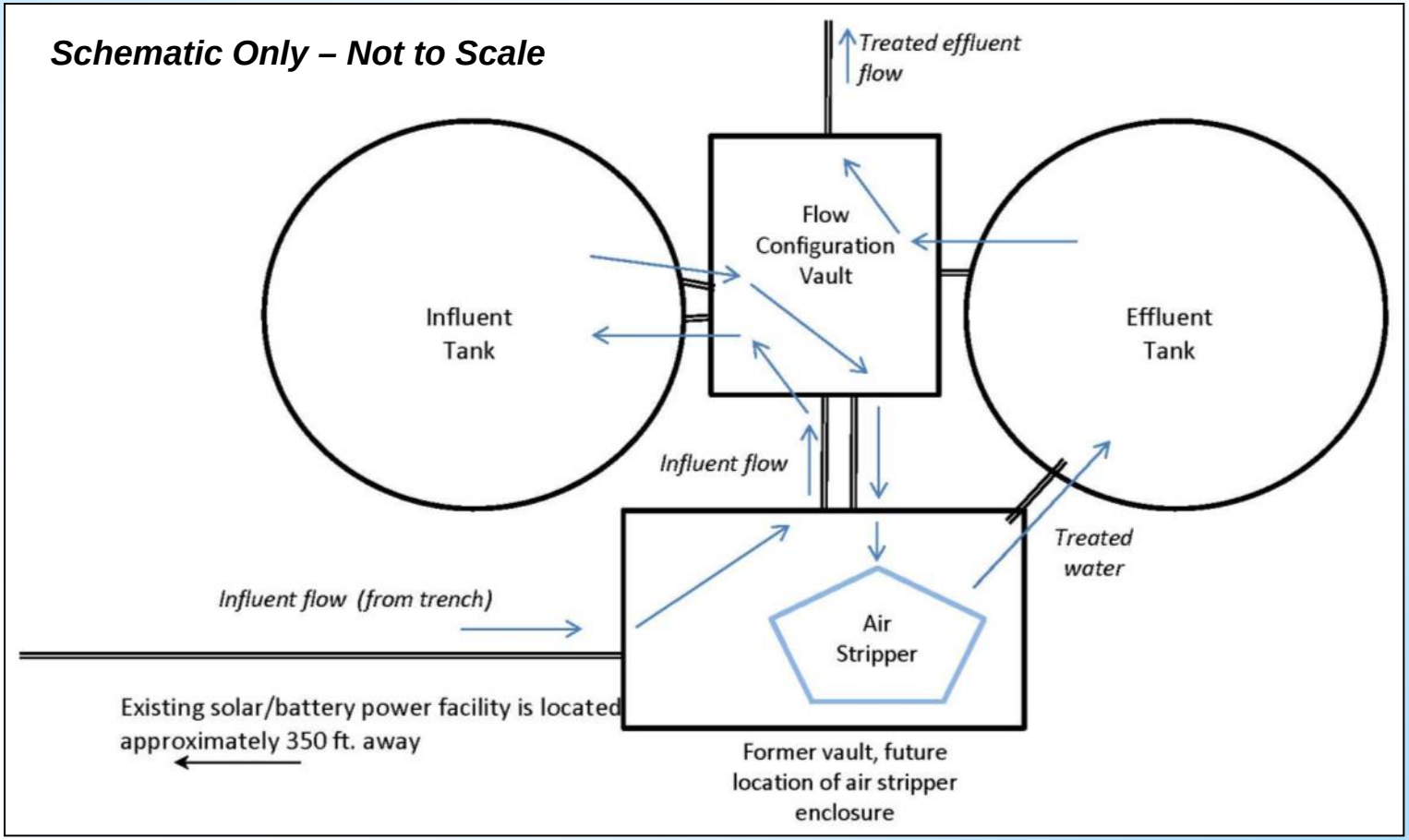
From 2013 Annual Report

ETPTS (continued)



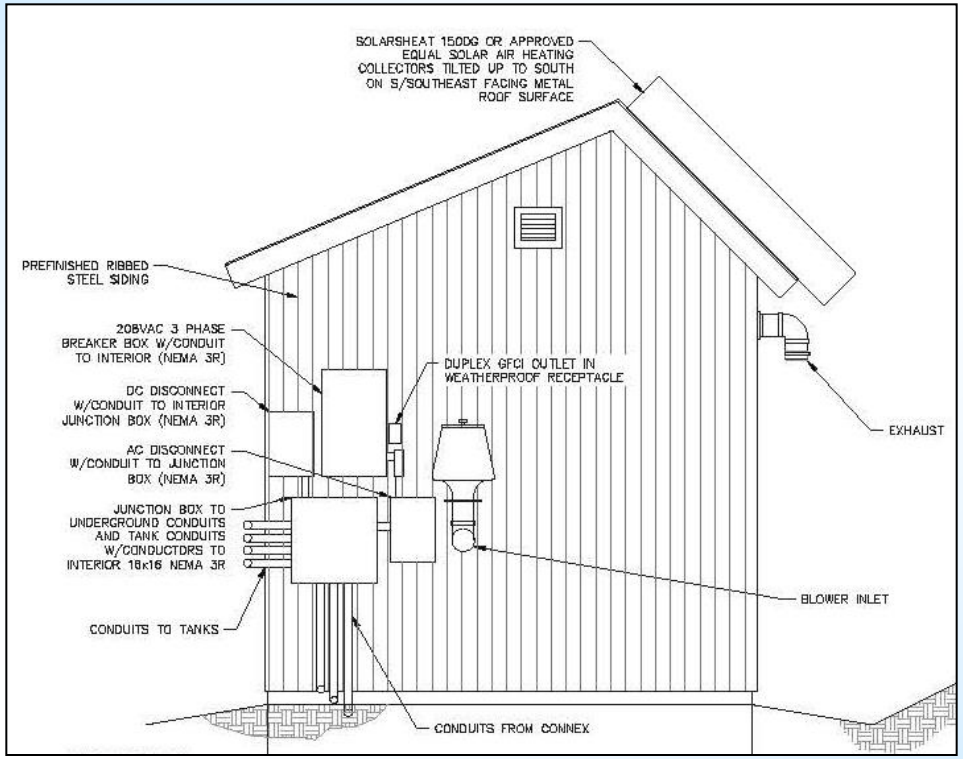
ETPTS (continued)

Currently reconfiguring ETPTS to treat water more effectively using commercial air stripper

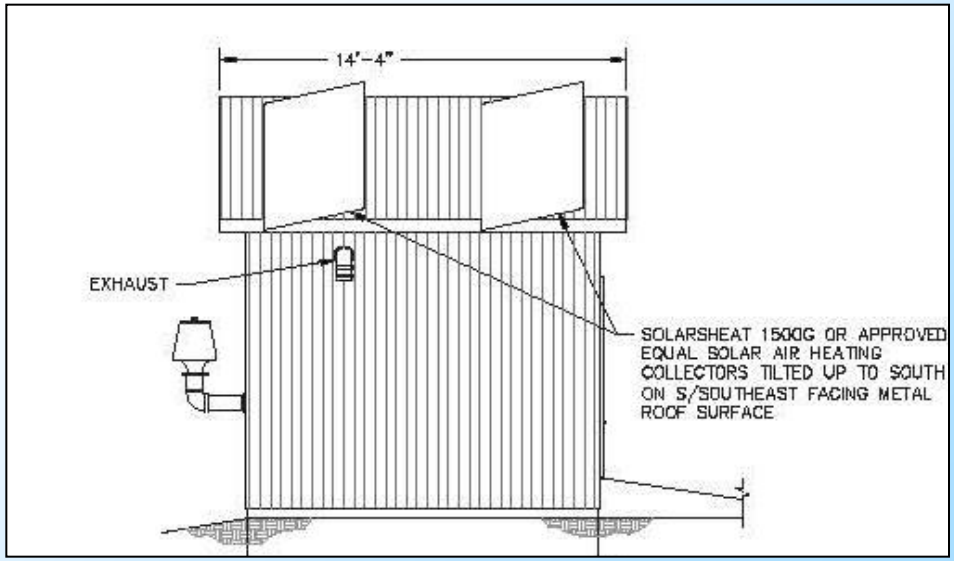


ETPTS (continued)

Commercial air stripper manufactured for ETPTS



Enclosure being built to house air stripper



SPPTS

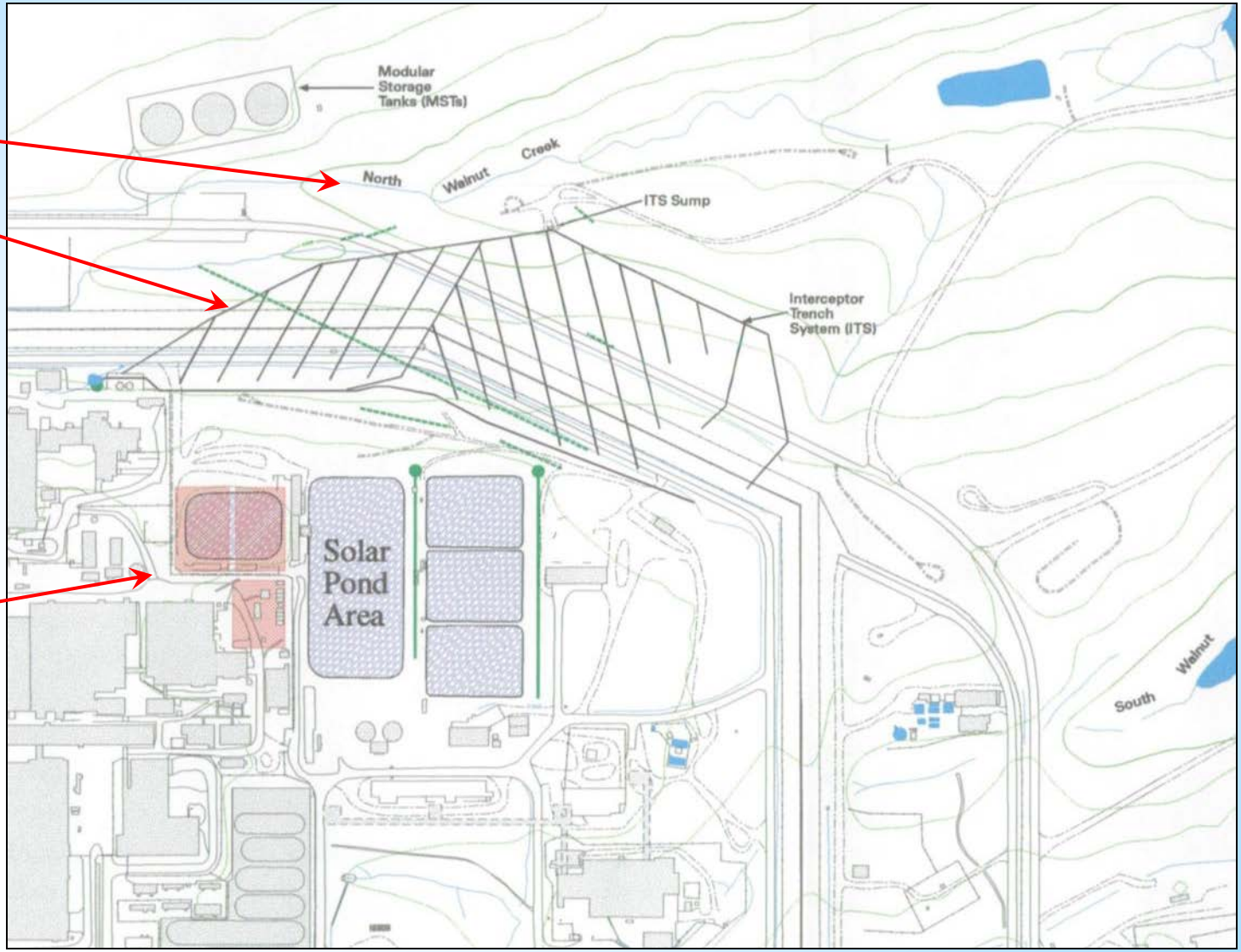
- More complex system, more complex story
- Pre-closure
  - Seeps and wells on hillside and in North Walnut Creek drainage produced contaminated groundwater
  - Nitrate from former Solar Evaporation Ponds (SEPs) detected in surface water
- Six intercept trenches installed in early 1970s to collect seepage, shallow groundwater
- Interceptor Trench System (ITS) completed in 1981
  - Approximately 2 miles of French drains intercept and collect shallow groundwater
  - Collected water drained to sump (at Interceptor Trench Pump House [ITPH]), then routed for disposition
- Numerous wells installed to define groundwater contamination
- Nitrate contamination was reaching valley bottom; uranium more localized in area of SEPs; VOCs present on western side of SEPs

SPPTS (continued)

North Walnut Creek

ITS (black network) and earlier trench system (dashed green lines in vicinity of ITS)

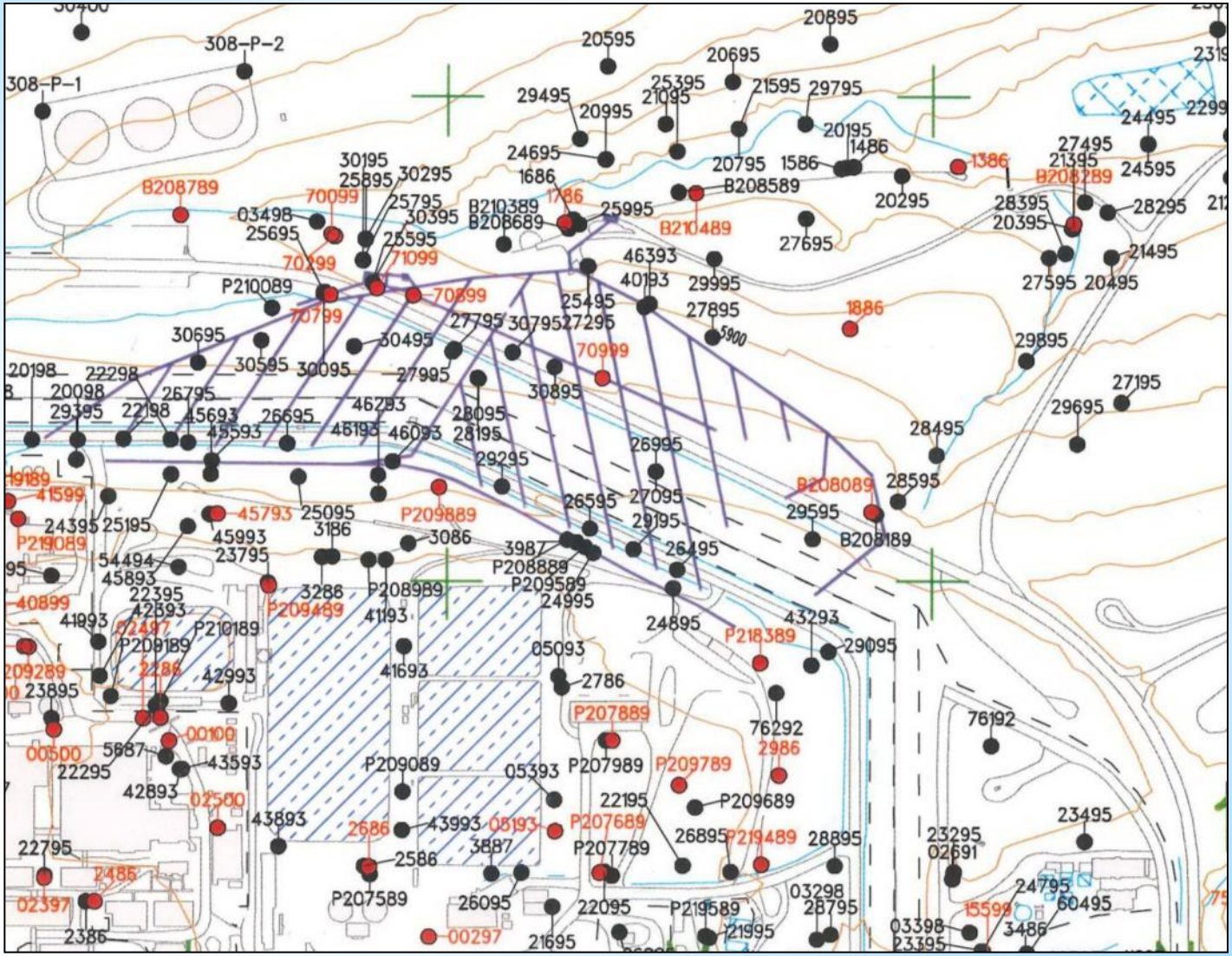
SEPs



From 1999 Solar Ponds Plume Decision Document

SPPTS (continued)

From unpublished, informal well map created to assist sampling personnel, 2000



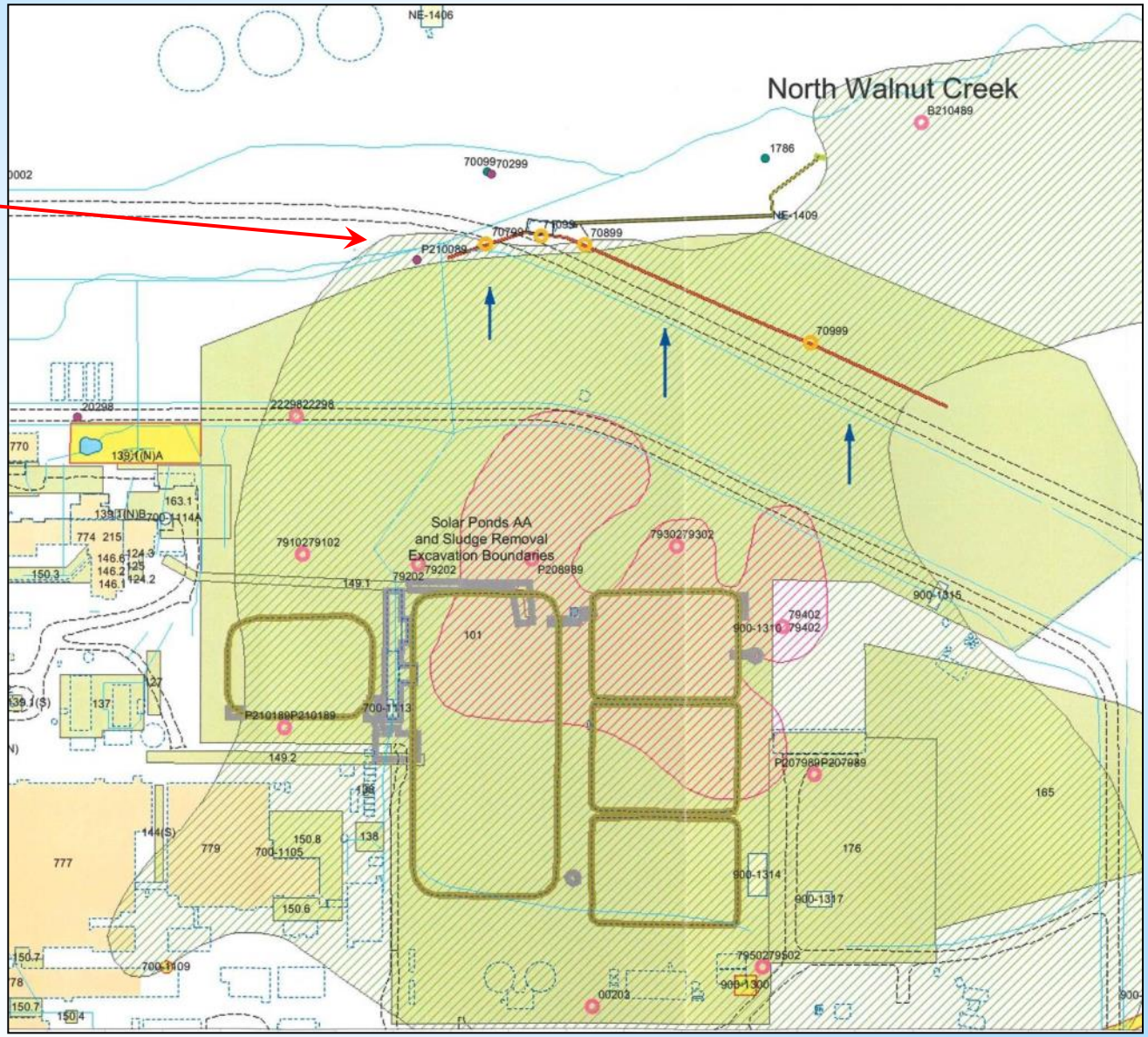
SPPTS (continued)

- 1999: SPPTS installed to intercept, treat Solar Ponds Plume as groundwater migrates toward creek
  - 1,100-foot-long groundwater intercept trench intercepts ITS
    - Removed several feet of each ITS line intercepted (on downgradient side)
    - Plugged remaining ends nearest SPPTS intercept trench
    - Balance of ITS remained in place
- Collected water routed through two cells: first contains sawdust with 10% ZVI, second contains ZVI with gravel
- Treated effluent routed back into downgradient portion of ITS, ultimately to subsurface Discharge Gallery
  - ITPH was ultimately removed for site closure
  - ITS connections to ITPH were disrupted

SPPTS (continued)

Groundwater intercept trench (dark red line)

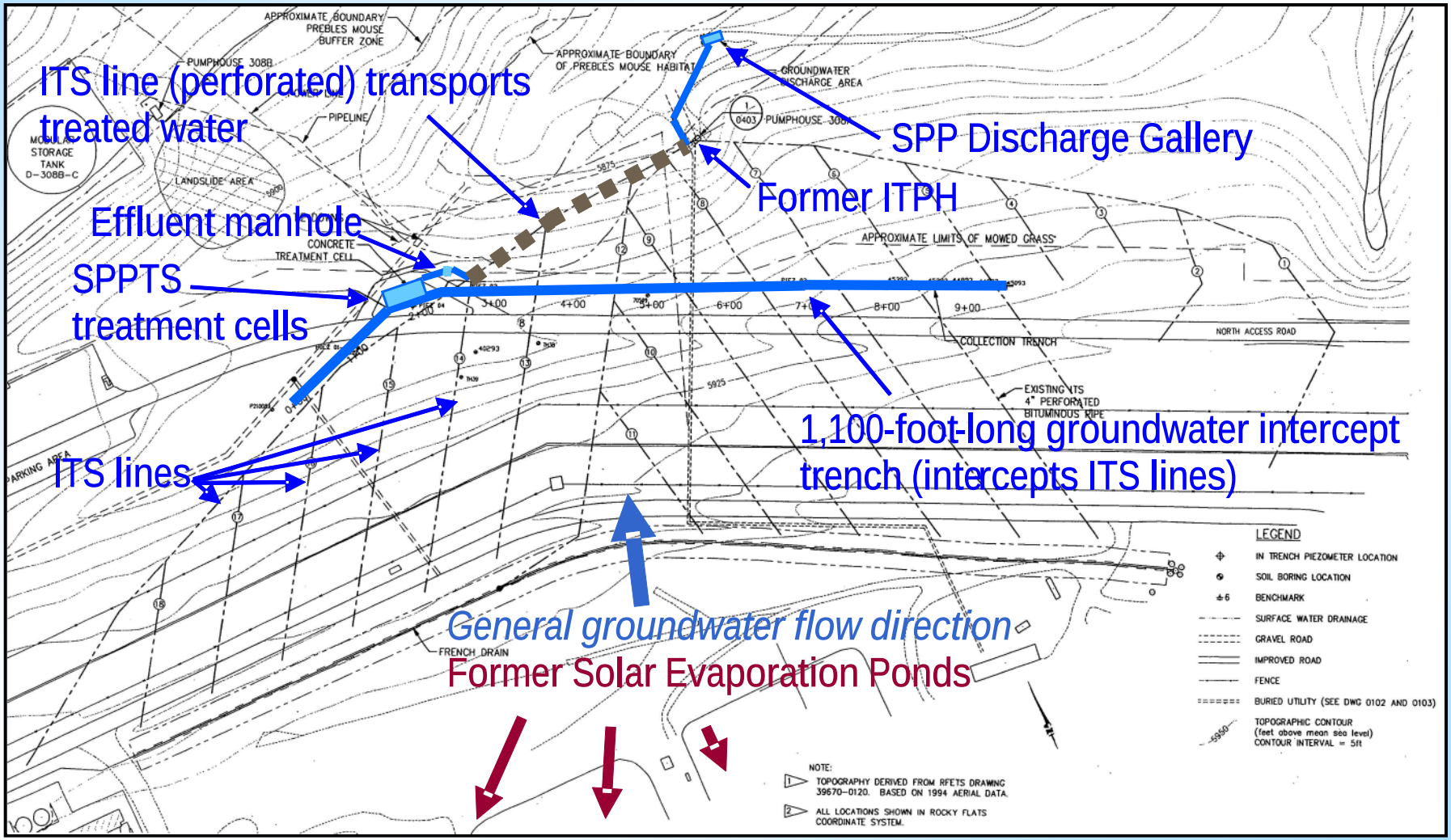
Nitrate (pre-closure) contour values are 10, 1,000 mg/L



From 2005 Groundwater IM/IRA

SPPTS (continued)

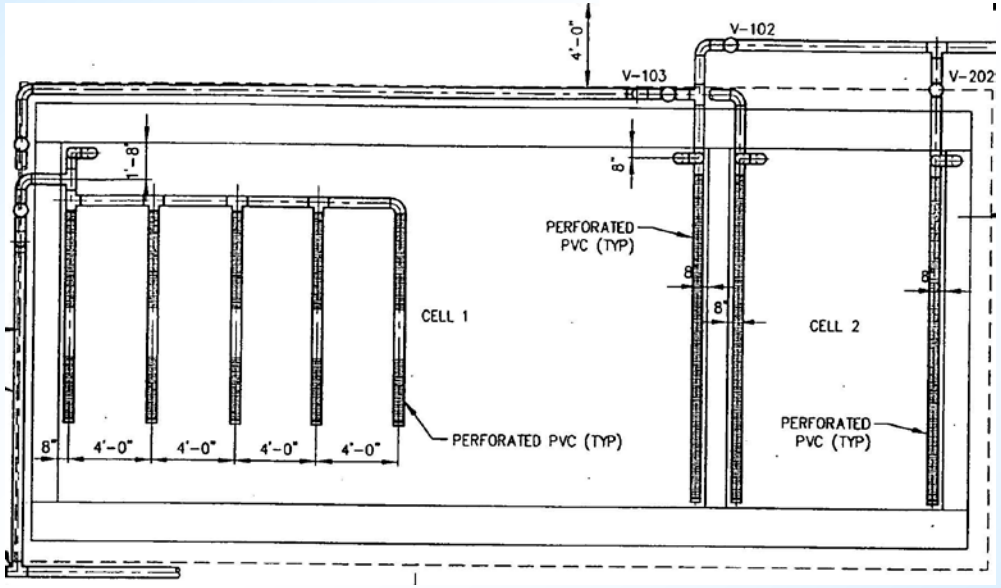
As completed in 1999

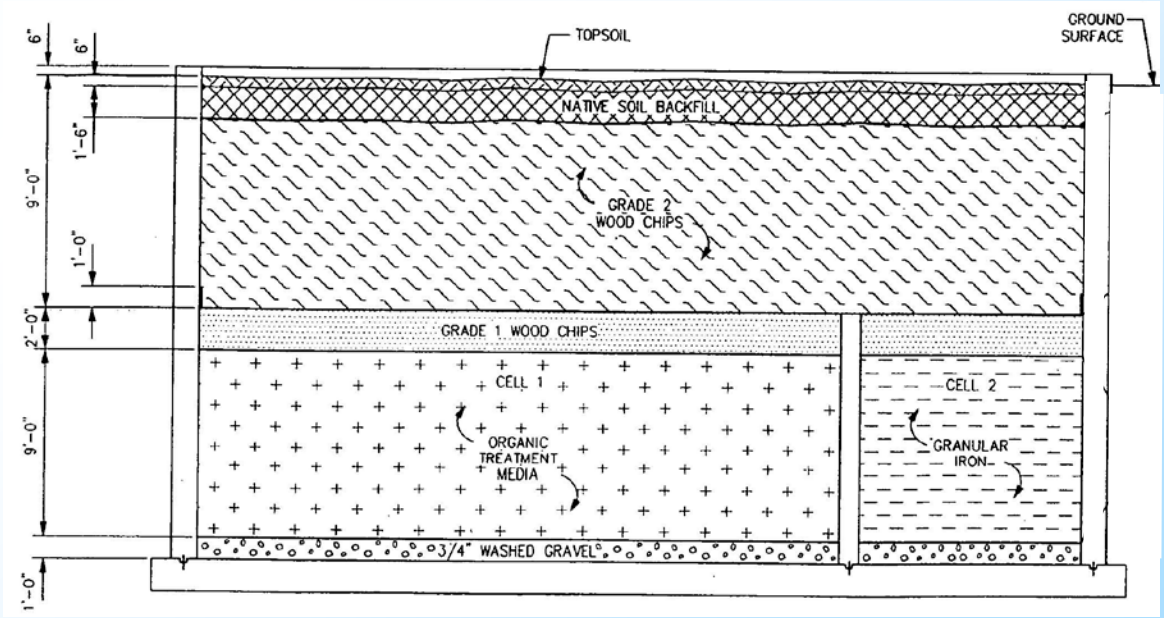


SPPTS (continued)

Two original treatment cells

Media beneath approximately 11 feet of overburden



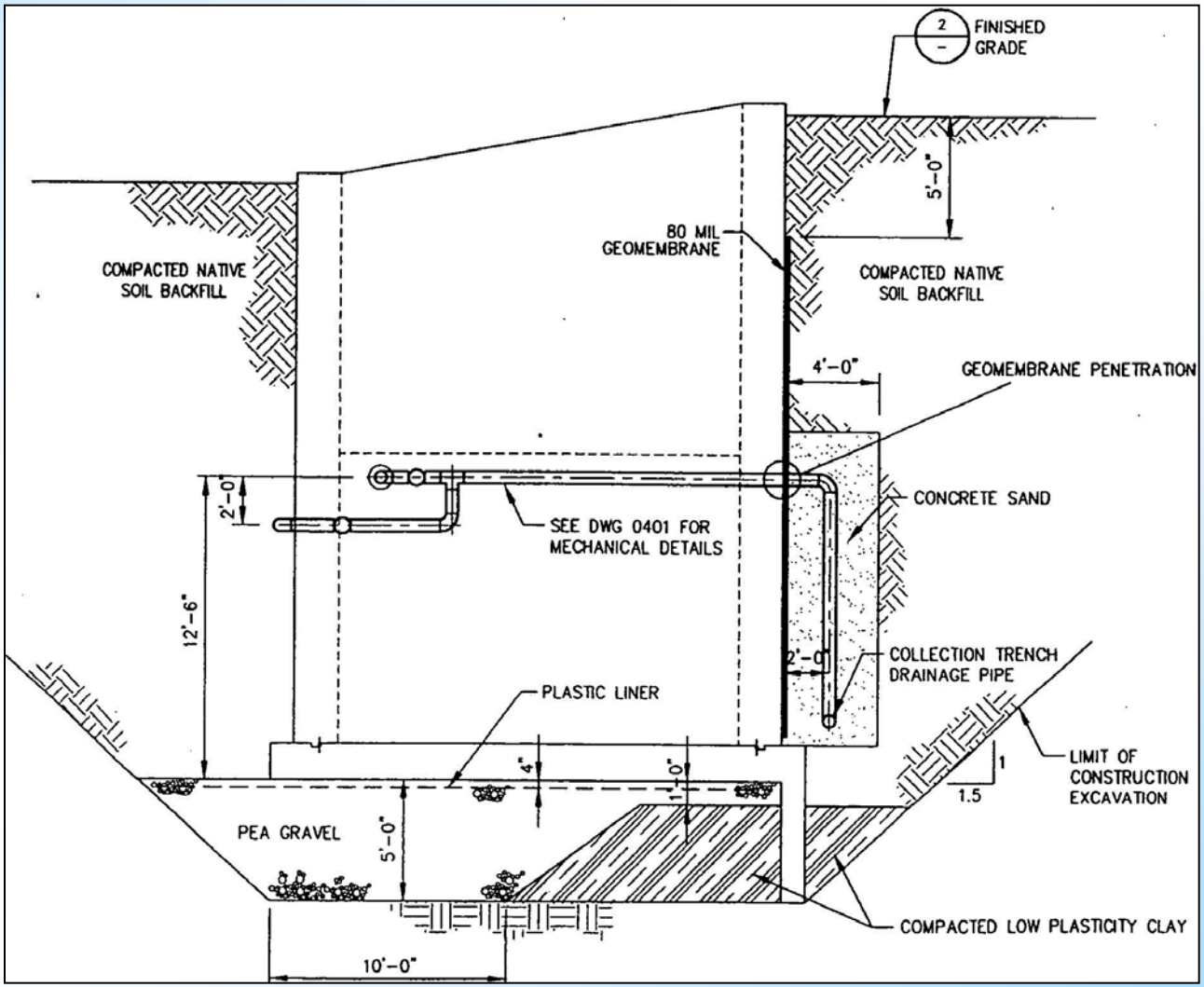


Modified after as-built drawings, 2000

SPPTS (continued)

Original design required water to build up in trench

Result: episodic flow, long periods of no flow

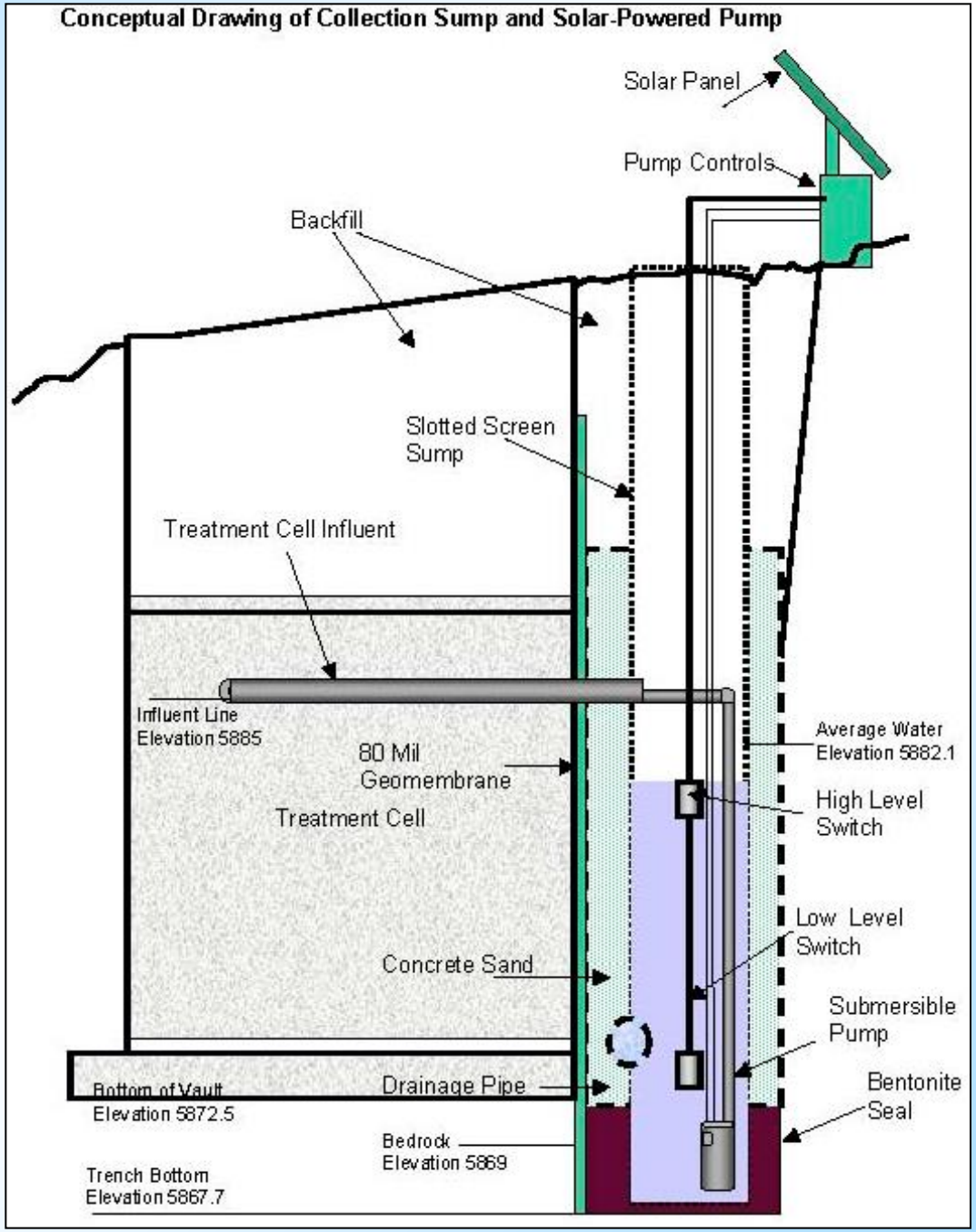


From as-built drawings, 2000

SPPTS (continued)

Collection well installed and equipped with solar-powered pump in 2002

From conceptual drawings, 2002

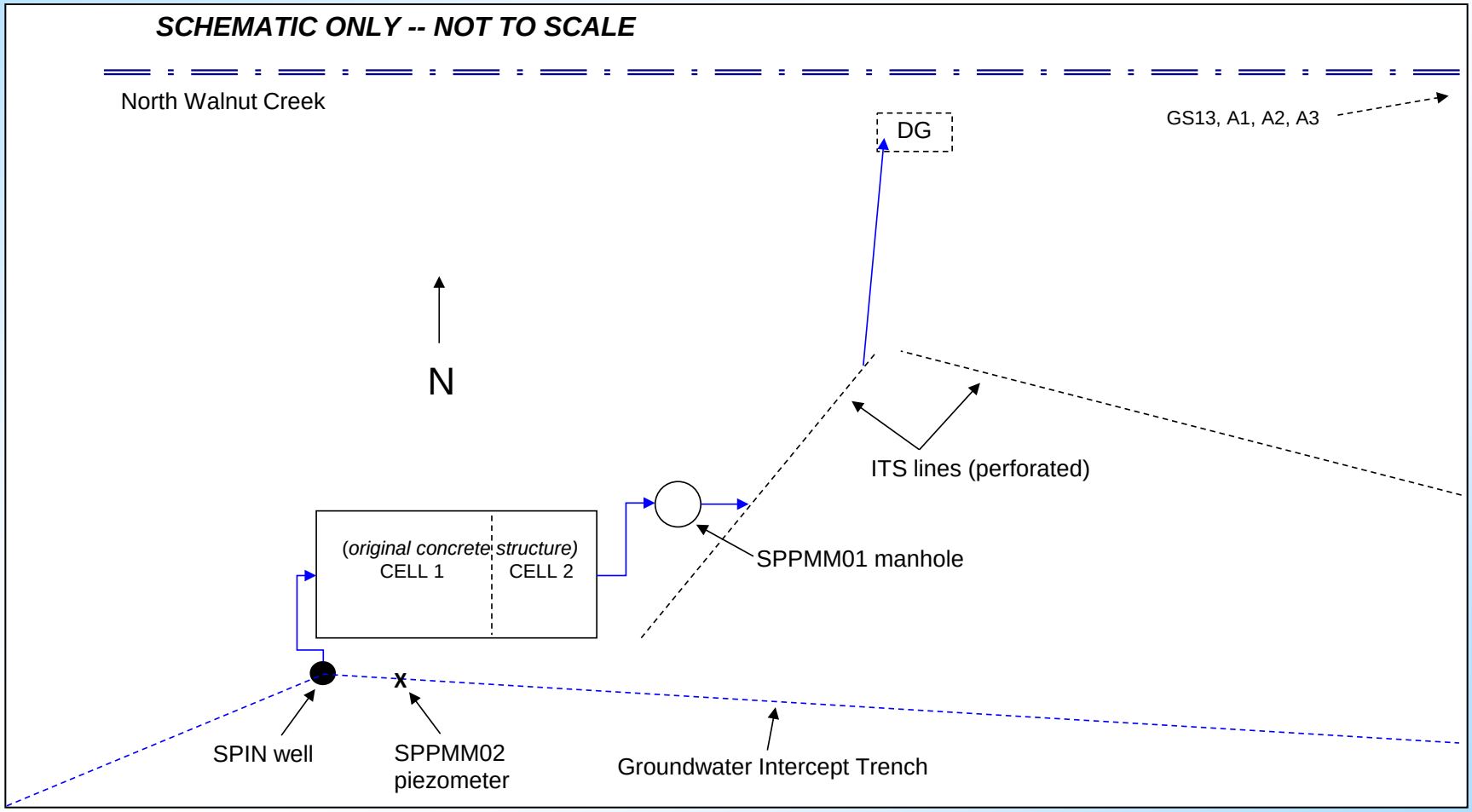


SPPTS (continued)

- Treatment system flows increased after pump installed
- Effluent data collected at manhole confirmed satisfactory treatment
- Water from vicinity of Discharge Gallery contained higher concentrations of contaminants than untreated influent
- Regulatory acceptance for conditions as they existed (CAD/ROD)
- Cell 2 clogged in early 2005 (pre-closure)
  - Media in Cell 2 (ZVI with pea gravel) replaced
- Site closed, late 2005
- Temporary Modification through 2009 for nitrate standard in North Walnut Creek (100 mg/L)

SPPTS (continued)

SPPTS at site closure



SPPTS (continued)

- In 2006, following site closure:
  - Changed influent monitoring location to represent actual influent
    - From “SPPMM02” to “SPIN”
  - Identified and repaired damaged plumbing
  - Repair costs high
  - Began evaluating design improvements
    - Deep, inaccessible media and plumbing
    - Effluent recontaminated by downgradient groundwater
- Lack of line power
  - Adds complexity, difficulty
  - Reduces options (especially “off-the-shelf” approaches, components)
    - System components must be passive or compatible with small-scale solar power arrays or manual labor

SPPTS (continued)

Investigations and repair, 2006

SPPTS (continued)

- Kicked off first of several treatability studies
  - Colorado State University studies, 2006 and 2007
  - Targeted subsurface sampling, 2007
    - Potholed to intercept and collect water samples from downgradient ITS lines draining to Discharge Gallery

SPPTS (continued)

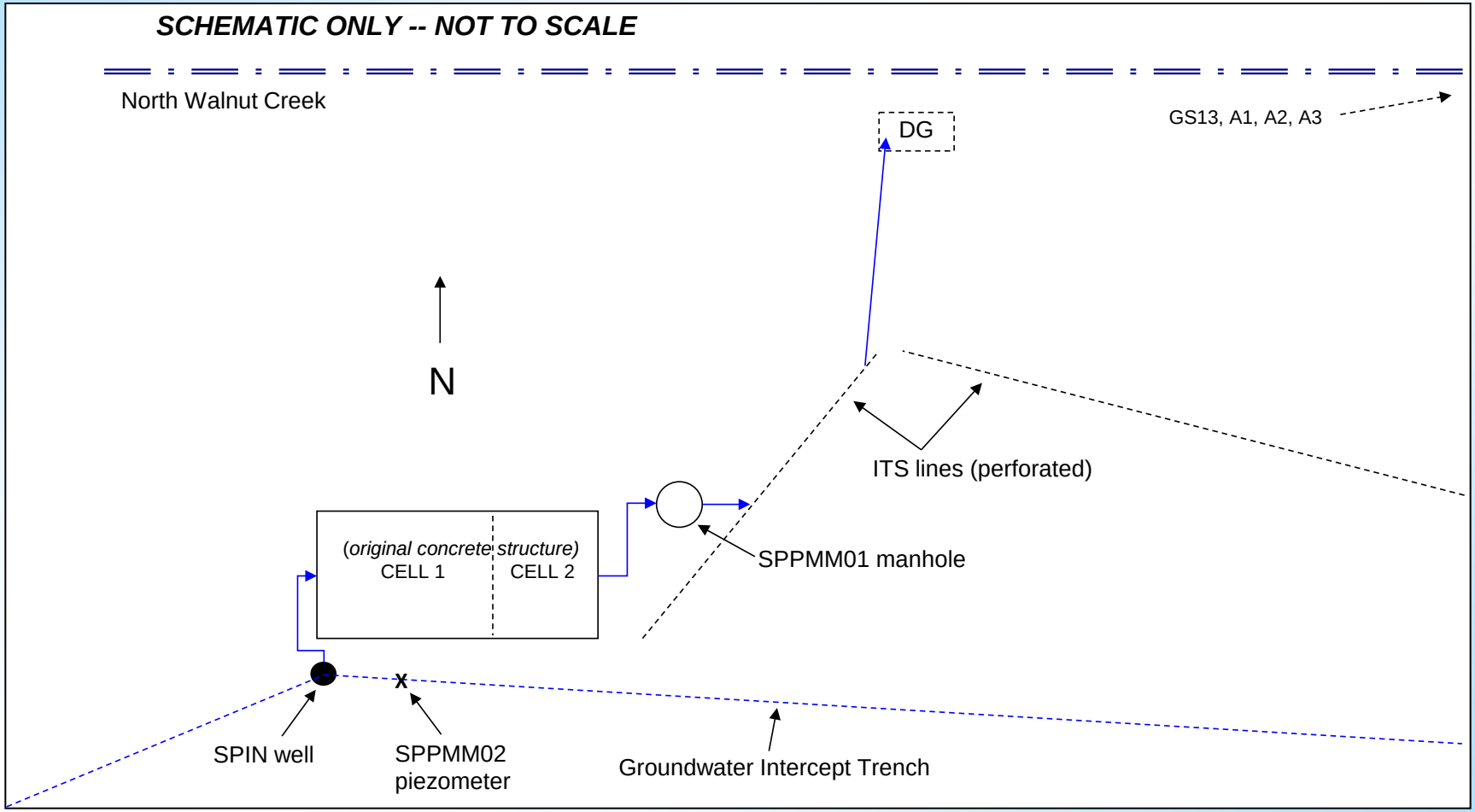
- Several reasons for considering upgrades to system
  - Original SPPTS costly, difficult to maintain
  - Meeting underlying drinking water standard for nitrate (10 mg/L, as opposed to 100 mg/L Temporary Modification) would require improved collection and treatment
  - Desire to treat uranium first, to allow nitrate treatment media to be disposed of as sanitary waste
- Began laboratory and bench-scale tests of different treatment components and approaches, 2008

SPPTS (continued)

- Phased upgrades conceived in 2008
  - Phase I: Collect, treat more of the contaminated groundwater
    - Water quality at Discharge Gallery showed a portion of the plume was not being intercepted
  - Phase II: Install new uranium treatment cell
    - Easily accessible
    - First in treatment train, so nitrate treatment media would not be potentially contaminated
  - Phase III: Install pilot-scale treatment cells and operate pilot studies to identify more efficient method of nitrate treatment
  - Phase IV: Install full-scale nitrate treatment component based on previous testing and results

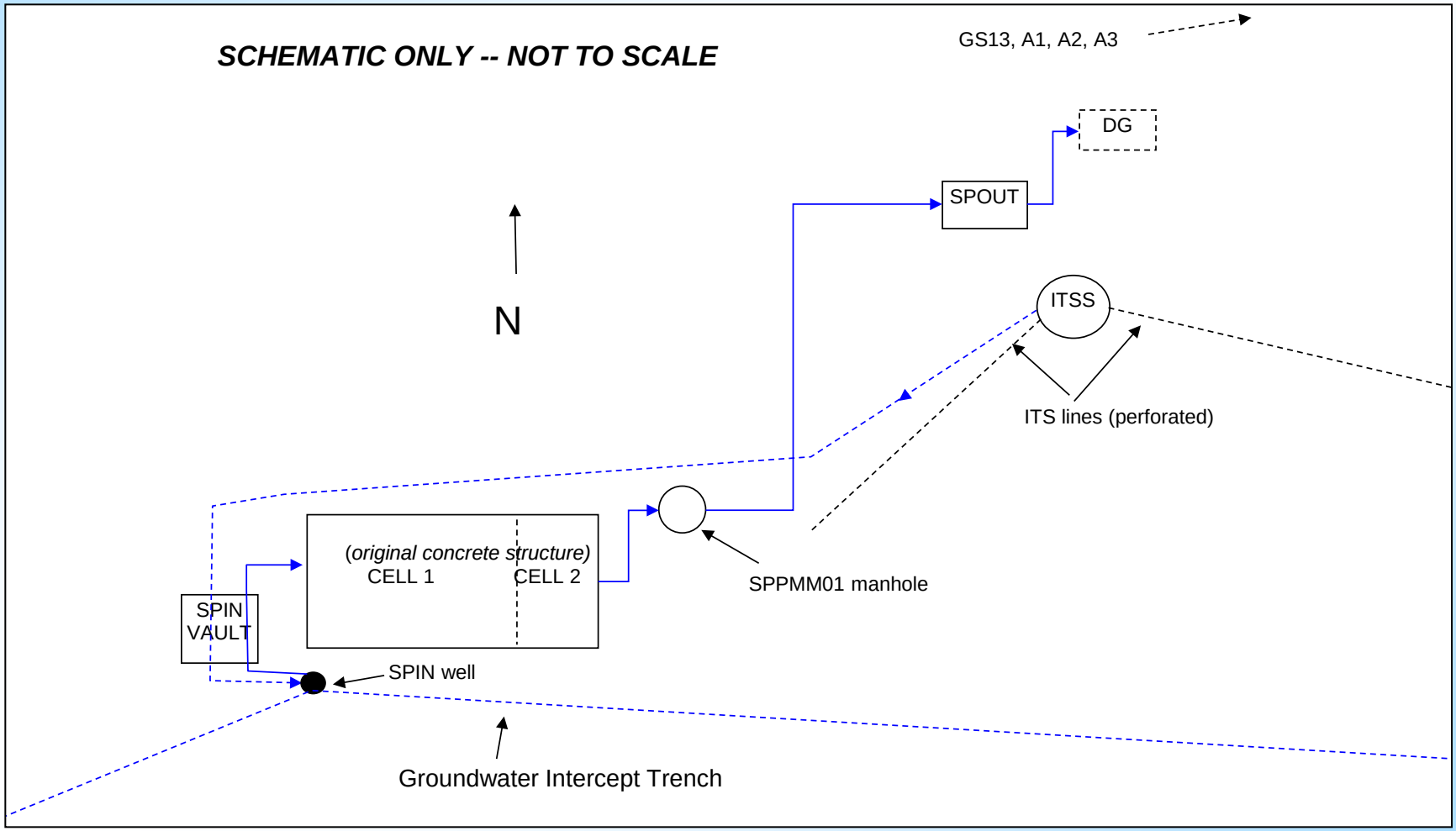
SPPTS (continued)

SPPTS at site closure



SPPTS (continued)

SPPTS with Phase I upgrades (ITSS, transfer and effluent lines, SPOUT vault)



SPPTS (continued)

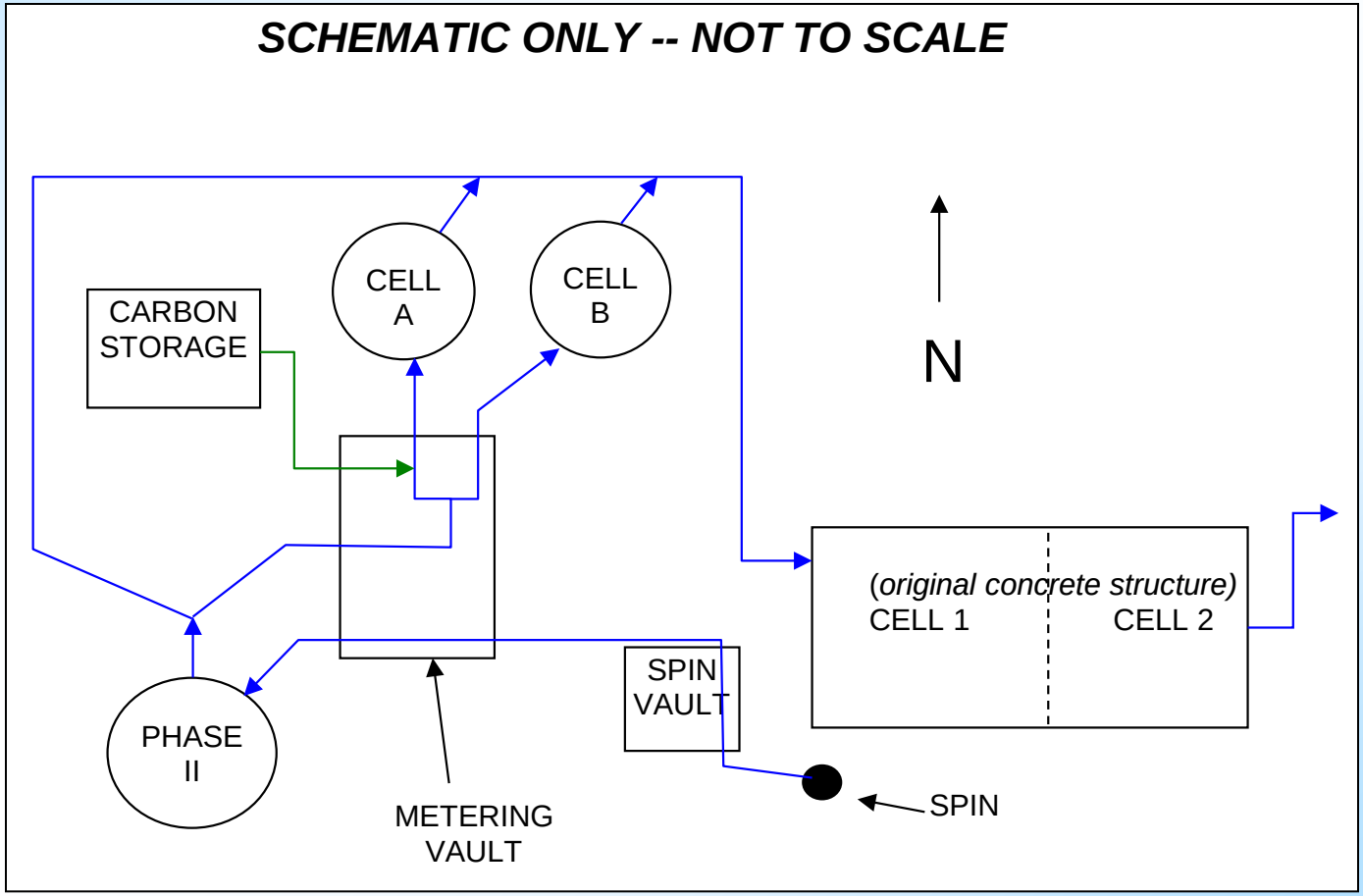
- Phase I upgrade, 2008
  - Captures more contaminated water
  - Uses new effluent line instead of ITS segment to convey treated effluent

Time Period	Average Volume Treated Per Year (gal)
Overall, 2000–2013	324,000
Pre-Closure, 2000–2005	194,500
Post-Closure, 2006–2013	442,500
Pre-Phase I Upgrades, 2000–2008	215,800
Post-Phase I Upgrades, 2009–2013	553,000

- Pre-Phase I influent nitrate averaged 276 mg/L, uranium 52 ug/L
- Post-Phase I influent nitrate averages 610 mg/L, uranium 69 ug/L (through 2013)

SPPTS (continued)

SPPTS treatment components with Phase II (uranium treatment), Phase III (pilot-scale nitrate treatment) upgrades



SPPTS (continued)

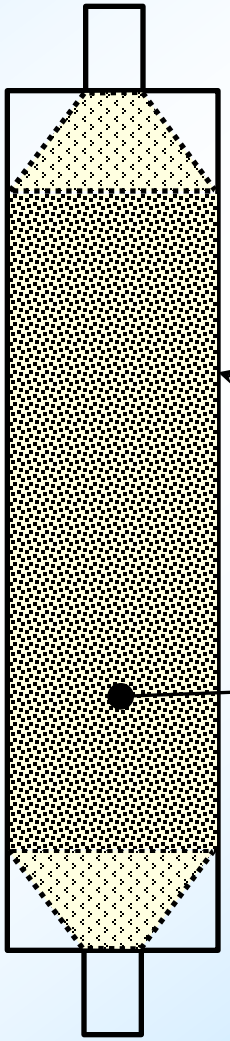
Phase II (uranium treatment)

- Media and plumbing are easily accessed
- First step in treatment train
  - Avoids potential for contaminating nitrate treatment media
- Based on successful lab tests of SPPTS influent
- Results: Uranium breakthrough within several weeks
  - Developed hypotheses
  - Replaced media, addressing several hypotheses
  - Results similar to original media – early uranium breakthrough
- Why? Probable reason: high concentrations of nitrate oxidized ZVI media so it was no longer effective

SPPTS (continued)

- Developed “microcell” approach to uranium treatment
  - Operation resembles successful lab tests (short residence time)

What is a “microcell”?



SPPTS (continued)

Results of moving from “treatment cell” approach to “microcells” on volume of spent media requiring disposition

From this

To this
(several at a time)

SPPTS (continued)

- Microcell media designs tested for uranium treatment
  - Ion exchange resins
  - ZVI (various grades, manufacturers)
  - Mixtures of ZVI of different grades, manufacturers
  - Steel wool (various grades)
  - Mixtures of ZVI plus other materials
    - Steel wool, sand, gravel, sawdust
- Different flow rates, microcell volumes
- Different media have different constraints (such as effective lifetimes, appropriate flow rates)
- Currently testing mixtures of ZVI and sawdust
- Recently added plumbing to support future tests of microcells using effluent from Phase III pilot-scale nitrate treatment cells

SPPTS (continued)

- Phase III (nitrate treatment)
- Nitrate treatment achieved via denitrifying bacteria
- First: Testing to identify promising approaches
  - Different organic media
    - Several treat better than sawdust
  - Dosing with different liquid carbon-containing nutrients
    - Alcohols, brewery byproducts, proprietary liquids
    - Wide variations in effectiveness, handling/management/storage, product consistency and availability
  - Different substrates
    - Pea gravel, engineered plastic pieces
- Designed two tests to be conducted at pilot scale
  - Cell A: Liquid carbon source (“MicroCg”) and engineered plastic substrate
  - Cell B: Corn stover (organic media)

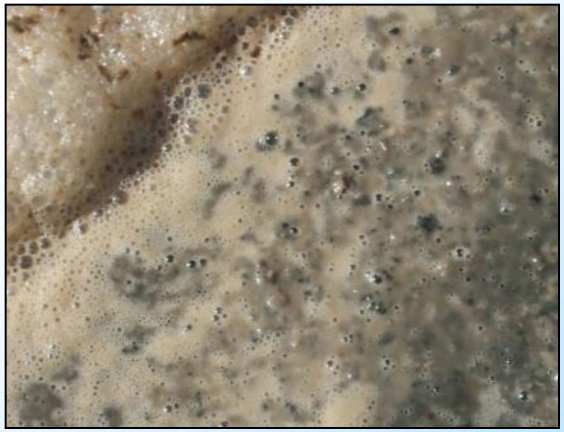
SPPTS (continued)

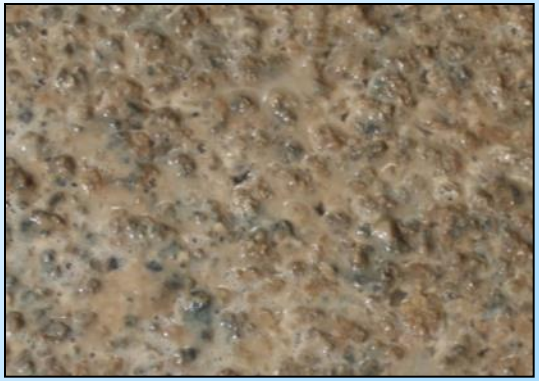
- Pilot-scale nitrate treatment cell tests
  - First round concluded 2012
  - Cell A: Liquid nutrient effective but leads to substrate clogging (high maintenance)

  - Cell B: Organic media inefficient (requires huge volume)

SPPTS (continued)

- Second round of pilot-scale nitrate treatment tests underway
  - Based on “lagoon” approach to treating nitrate
    - No substrate or media to clog
    - Successful bench-scale tests in 2012
  - Pilot-scale testing
    - Recirculation
    - Residence time and flow rate
    - Seasonal effects





SPPTS (continued)

- Potential path forward
  - Microcells for uranium treatment
    - Continue testing to determine optimal treatment media for raw influent
    - Testing microcells using lagoon effluent
      - May require effluent polishing (settling, filtration, sterilization) to reduce clogging
      - May require different media design
    - Results drive design of uranium treatment component
      - How many microcells, what size, what media, effective lifetime….
  - Lagoons for nitrate treatment
    - Continue testing to determine response to cold weather, suitable controls
    - Provide effluent to test with downstream uranium-treating microcells
    - Results drive design of nitrate treatment component
  - Anticipated timing of installed full-scale components: 2016

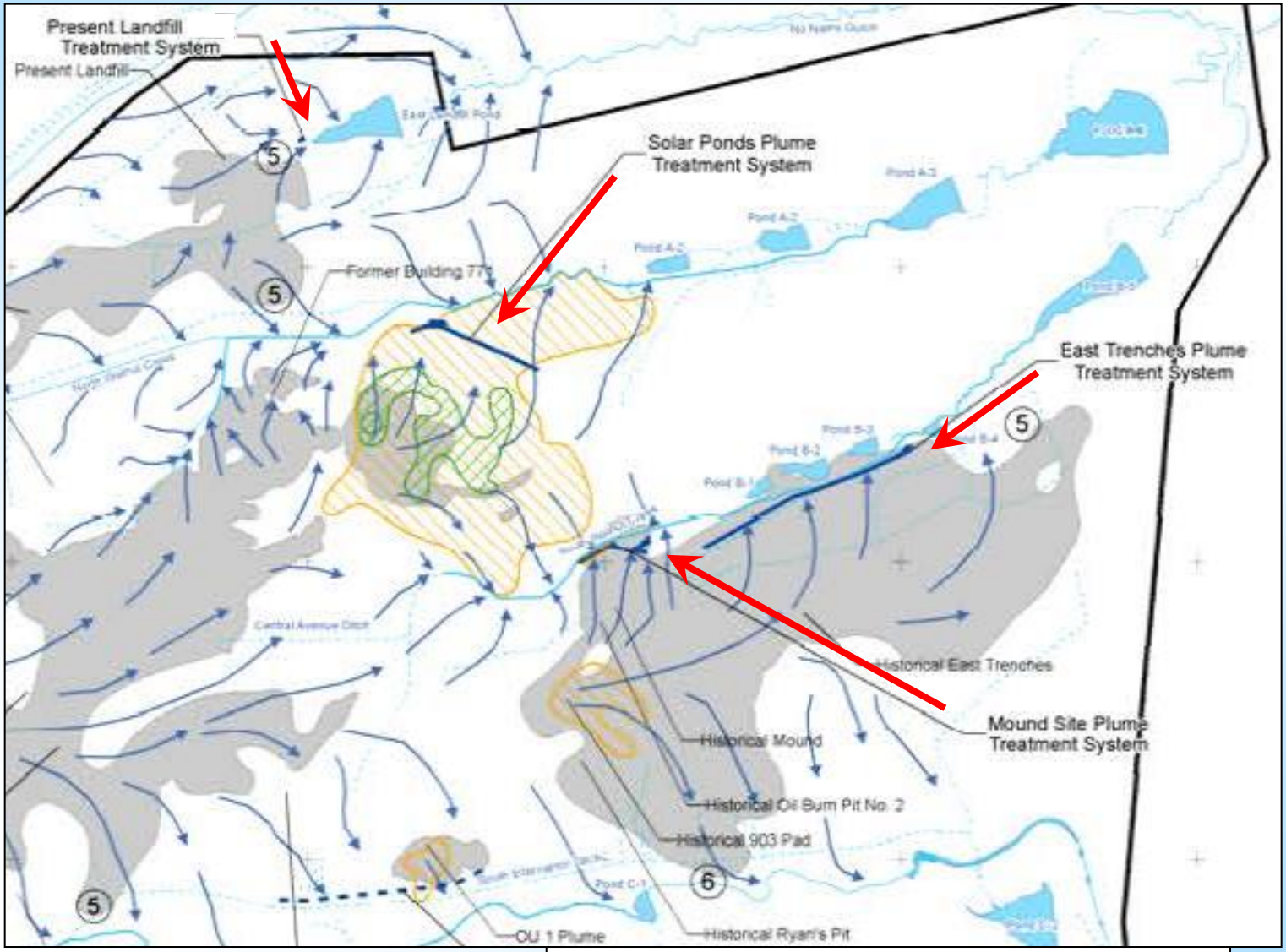
Summary and Conclusions

- Rocky Flats has four treatment systems
  - Each designed to reduce load
  - Each originally designed to be 100 percent passive
- CERCLA process requires consideration of new technologies
- RFLMA requires effluent meet Table 1 levels
- Adjustments to systems are result of several factors, such as:
  - RFLMA requirements more stringent than original treatment objectives
  - CERCLA 5-year review process
  - Need for environmentally-sensitive, cost-effective, efficient systems
  - Requirements for maintenance and spent media disposition

Summary and Conclusions (continued)

- PLFTS is very simple, influent has very little load
- MSPTS and ETPTS are more complex
  - Greater influent contaminant loads than PLFTS
  - Both now incorporate air stripping
  - ETPTS undergoing additional reconfiguration right now
- SPPTS is complex
  - Partly due to history, setting
  - Undergoing lengthy testing to support ultimate reconfiguration
- Adjustments can be expected to continue, episodically
- Updates will be provided in quarterly and annual reports, and in presentations to RFSC

Questions?



Modified after RFLMA Attachment 2, Figure 2, December 2012, Page 25