Appendix B. Documentation and Analysis of Interpreted CFC, SF_6, and $^3H/^3He$ Data

Tracer data from a total of 812 sites are summarized in table 1 in the body of the report. The tracer data interpretations for these sites, along with selected ancillary chemical and well construction data, are presented in this appendix and are organized by Study Unit and network. Tables mentioned in this appendix are available for download as Microsoft© Excel files at http://pubs.usgs.gov/sir/2012/5141/.

A synopsis is given for each network, which includes:

- Number of wells in each network,
- Year of sample collection,
- Tracer(s) that were analyzed in the samples,
- General type of aquifer materials,
- Relevant notes about the approach used for estimating recharge temperature and (for CFCs and SF_6) excess air,
- A list of some of the notable advantages and disadvantages associated with the datasets,
- Range of water-level depths,
- A plot of tracer-based piston-flow age versus depth below water table (age gradient), (a reconstructed ^3H plot (where ^3H data were available), and
- A tracer-tracer comparison where possible.

The data also are presented in tables B1-B57 that include the raw tracer data, major dissolved-gas data, and the ancillary chemical and well construction data that are used in the interpretations.

The three types of figures used in this appendix (age gradient plots, reconstructed ^3H plots, and tracer age comparisons) can provide insight into tracer interpretations and the hydrologic systems associated with the tracer results. This was addressed in detail in Hinkle and others (2010) and will not be repeated in this discussion because the same procedures were used in the tracer interpretations.

Study Unit abbreviations in this appendix are defined in table A1 (appendix A). Network names in this appendix are as listed in the NAWQA DWH (http://infotrek.er.usgs.gov/traverse/f?p=NAWQA:HOME:0:). Well construction, water level, and ancillary chemistry data are from the NAWQA DWH.

Reference Cited

Hinkle, S.R., Shapiro, S.D., Plummer, L.N., Busenberg, E., Widman, P.K., Casile, G.C., and Wayland, J.E., 2010, Estimates of tracer-based piston-flow ages of groundwater from selected sites—National Water-Quality Assessment Program, 1992–2005: U.S. Geological Survey Scientific Investigations Report 2010-5229, 90 p. (Also available at http://pubs.usgs.gov/sir/2010/5229/.)

ACAD LUSRC1

Samples from seven sites in the ACAD Study Unit were collected during 2007 for CFCs and SF_6 (network and, in parentheses, number of sites):

. LUSRC1 (7)

. The wells were installed in the coastal lowlands aquifer system of the Chicot aquifer, Upper sand unit.

. Major dissolved-gas data were available for all seven sites. Of these seven sites, only one was oxic and one site was degassed.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table, that recharge temperature was equal to the mean annual air temperature +1°C, and that excess air concentrations were 2 cc STP/kg.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B1.

. Advantages associated with these samples:

. Short open intervals (10 feet).

. Median penetration of center of open interval into water table was 14.37 feet (sampling close to the water table, potentially minimizing mixing).

. Monitoring wells, therefore low pumping stress.

. Multiple tracers (CFCs and SF_6, as well as major dissolved gases).

. Disadvantages associated with these samples:

. Most sites were suboxic and one site degassed, so major dissolved-gas data not useful for defining recharge temperatures and excess air.

. CFC data affected by degradation due to suboxic conditions.

. Large discrepancy in recharge temperature estimates from major dissolved-gas data and MAAT +1°C.

. Depth to water (can affect tracer transport to water table):

. Median: 49.48 feet

. Mean: 49.92 feet

. Min: 41.51 feet

. Max: 63.14 feet

. Brief analysis:

. The SF_6-based age gradient for these sites is shown in figure B1. There is no increase in age with depth. LUS wells generally are designed to be located in recharge areas; the large range in tracer ages at similar depths, however, indicates that these wells may be located in both recharge and discharge areas. Alternatively, the samples with the oldest SF_6-based ages correspond to the most degraded CFC samples, as well as samples that had methane present, indicating that degassing issues, such as gas stripping, may have altered the SF_6 concentrations leading to the older SF_6-based ages.

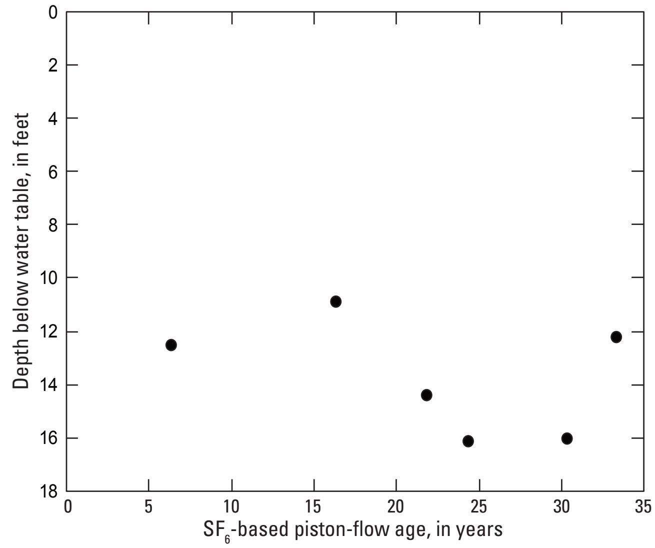

Figure B1. SF_6-based age gradient for dated sites from the LUSRC1 network, ACAD Study Unit.

ACAD SUS1

Samples from the ACAD Study Unit were collected during 2007 and 2008 for CFCs, SF_6, and $^3H/^3He$ (network and, in parentheses, number of sites):

. SUS1 (CFCs, 7 in 2007; SF_6, 7 in 2007, $^3H/^3He$, 19 in 2008).

The wells were installed in the coastal lowlands aquifer system of the Chicot aquifer, Upper sand unit, and the 20-foot sands of the Lake Charles Area.

Major dissolved-gas data were available for 7 sites in 2007 and 18 sites in 2008. Of the seven sites from 2007, three were oxic and four were suboxic. Of the 18 sites in 2008, only 1 site was oxic and 17 sites were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table, that recharge temperature was equal to the mean annual air temperature +1°C, and that excess air concentrations were 2 cc STP/kg.

$^3H/^3He$ ages were calculated for only 6 sites (only 1 of the 6 sites required a correction for terrigenic He), while 13 sites were not datable due to low tritium concentrations.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B2.

- Advantages associated with these samples:
  - Multiple tracers (CFCs, SF_6, and $^3H/^3He$, as well as major dissolved gases).
- Disadvantages associated with these samples:
  - Open intervals of wells range from 5 to 30 feet.
  - Median penetration of center of open interval into water table was 85.61 feet (not sampling close to the water table).
  - Domestic wells.
  - Generally highly reducing conditions. Only four sites contained >1 mg O_2/L (field O_2). Of the 25 samples with major dissolved-gas data, 18 contained detectable CH_4.
  - CFC data affected by degradation due to suboxic conditions.
  - Large discrepancy in recharge temperature estimates from major dissolved-gas data and MAAT +1°C.
- Depth to water (can affect tracer transport to water table):
  - Median: 51.00 feet
  - Mean: 50.85 feet
  - Min: 4.33 feet
  - Max: 91.01 feet
- Brief analysis:
  - The SF_6- and $^3H/^3He$-based age gradients for these sites are shown in figures B2 and B3. SUS wells generally are randomly distributed wells (usually domestic supply wells), and the SUS wells in this ACAD network are domestic wells and generally are fairly deep. Despite the randomness of the distribution of the wells, there is an age structure with generally increasing tracer-based piston-flow age with increasing depth below the water table. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

The reconstructed ^3H plots for CFC-, SF_6-, and $^3H/^3He$-based ages are shown in figures B4, B5, and B6. With only two datable CFC samples, and four datable SF_6 samples, there is limited value in the reconstructions. The $^3H/^3He$-based reconstruction, however, shows at least four samples that appear to be relatively unmixed and represent piston-flow transport, while two samples appear to be affected by mixing processes or diffusive ^3He loss. In addition, many of the $^3H/^3He$ samples that were not datable due to low tritium concentrations are still useful in determining that the water in these locations is old.

The SF_6- versus CFC-based age comparison for this network is shown in figure B7. The three sites sample oxic water and are not affected by suboxic conditions that would cause CFC-degradation. The age comparison for the three sites is good, but is complicated by the fact that the CFC-based ages appear to extend beyond the range of SF_6-based dating capability.

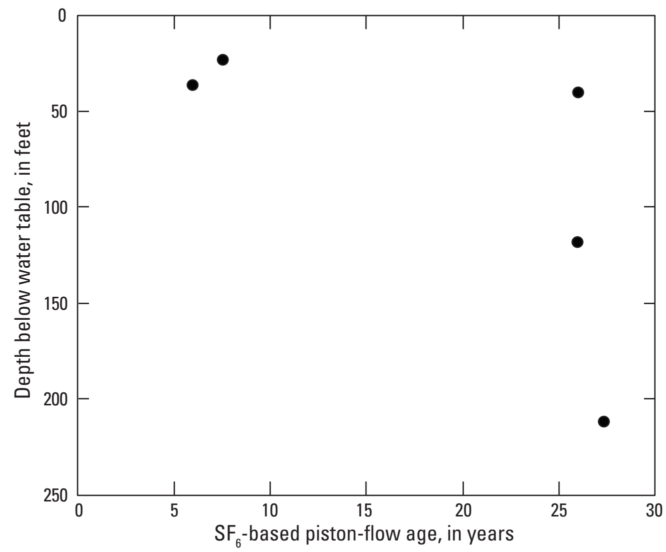

Figure B2. SF_6-based age gradient for dated sites from the SUS1 network, ACAD Study Unit.

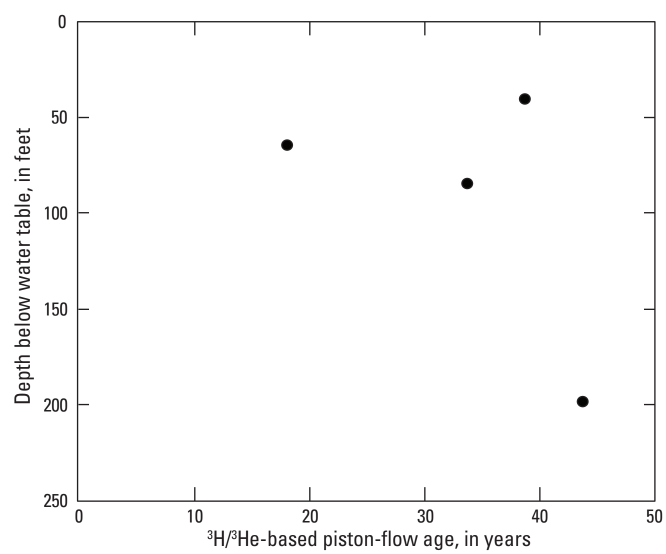

Figure B3. $^3H/^3He$-based age gradient for dated sites from the SUS1 network, ACAD Study Unit.

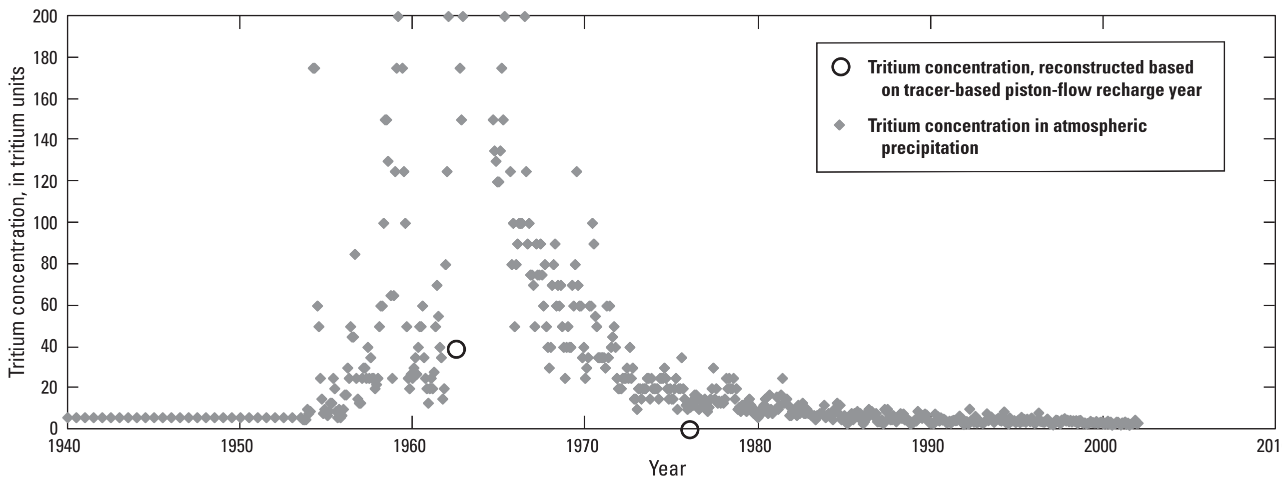

Figure B4. Reconstructed tritium concentrations (using CFC-based ages) and tritium in atmospheric precipitation, SUS1 network, ACAD Study Unit.

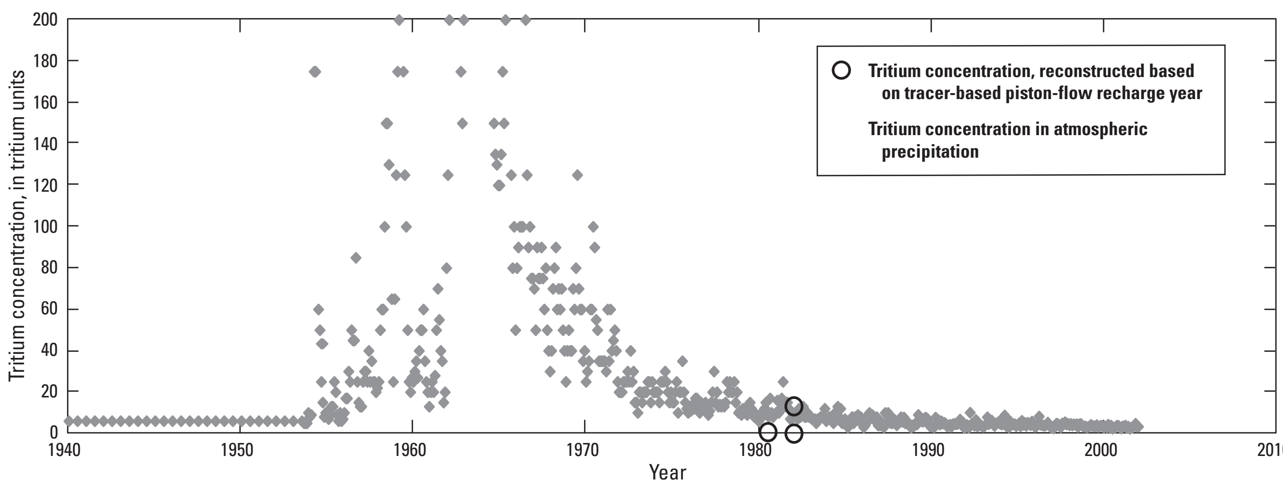

Figure B5. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, SUS1 network, ACAD Study Unit.

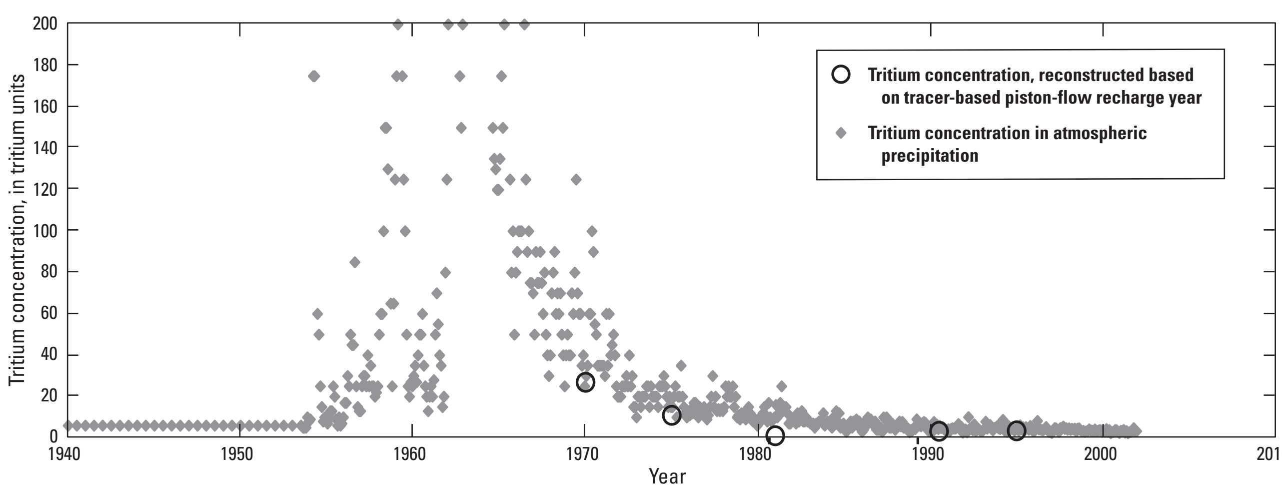

Figure B6. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, SUS1 network, ACAD Study Unit.

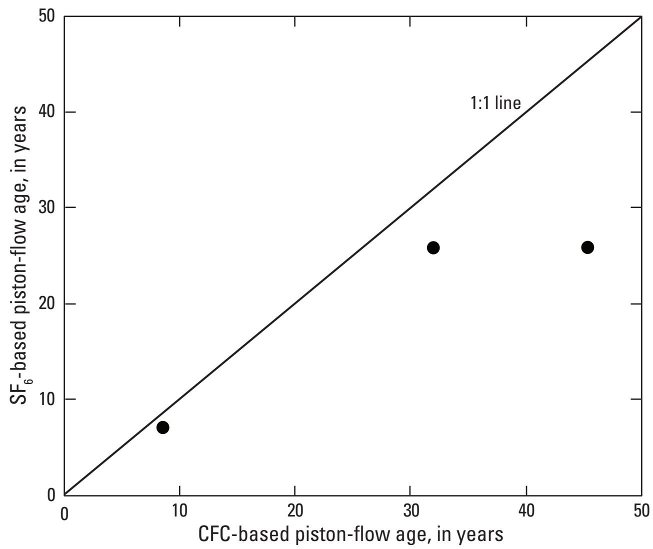

Figure B7. SF_6- versus CFC-based age comparison, SUS1 network, ACAD Study Unit.

ACFB SUS1, LUSCR3, and REFFO4

Samples from 12 sites in the ACFB Study Unit were collected in 2007 for CFCs and $^3H/^3He$ (networks and, in parentheses, number of sites):

- SUS1 (5)
- LUSCR3 (5)
- REFF04 (2)

The aquifer is composed of limestone (of the Floridian Aquifer System) and residium (of the surficial aquifer).

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table, that recharge temperature was equal to the mean annual air temperature +1°C, and that excess air concentrations were 2 cc STP/kg.

$^3H/^3He$ ages were calculated for 10 sites (none of the sites required a correction for terrigenic He), while 2 sites were not datable due to fractionation.

The raw tracer data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B3.

- Advantages associated with these samples:
  - Multiple tracers (CFCs and $^3H/^3He$).
  - 4 domestic wells, 1 institutional well, and 7 unused wells, so generally low pumping rates.
  - All oxic sites so no problems with CFC degradation.
- Disadvantages associated with these samples:
  - No major dissolved-gas data.
  - Relatively large open intervals ranging from 3.62–63 feet.
- Depth to water (can affect tracer transport to water table):
  - Median: 39.48 feet
  - Mean: 39.71 feet
  - Min: 0.82 feet
  - Max: 101.05 feet
- Brief analysis:
  - The CFC- and $^3H/^3He$-based age gradients for these sites are shown in figures B8 and B9. The CFC-based and $^3H/^3He$-based age gradients are similar, with relatively old ages at shallow depths, but with age generally increasing with depth. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth. The $^3H/^3He$ ages are younger than the CFC ages at shallow depths, which may indicate that there was helium loss near the water table.

The reconstructed ^3H plots for CFC- and $^3H/^3He$-based ages are shown in figures B10 and B11. Both reconstructions show that samples appear to be relatively unmixed and represent piston-flow transport.

The $^3H/^3He$- versus CFC-based age comparison for this network is shown in figure B12. The age comparison is good, which indicates that the tracer-based piston-flow ages for this network can be used with a good deal of confidence.

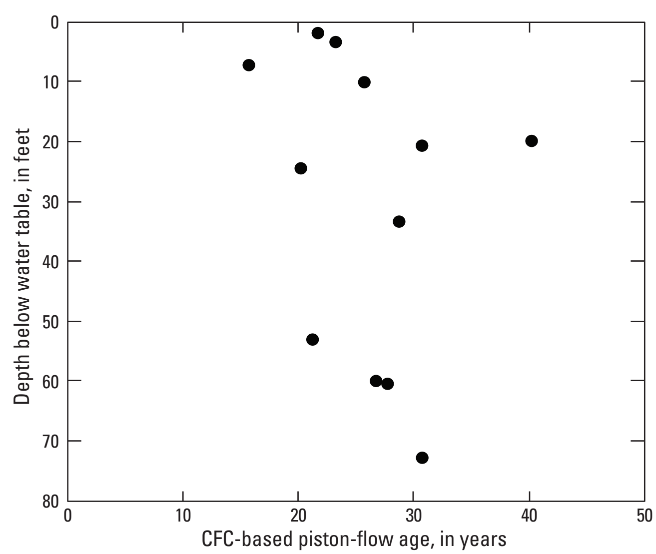

Figure B8. CFC-based age gradient for dated sites from the SUS1, luscr3, and REFF04 networks, ACFB Study Unit.

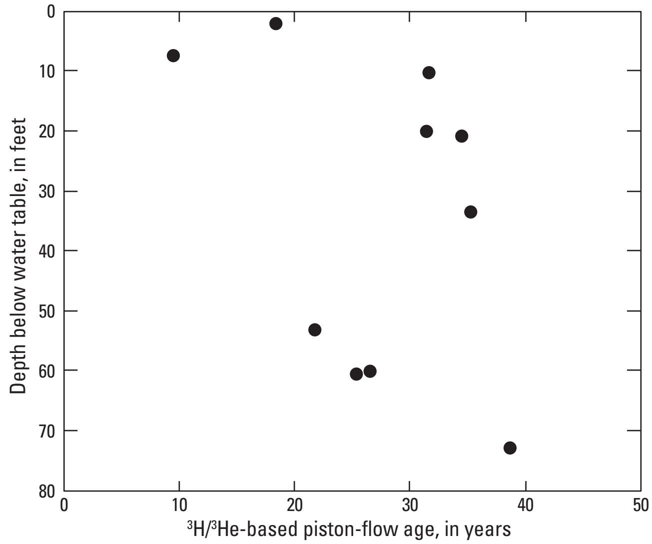

Figure B9. $^3H/^3He$-based age gradient for dated sites from the SUS1, LUSCR3, and REFF04 networks, ACFB Study Unit.

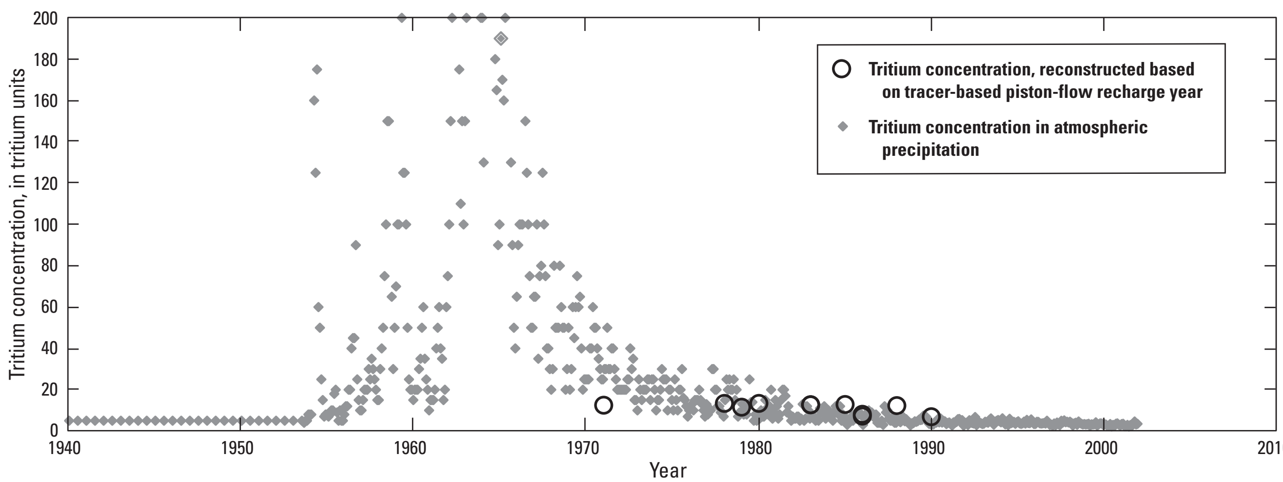

Figure B10. Reconstructed tritium concentrations (using CFC-based ages) and tritium in atmospheric precipitation, sus1, luscr3, and REFF04 networks, ACFB Study Unit.

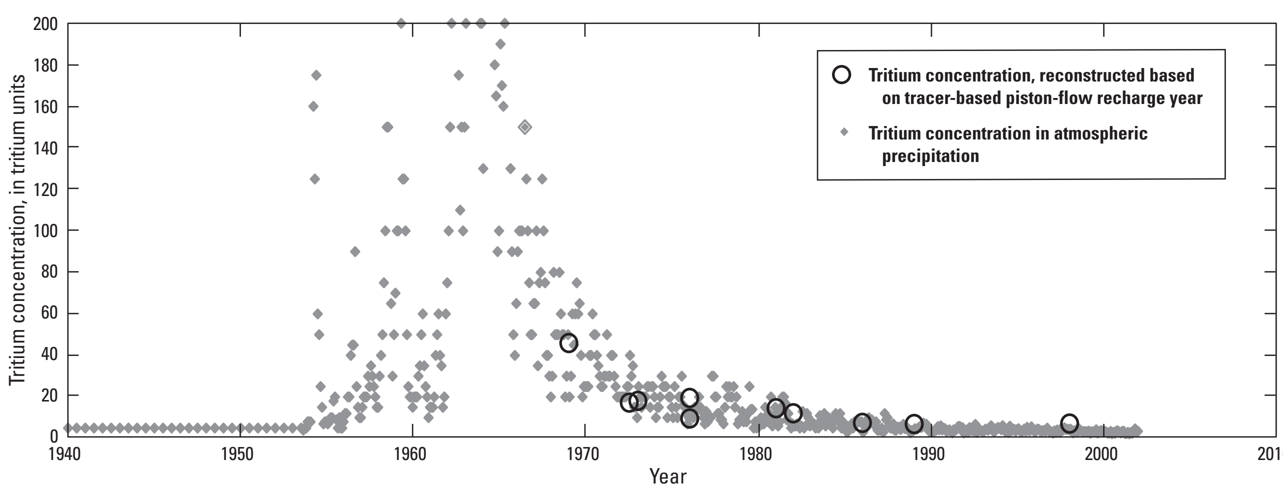

Figure B11. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, sus1, luscr3, and reff04 networks, ACFB Study Unit.

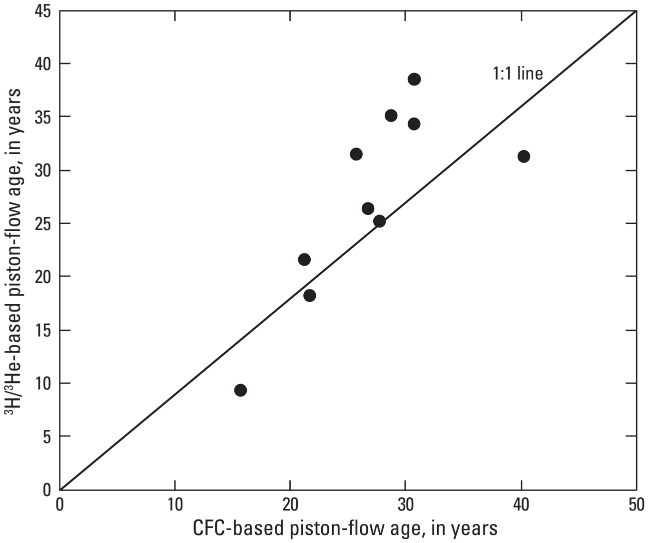

Figure B12. $^3H/^3He$- versus CFC-based age comparison, SUS1, LUSCR3, AND REFF04 networks, ACFB Study Unit.

ALBE SUS7, LUSAG1, and REFFO1

Samples from 12 sites in the ALBE Study Unit were collected in 2007 for CFCs and $^3H/^3He$ (networks and, in parentheses, number of sites):

- SUS7 (5)
- LUSAG1 (5)
- REFFO1 (2)

The aquifer is composed of limestone (of the Castle Hayne Limestone) and sand and silt (of the surficial aquifer system).

Major dissolved-gas data were available for all 12 sites. Of these 12 sites, only 1 site was oxic and 11 were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data. Although most sites were suboxic, the dissolved-gas data did not show evidence of denitrification or other problems.

$^3H/^3He$ ages were calculated for two sites (these two sites did not require a correction for terrigenic He), while five sites were not datable due to fractionation, one site was not datable due to low tritium, one site was not datable because there was no tritium measured, and samples from three sites were lost due to high pressure or other laboratory issues.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B4.

- Advantages associated with these samples:
  - Mostly unused wells drilled for water level or water quality observations, so generally low pumping rates.
  - Multiple tracers (CFCs and $^3H/^3He$, as well as major dissolved gases).
- Disadvantages associated with these samples:
  - Only one oxic site, CFCs affected by degradation.
  - Relatively large open intervals ranging from 1.87 to 33 feet so mixing likely.
  - Median penetration of center of open interval into water table was 19.83 feet (sampling close to the water table, potentially minimizing mixing).
- Depth to water (can affect tracer transport to water table):
  - Median: 6.67 feet
  - Mean: 7.78 feet
  - Min: 0.43 feet
  - Max: 26.17 feet
- Brief analysis:
  - The $^3H/^3He$-based age gradient for these sites is shown in figure B13. The $^3H/^3He$-based age gradient generally increases with depth, with very young ages near the surface and old ages at depth. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

The reconstructed ^3H plots for CFC- and $^3H/^3He$-based ages are shown in figures B14 and B15. There is only one sample in the CFC-based reconstruction, but it plots within the given range for the ^3H input function. In the $^3H/^3He$-based reconstruction, three samples (1 LUSAG, 2 REF) appear to be relatively unmixed and represent piston-flow transport, while two samples (SUS wells) appear to have been affected by dispersion and/or mixing processes. The two SUS wells are deep wells with large open intervals that likely capture water with a large range of ages.

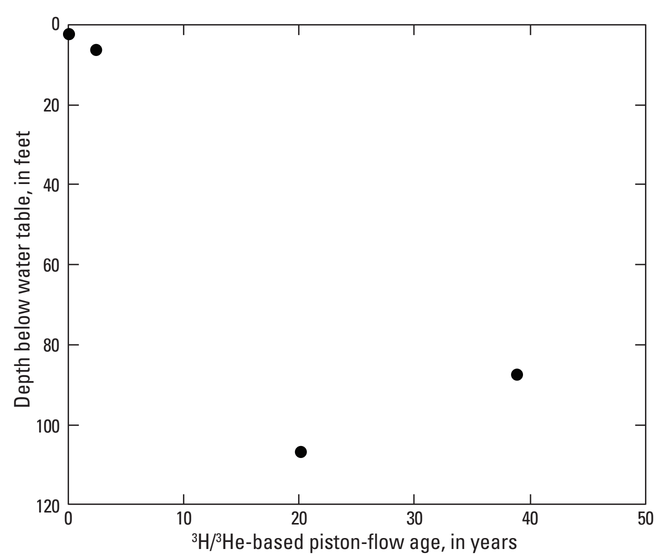

Figure B13. $^3H/^3He$-based age gradient for dated sites from the sus7, lusag1, and REFFO1 networks, ALBE Study Unit.

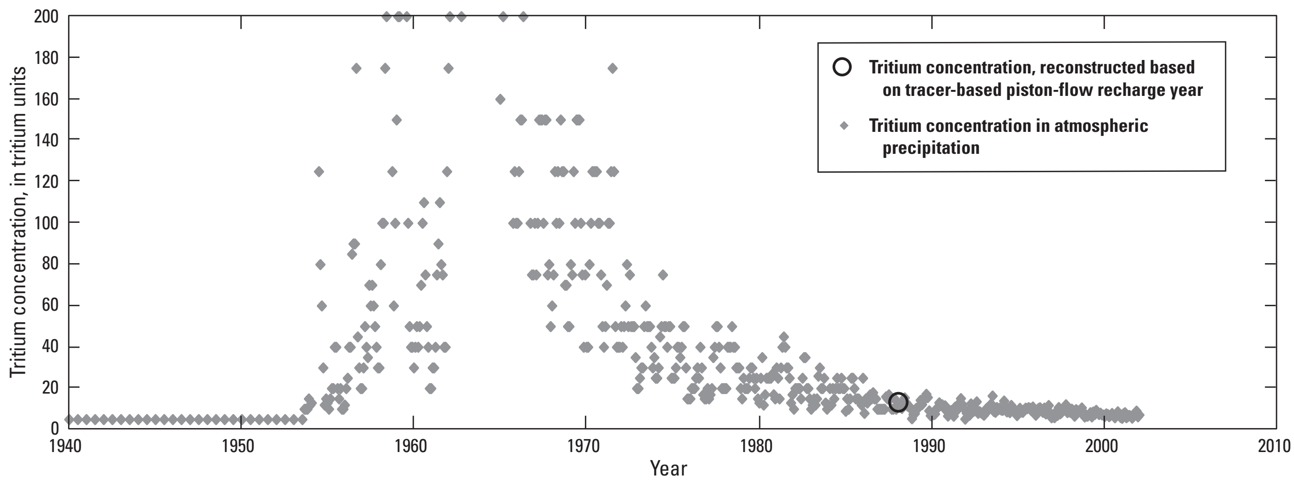

Figure B14. Reconstructed tritium concentrations (using CFC-based ages) and tritium in atmospheric precipitation, SUS7, LUSAG1, AND REFF01 networks, ALBE Study Unit.

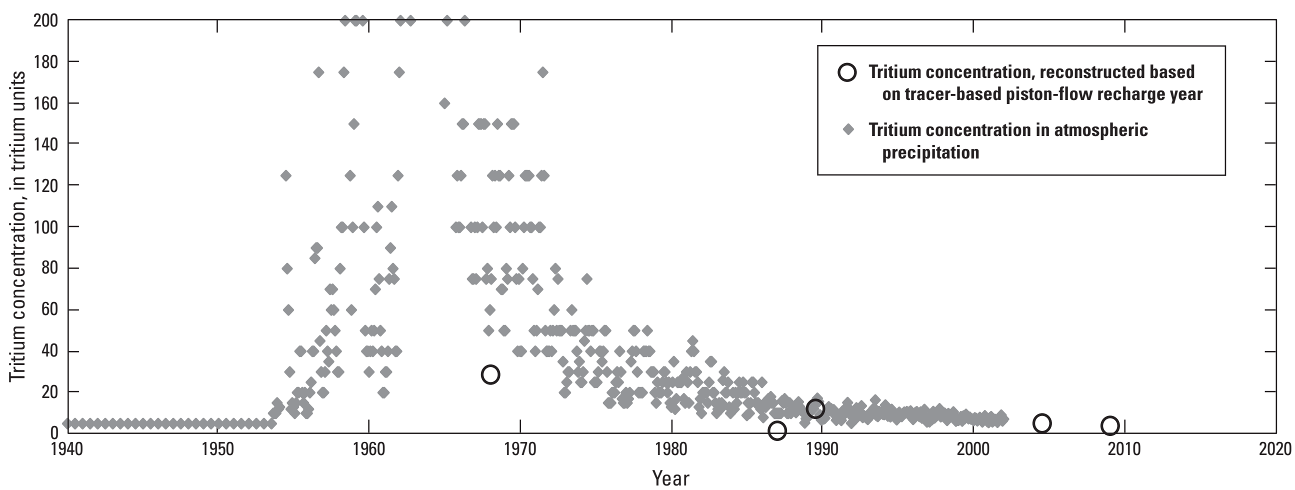

Figure B15. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, SUS7, LUSAG1, AND REFF01 networks, ALBE Study Unit.

ALBE SUS8

Samples from sites in the ALBE Study Unit were collected in 2007 for CFCs (17) and $^3H/^3He$ (5) (networks and, in parentheses, number of sites):

- SUS8 (17)

The aquifer is composed of Piedmont and Blue Ridge crystalline-rock.

Major dissolved-gas data were available for 17 sites. Of these 17 sites, 9 were oxic and 8 were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites.

$^3H/^3He$ ages were calculated for three sites (only one of the three sites required a correction for terrigenic helium), while one site was not datable due to fractionation, and the sample from one site was lost due to high pressure or other laboratory issues.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B5.

- Advantages associated with these samples:
  - Domestic wells, so generally low pumping rates.
  - Multiple tracers (CFCs and $^3H/^3He$, as well as major dissolved gases).
- Disadvantages associated with these samples:
  - Relatively large open intervals ranging from 5 to 354 feet so mixing likely.

. Median penetration of center of open interval into water table was 105.9 feet (not sampling close to the water table, potentially mixing).

. Depth to water (can affect tracer transport to water table):

. Median: 34.61 feet

. Mean: 37.62 feet

. Min: 22.07 feet

. Max: 64.9 feet

. Brief analysis:

. The age gradient for these sites is shown in figure B16. The data show a great deal of scatter, which would be expected from SUS wells with large open intervals.

The reconstructed ^3H plots for CFC- and $^3H/^3He$-based ages are shown in figures B17 and B18. Several samples plot to the right of the ^3H reconstruction, which might suggest that there is either some tritium enrichment or mixed waters. The remaining samples, however, are consistent with the ^3H input function.

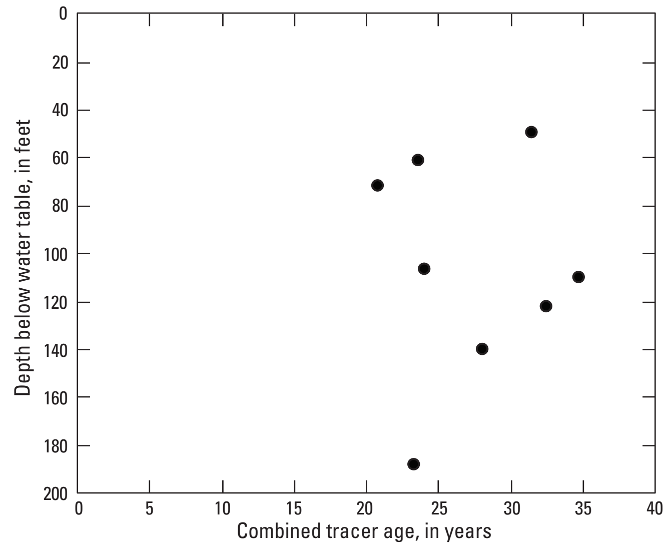

Figure B16. Age gradient for dated sites from the SUS8 network, ALBE Study Unit.

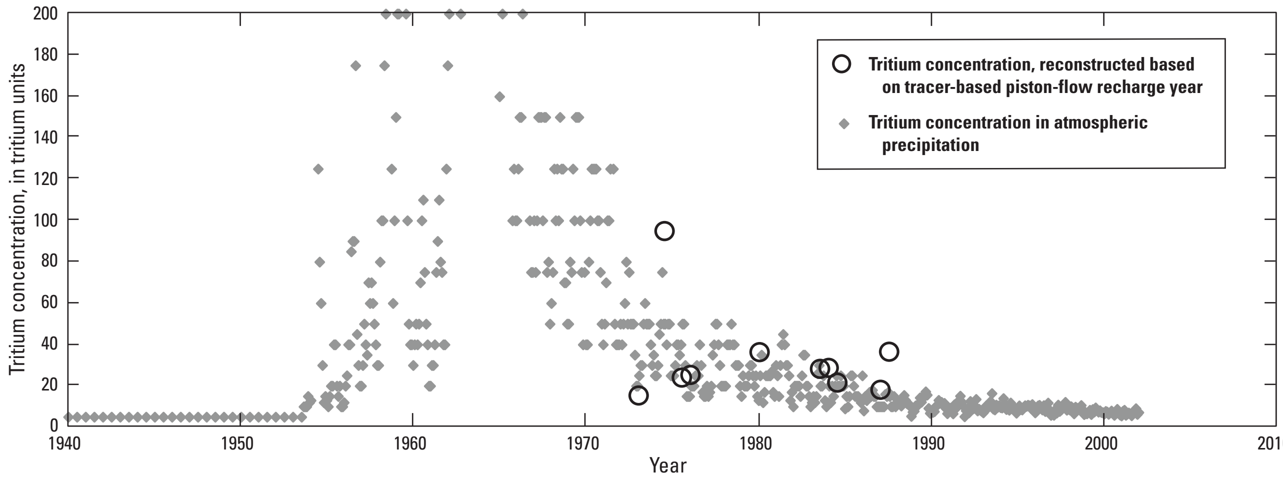

Figure B17. Reconstructed tritium concentrations (using CFC-based ages) and tritium in atmospheric precipitation, SUS8 network, ALBE Study Unit.

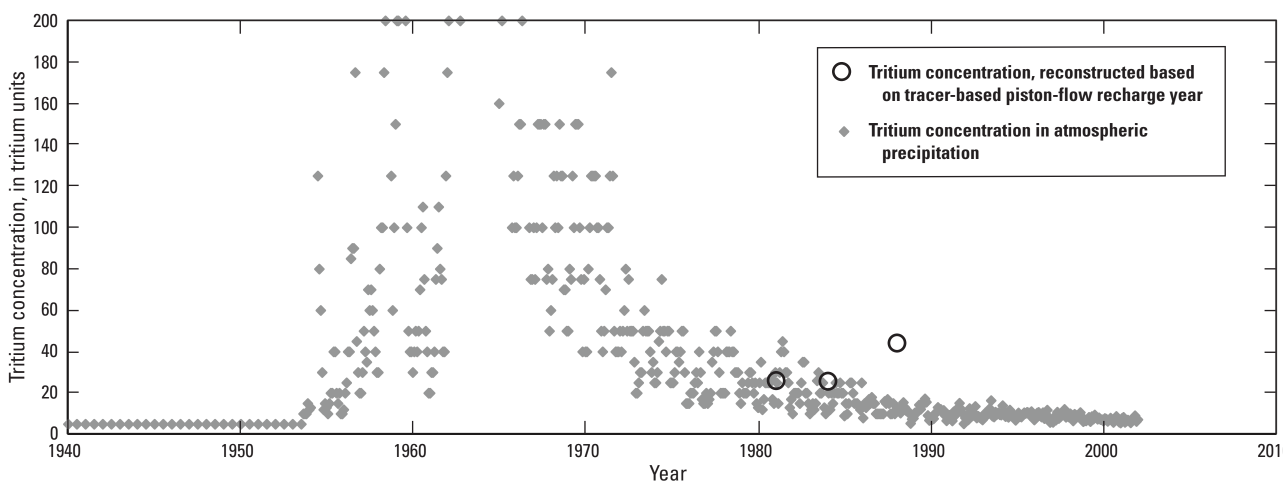

Figure B18. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, SUS8 network, ALBE Study Unit.

CAZB SUS1a

Samples from 8 sites in the CAZB Study Unit were collected in 2008 for $^3H/^3He$ (networks and, in parentheses, number of sites):

- SUS1a ($^3H/^3He$, 8; major dissolved gases, 35)

The aquifer is composed of Basin and Range basin-fill sands, gravel, clay, and conglomerates.

Major dissolved-gas data were available for 35 sites. Of these 35 sites, 29 were oxic and 6 were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites.

$^3H/^3He$ ages were calculated for eight sites (only one of the eight sites required a correction for terrigenic helium).

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B6.

- Advantages associated with these samples:
    - $^3H/^3He$, as well as major dissolved gases.
- Disadvantages associated with these samples:
    - Mixture of domestic, irrigation, stock, and public supply wells, so variable pumping rates.
    - Relatively large open intervals ranging from 4 to 650 feet so mixing likely.
    - Median penetration of center of open interval into water table was 212.9 feet (not sampling close to the water table, potentially mixing).
- Depth to water (can affect tracer transport to water table):
    - Median: 208.61 feet
    - Mean: 218.36 feet
    - Min: 7.36 feet
    - Max: 619.06 feet
- Brief analysis:
    - The $^3H/^3He$-based age gradient for these sites is shown in figure B19. Despite sampling from a mixture of well types, with relatively deep unsaturated zones and long open intervals, there is a structure to the age gradient with young ages at shallow depths and older ages at deeper intervals. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

The reconstructed ^3H plot for CFC-based ages is shown in figure B20. The reconstruction shows that samples appear to be relatively unmixed and represent piston-flow conditions.

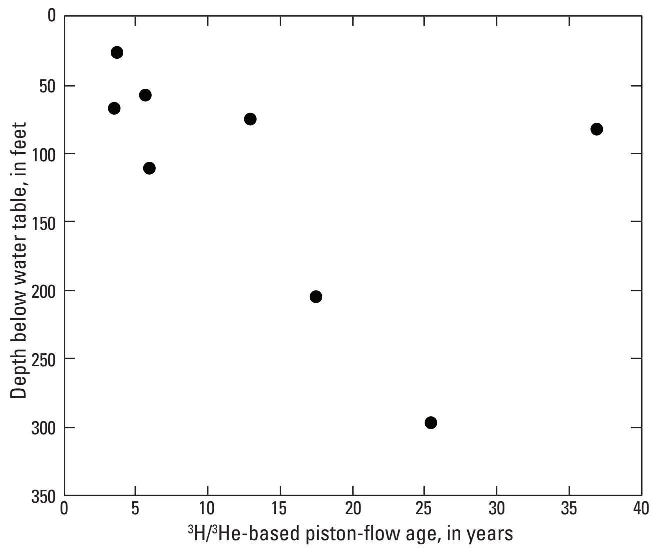

Figure B19. $^3H/^3He$-based age gradient for dated sites from the SUS1a network, CAZB Study Unit.

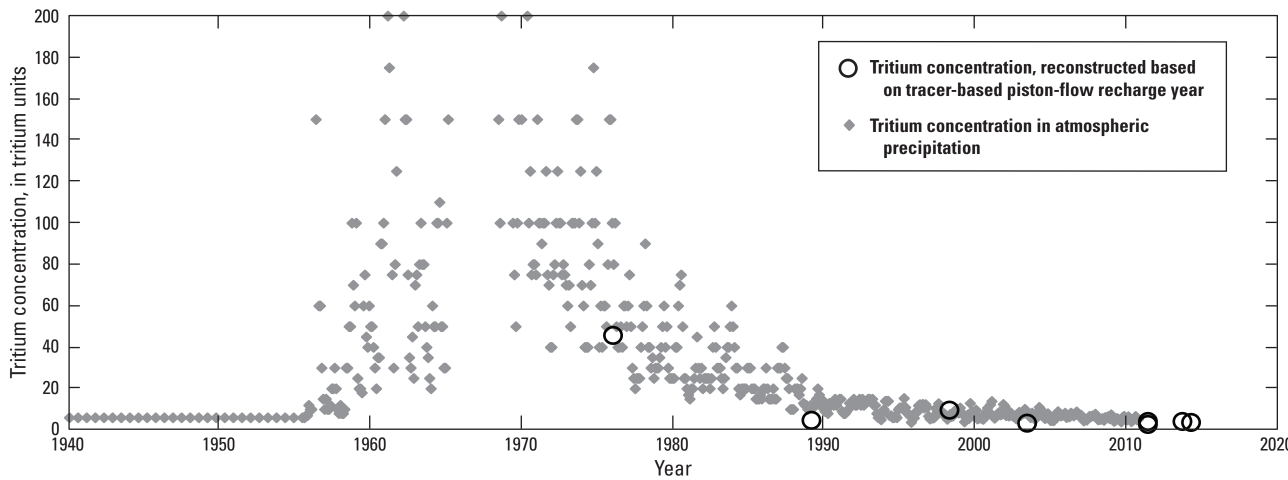

Figure B20. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, SUS1a network, CAZB Study Unit.

CCYK CCPTLUSAG2b

Samples from five sites in the CCYK Study Unit were collected in 2008 for CFCs, SF_6, and $^3H/^3He$ (networks and, in parentheses, number of sites):

- CCPTLUSAG2b (5)

The aquifer is composed of sand, silt, gravel, and clay.

Major dissolved-gas data were available for all five of the sites samples. Of these five sites, all five were oxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data.

$^3H/^3He$ ages were calculated for three sites (no sites required a correction for terrigenic He), while two sites were not datable because of fractionation.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B7.

- Advantages associated with these samples:
  - Monitoring wells, so generally low pumping rates.
  - Multiple tracers (CFCs, SF_6, and $^3H/^3He$, as well as major dissolved gases).
  - Relatively small open intervals ranging from 5 to 15 feet so mixing minimized.
  - Median penetration of center of open interval into water table was 14.91 feet (sampling close to the water table, potentially reduces mixing).
- Disadvantages associated with these samples:
  - None.
- Depth to water (can affect tracer transport to water table):
  - Median: 40.11 feet
  - Mean: 33.4 feet
  - Min: 4.45 feet
  - Max: 66.86 feet
- Brief analysis:

The CFC-, SF_6-, and $^3H/^3He$-based age gradients for these sites are shown in figures B21, B22, and B23. All three gradients show a general structure of increasing age with depth, however, the $^3H/^3He$ ages are somewhat younger in the shallow wells indicating possible helium loss near the water table. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

The reconstructed ^3H plots for CFC-, SF_6-, and $^3H/^3He$-based ages are shown in figures B24, B25, and B26. The three reconstructions are similar, and all of them have samples that plot above the ^3H input function.

The $^3H/^3He$- versus CFC-based age comparison and the SF_6- versus CFC-based age comparison for this network are shown in figures B27 and B28. The age comparisons show the same bias of younger $^3H/^3He$ ages, likely resulting from degassing near the water table, but comparable CFC- and SF_6-based ages.

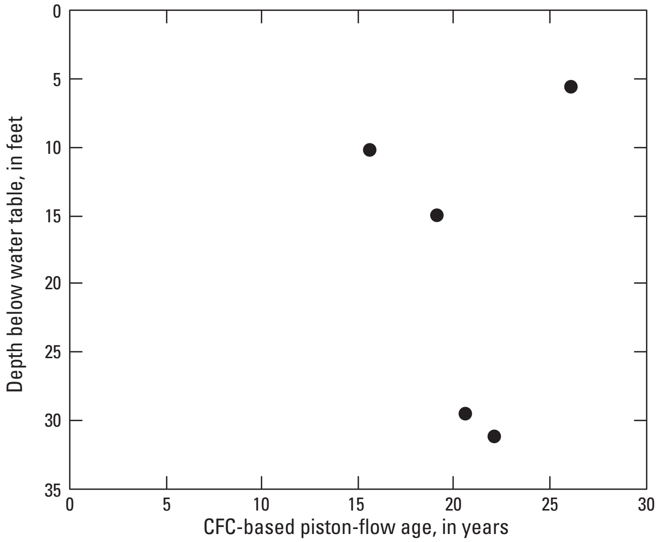

Figure B21. CFC-based age gradient for dated sites from the CCPTLUSAG2b network, CCYK Study Unit.

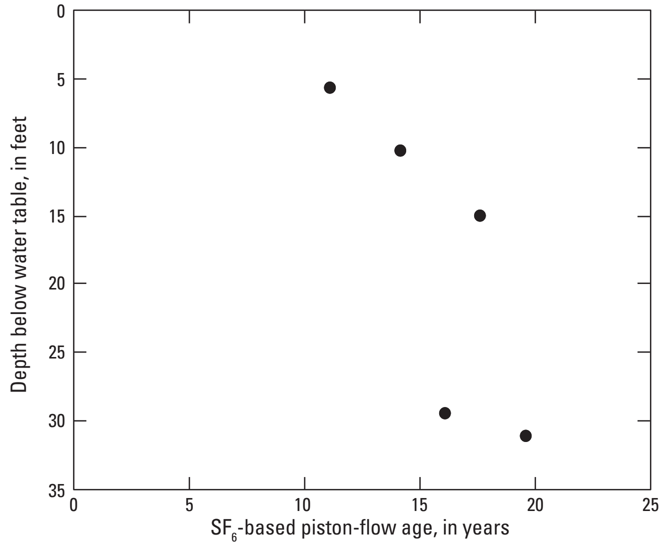

Figure B22. SF_6-based age gradient for dated sites from the CCPTLUSAG2b network, CCYK Study Unit.

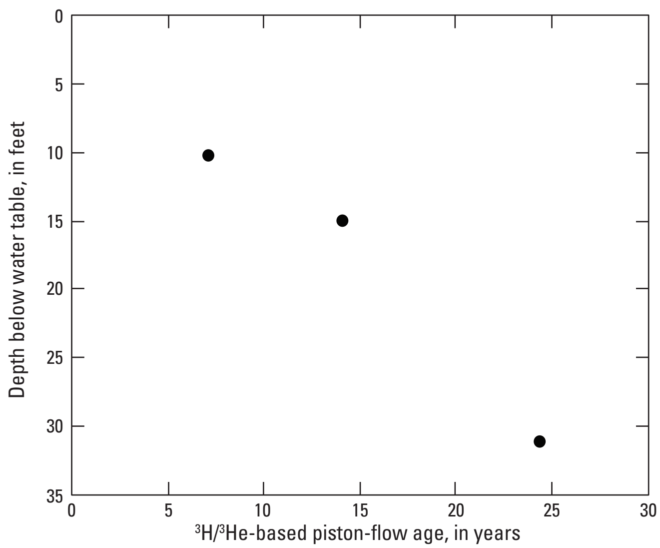

Figure B23. $^3H/^3He$-based age gradient for dated sites from the CCPTLUSAG2b network, CCYK Study Unit.

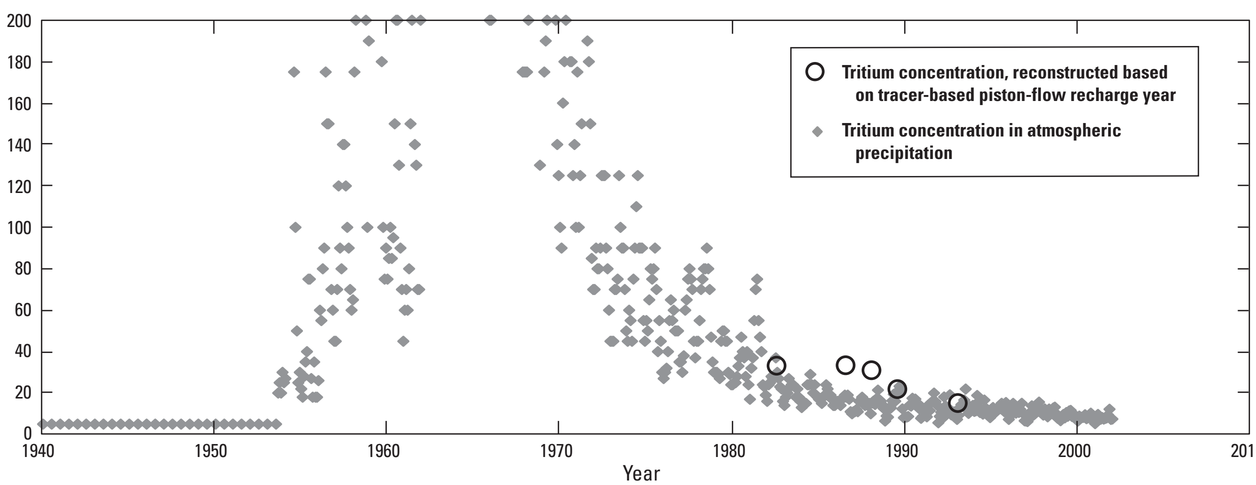

Figure B24. Reconstructed tritium concentrations (using CFC-based ages) and tritium in atmospheric precipitation, CCPTLUSAG2b network, CCYK Study Unit.

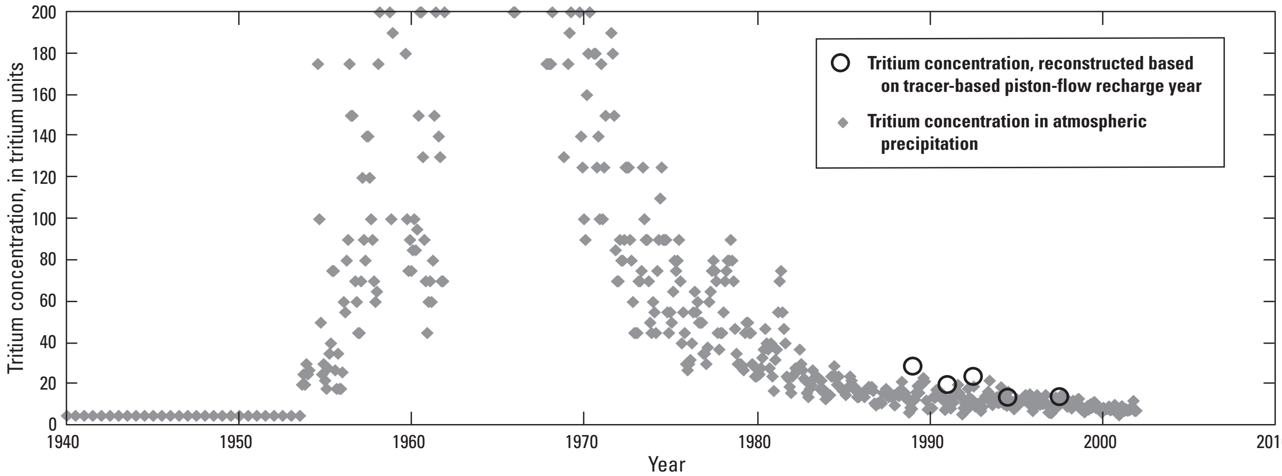

Figure B25. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, CCPTLUSAG2b network, CCYK Study Unit.

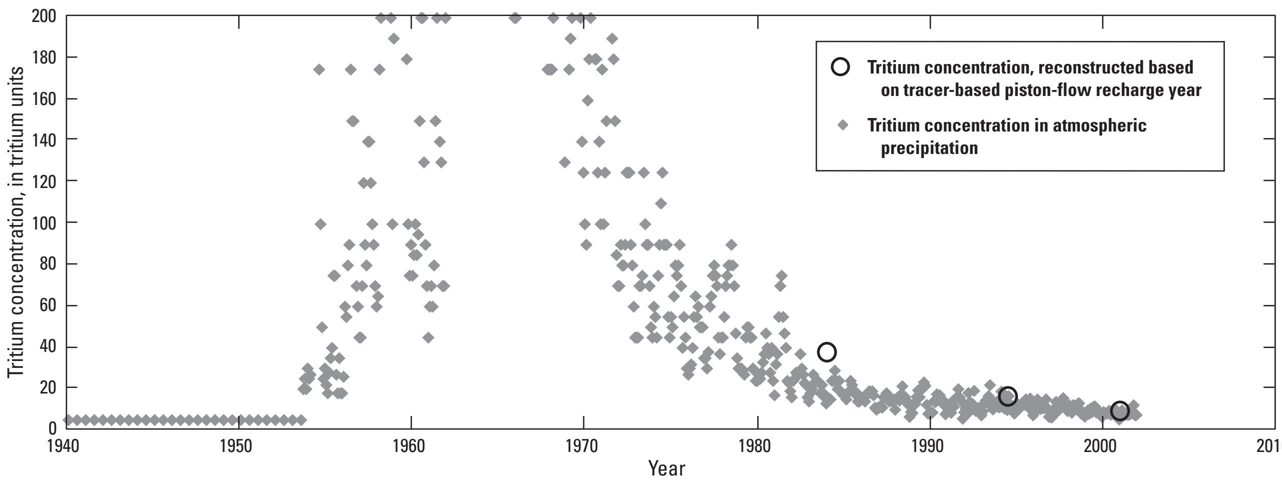

Figure B26. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, CCPTLUSAG2b network, CCYK Study Unit.

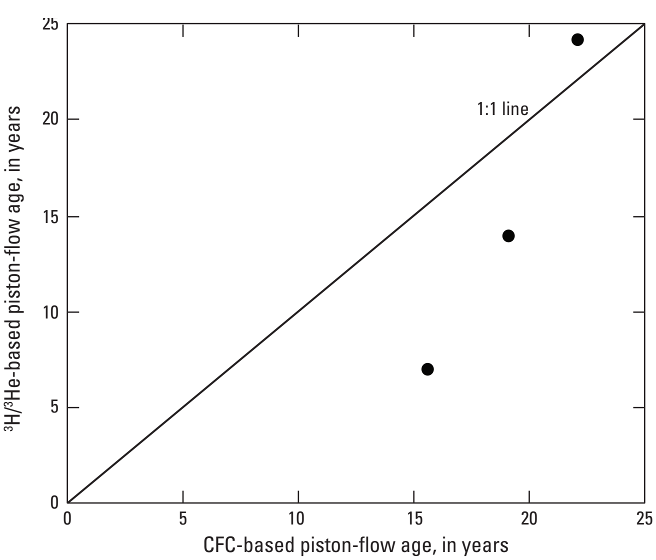

Figure B27. $^3H/^3He$- versus CFC-based age comparison, CCPTLUSAG2b network, CCYK Study Unit.

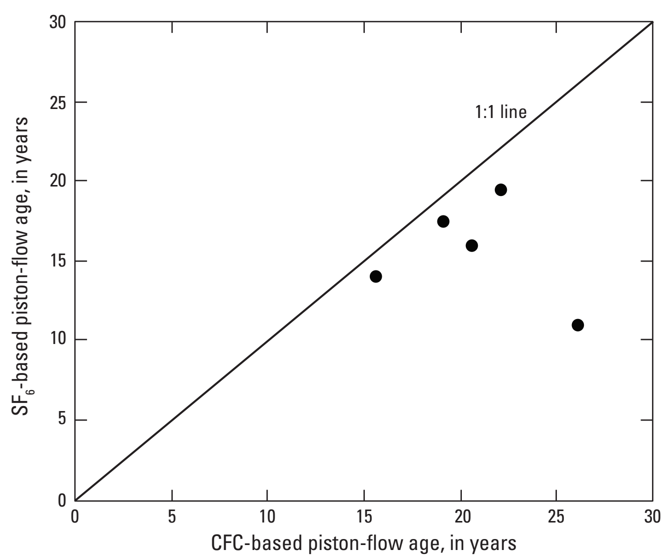

Figure B28. SF_6- versus CFC-based age comparison, CCPTLUSAG2b network, CCYK Study Unit.

CCYK CCPTLUSOR1b

Samples from five sites in the CCYK Study Unit were collected in 2008 for CFCs, SF_6, and $^3H/^3He$ (networks and, in parentheses, number of sites):

- CCPTLUSOR1b (5)

The aquifer is composed of overburden sands and silts.

Major dissolved-gas data were available for all five sites. Of these five sites, all five were oxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data.

$^3H/^3He$ ages were calculated for two sites (none of these sites required a correction for terrigenic He), while three sites were not datable due to fractionation.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B8.

- Advantages associated with these samples:
  - Multiple tracers (CFCs, SF_6, and $^3H/^3He$, as well as major dissolved gases).
  - Monitoring wells so generally low pumping stress.
  - Relatively short open intervals, ranging from 5 to 5.5 feet.
  - Median penetration of center of open interval into water table was 13.26 feet (sampling close to the water table, potentially minimizes mixing).
- Disadvantages associated with these samples:
  - None.
- Depth to water (can affect tracer transport to water table):
  - Median: 15.59 feet
  - Mean: 19.68 feet
  - Min: 5.03 feet
  - Max: 46.71 feet
- Brief analysis:
  - The CFC- and SF_6-based age gradients for these sites are shown in figures B29 and B30. Both gradients show a general structure of increasing age with depth, and relatively old ages at shallow depths. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

The reconstructed ^3H plots for CFC-, SF_6-, and $^3H/^3He$-based ages are shown in figures B31, B32, and B33. All three reconstructions show a general consistency with unmixed, piston-flow transport, however, the CFC- and SF_6-based reconstructions have samples that plot above the ^3H input function.

The SF_6- versus CFC-based age comparison for this network is shown in figure B34. The age comparison shows a great deal of scatter with no particular bias.

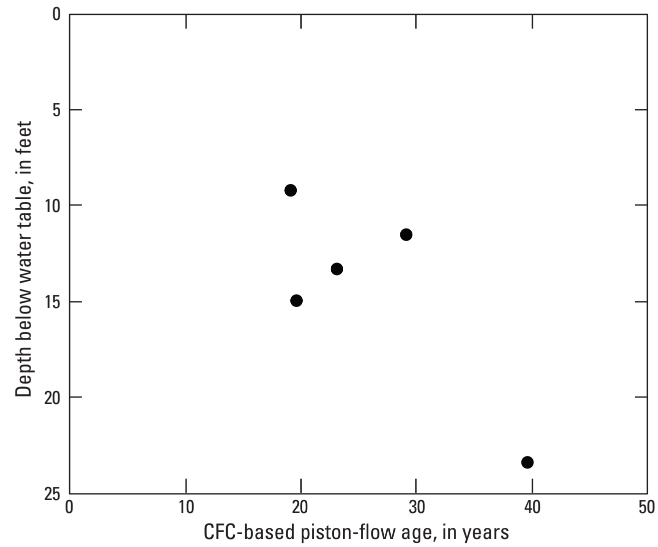

Figure B29. CFC-based age gradient for dated sites from the CCPTLUSOR1b network, CCYK Study Unit.

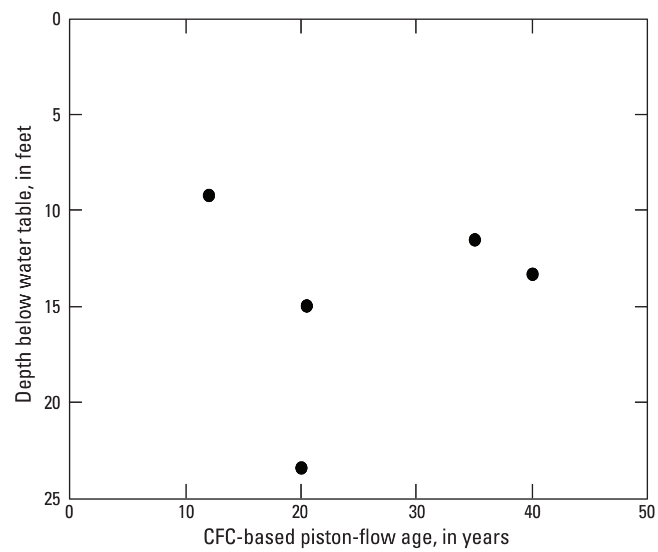

Figure B30. SF_6-based age gradient for dated sites from the CCPTLUSOR1b network, CCYK Study Unit.

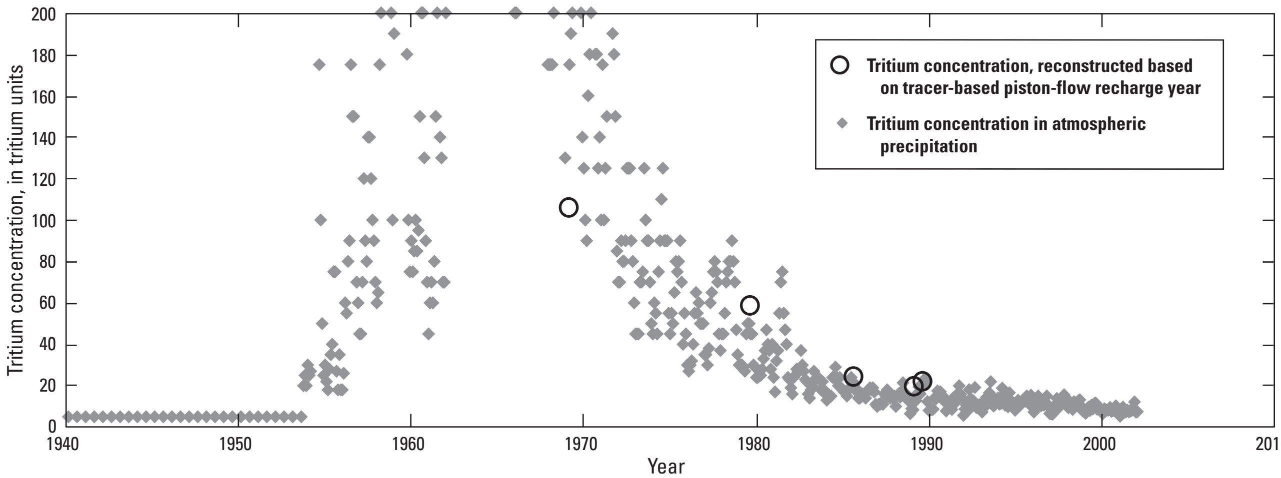

Figure B31. Reconstructed tritium concentrations (using CFC-based ages) and tritium in atmospheric precipitation, CCPTLUSOR1b network, CCYK Study Unit.

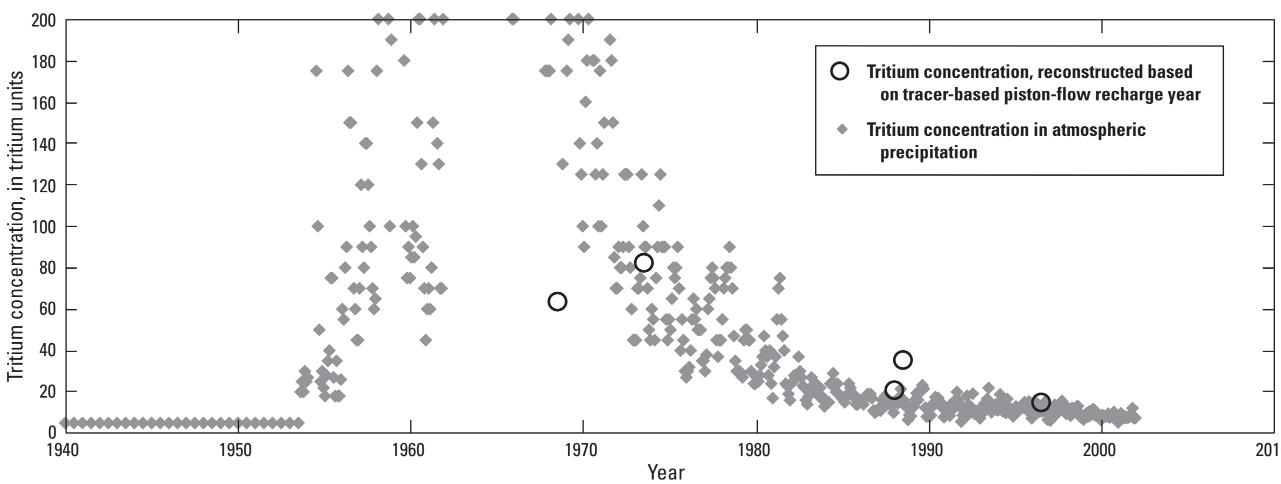

Figure B32. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, CCPTLUSOR1b network, CCYK Study Unit.

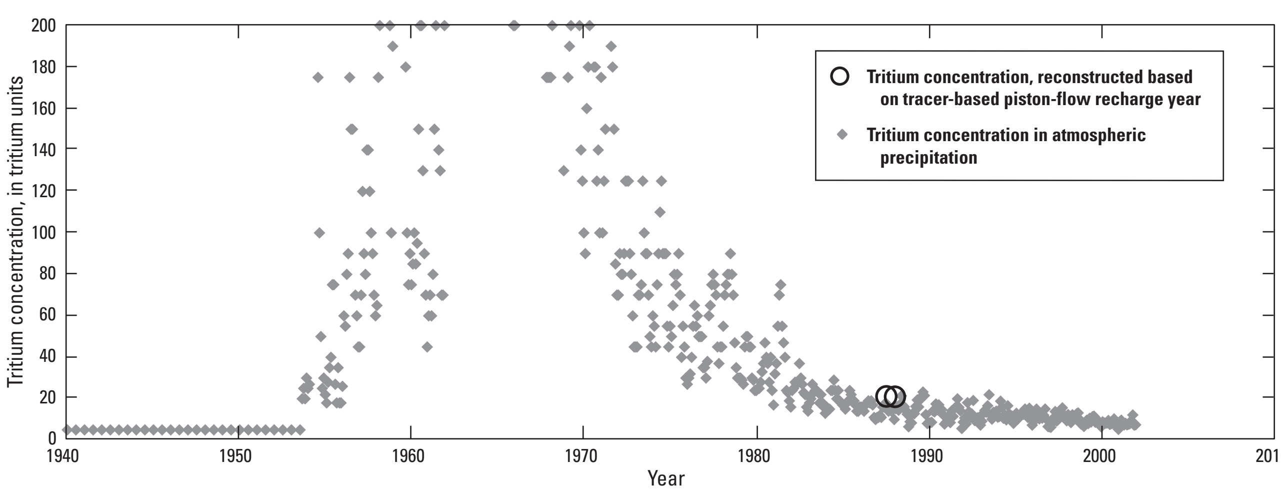

Figure B33. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, CCPTLUSOR1b network, CCYK Study Unit.

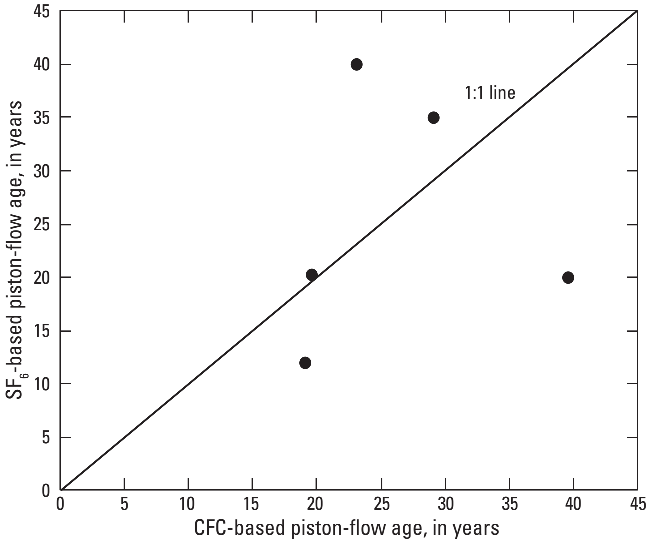

Figure B34 SF_6- versus CFC-based age comparison, CCPTLUSOR1b network, CCYK Study Unit.

CCYK CCPTSUS1b

Samples from five sites in the CCYK Study Unit were collected in 2008 for CFCs, SF_6, and $^3H/^3He$ (networks and, in parentheses, number of sites):

. CCPTSUS1b (5)

The aquifer is composed of the Columbia River Basalt Group basalts; however, one well is finished in the overburden.

Major dissolved-gas data were available for five sites. Of these five sites, all five were oxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data.

$^3H/^3He$ ages were calculated for three sites (two of the three sites required a correction for terrigenic helium), while one site was not datable due to fractionation, and the sample from one site was lost due to high pressure or other laboratory issues.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B9.

. Advantages associated with these samples:

. Multiple tracers (CFCs, SF_6, and $^3H/^3He$, as well as major dissolved gases).

. Disadvantages associated with these samples:

. Public supply wells, so generally high pumping stress.

. Relatively large open intervals ranging from 165 to 741 feet so mixing likely.

. Median penetration of center of open interval into water table was 173.13 feet (not sampling close to the water table, potentially mixing).

. Depth to water (can affect tracer transport to water table):

. Median: 180.00 feet

. Mean: 165.9 feet

. Min: 60.00 feet

. Max: 259.00 feet

. Brief analysis:

. The CFC-, SF_6-, and $^3H/^3He$-based age gradients for these sites are shown in figures B35, B36, and B37. The age gradients do not show any particular structure. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

The reconstructed ^3H plots for CFC-, SF_6-, and $^3H/^3He$-based ages are shown in figures B38, B39, and B40. The reconstructions show evidence of unmixed, piston-flow transport for some samples, and mixing for other samples. Additional evidence for mixing is seen in the large discrepancy between the tracer ages for two wells for which CFC- and SF_6-based ages are more than 30 years younger than the $^3H/^3He$-based ages.

The SF_6- versus CFC-based age comparison and the $^3H/^3He$- versus CFC-based age comparison for this network are shown in figures B41 and B42. The age comparisons show similar results to the age-gradient and tritium reconstruction plots shown above. The CFC- and SF_6-based ages compare well, but are significantly younger than the $^3H/^3He$-based ages. The low tritium concentrations and high terrigenic helium concentrations limit the reliability of the $^3H/^3He$-based age dating for this network, and the CFC- and SF_6-based ages probably are more reliable.

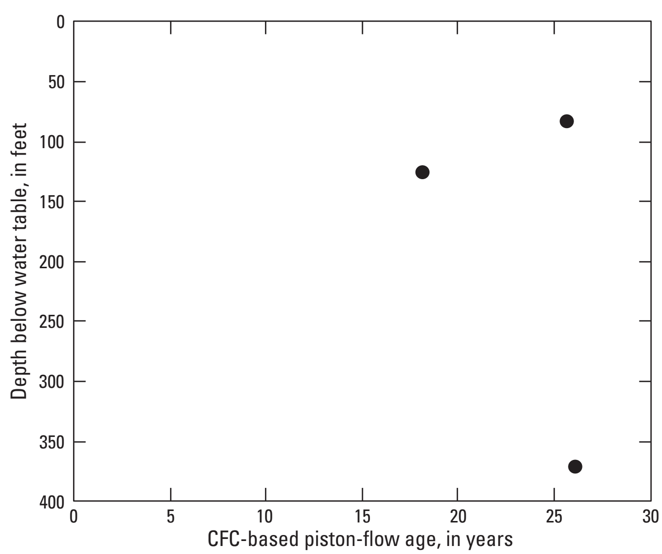

Figure B35. CFC-based age gradient for dated sites from the CCPTSUS1b network, CCYK Study Unit.

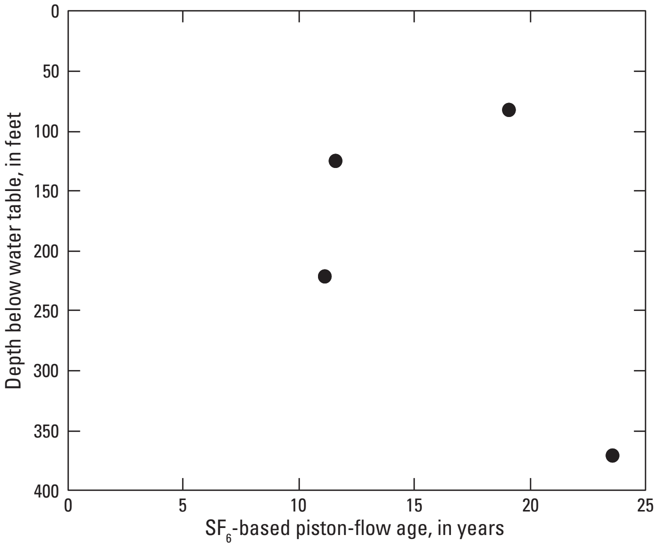

Figure B36. SF_6-based age gradient for dated sites from the CCPTSUS1b network, CCYK Study Unit.

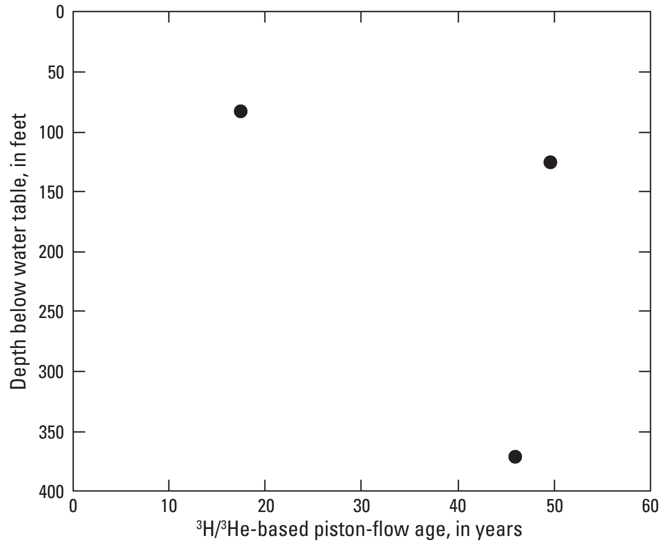

Figure B37. $^3H/^3He$-based age gradient for dated sites from the CCPTSUS1b network, CCYK Study Unit.

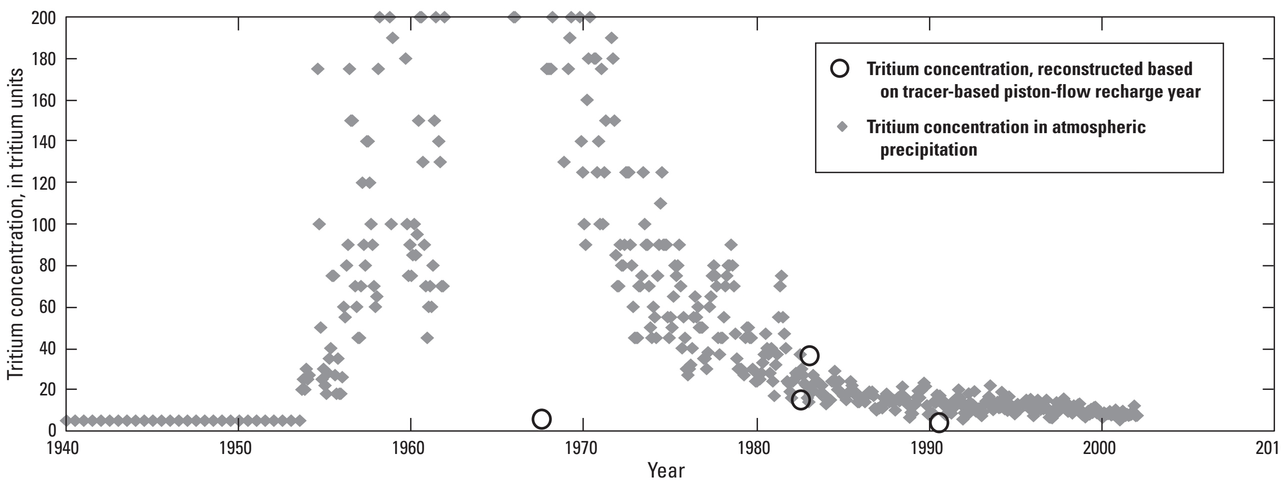

Figure B38. Reconstructed tritium concentrations (using CFC-based ages) and tritium in atmospheric precipitation, CCPTSUS1b network, CCYK Study Unit.

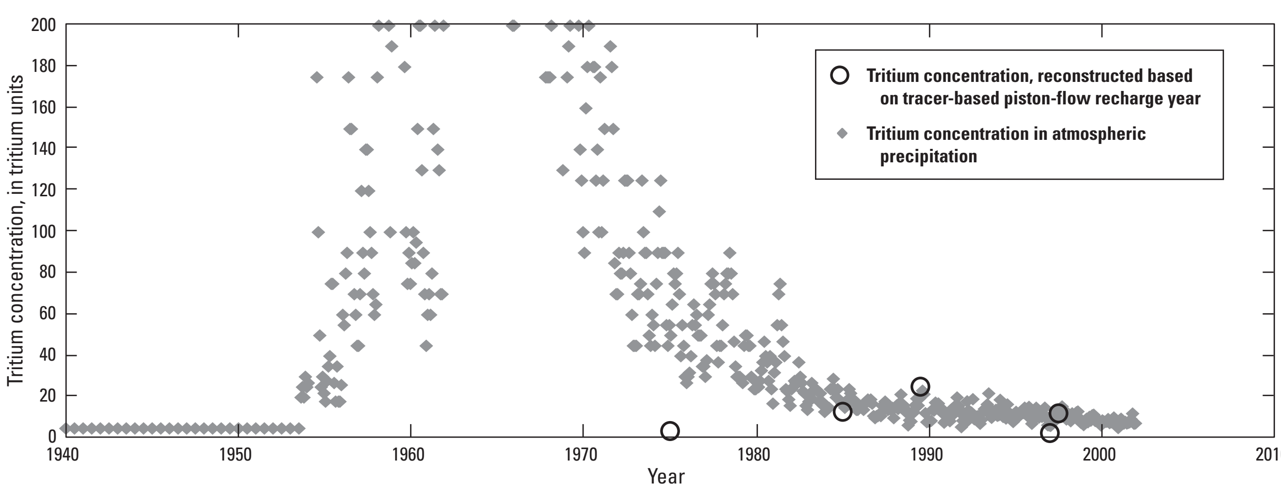

Figure B39. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, CCPTSUS1b network, CCYK Study Unit.

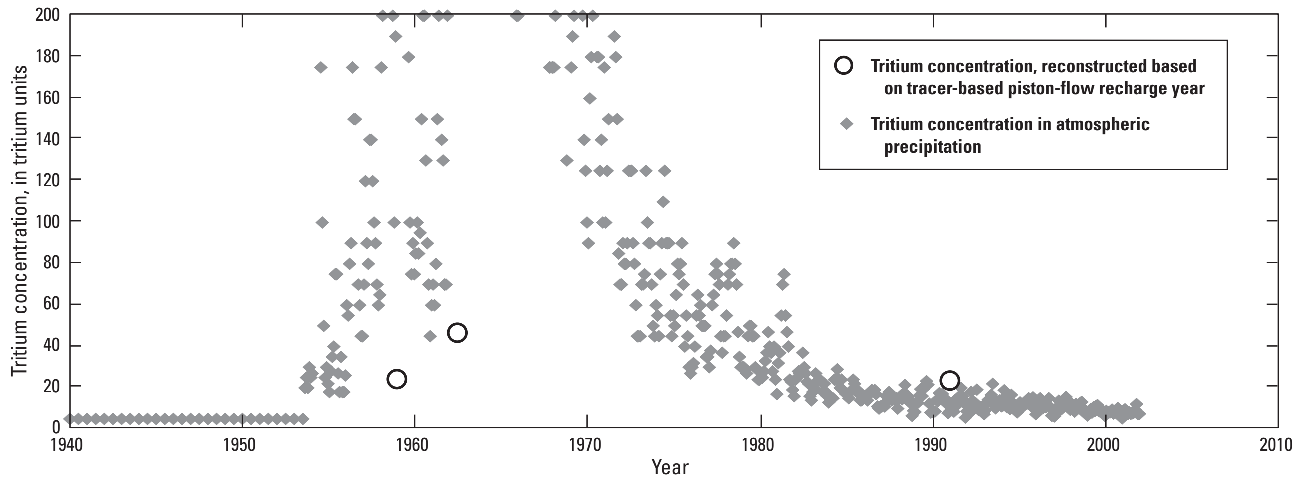

Figure B40. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, CCPTSUS1b network, CCYK Study Unit.

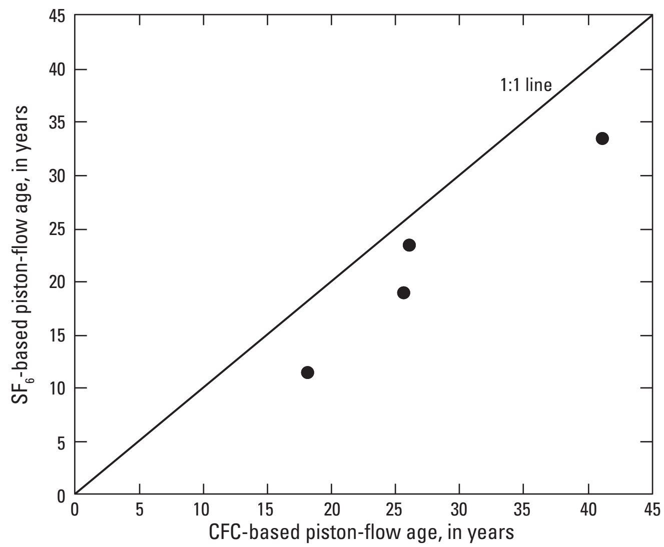

Figure B41. SF_6- versus CFC-based age comparison, CCPTSUS1b network, CCYK Study Unit.

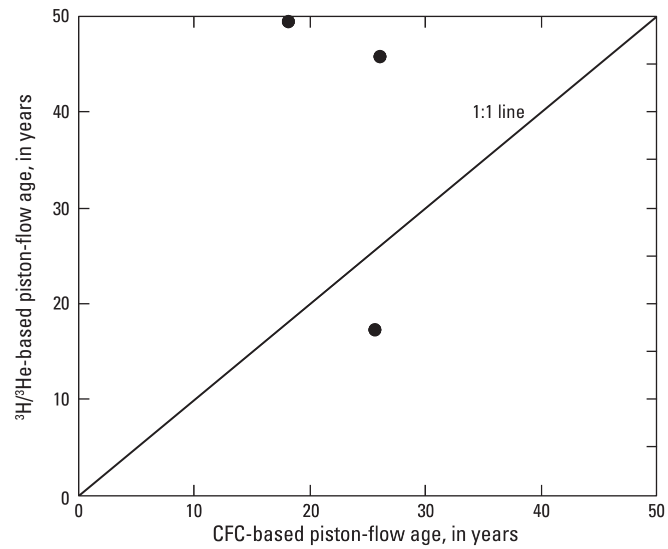

Figure B42. $^3H/^3He$- versus CFC-based age comparison, CCPTSUS1b network, CCYK Study Unit.

CONN SUS2

Samples from five sites in the CONN Study Unit were collected in 2007 for $^3H/^3He$ (networks and, in parentheses, number of sites):

. SUS2 (5)

The aquifer is composed of sand, silt, and gravel in a glaciated region.

Major dissolved-gas data were available for eight sites. Of these eight sites, six were oxic and two were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites.

$^3H/^3He$ ages were calculated for three sites (all three sites required a correction for terrigenic He), while two sites were not datable due to fractionation.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B10.

- Advantages associated with these samples:
  - Relatively short open intervals ranging from 1 to 12.8 feet so mixing minimized.
  - $^3H/^3He$, as well as major dissolved gases.
- Disadvantages associated with these samples:
  - Mixture of domestic and monitoring wells, so relatively low pumping stress.
  - Median penetration of center of open interval into water table was 49 feet (not sampling close to the water table, potentially mixing).
- Depth to water (can affect tracer transport to water table):
  - Median: 34.04 feet
  - Mean: 43.59 feet
  - Min: 5.94 feet
  - Max: 100.36 feet
- Brief analysis:
  - The $^3H/^3He$-based age gradient for these sites is shown in figure B43. There is an inverse age gradient, in which tracer-based piston-flow ages are younger at greater depth. These sites are located across multiple states and do not share a common flow path, so the age gradient presented here is not a valid measure of age stratification for this aquifer.

The reconstructed ^3H plot for $^3H/^3He$-based ages is shown in figure B44. There is excellent agreement between the ^3H input function and the reconstructed ages.

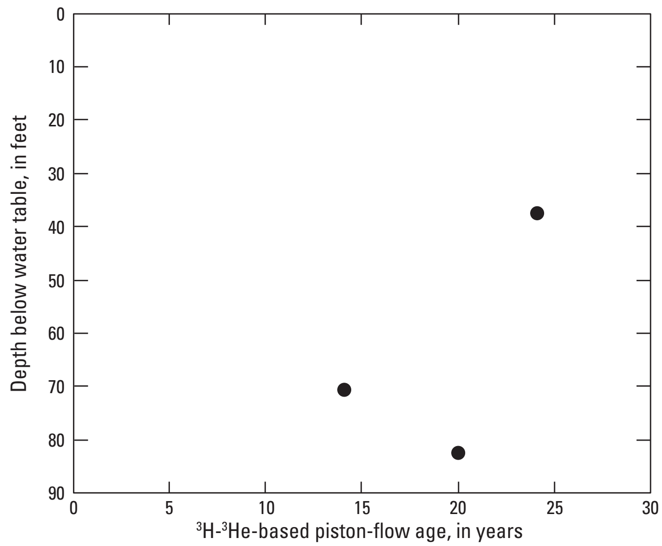

Figure B43. $^3H/^3He$-based age gradient for dated sites from the SUS2 network, CONN Study Unit.

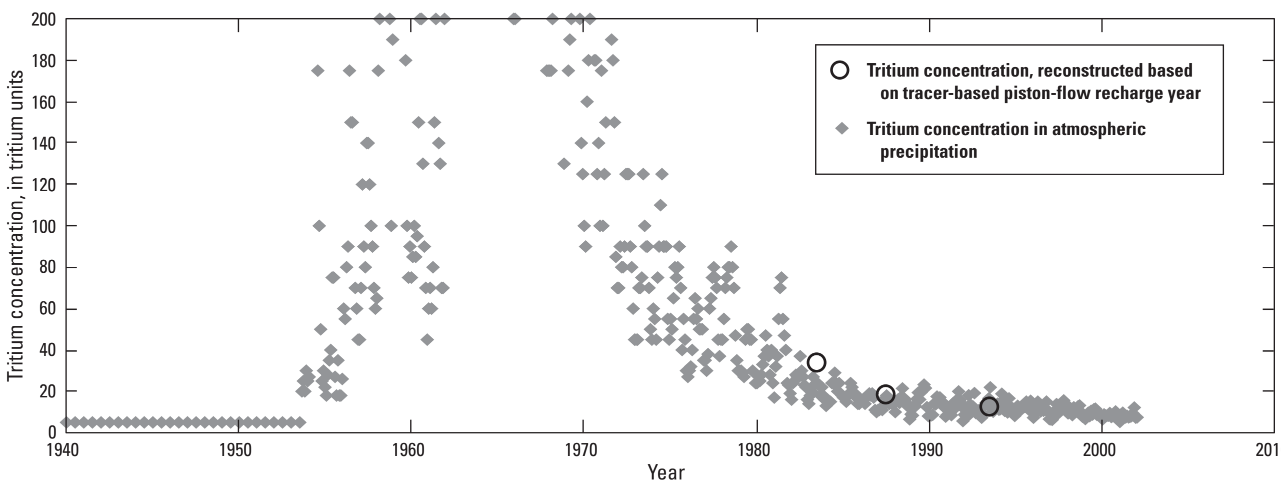

Figure B44. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, SUS2 network, CONN Study Unit.

EIWA FPSAG2

Samples from 9 sites in the EIWA Study Unit were collected in 2007 for CFCs, SF_6, and $^3H/^3He$ (networks and, in parentheses, number of sites):

- FPSAG2 (CFCs, 2; SF_6, 8; $^3H/^3He$, 5).

The aquifer is composed of sand and gravel in a glaciated region.

Major dissolved-gas data were available for 9 sites.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table, that recharge temperature was equal to mean annual air temperature +1°C, and that excess air concentrations were 2 cc STP/kg.

$^3H/^3He$ ages could not be calculated for this network as a result of fractionation.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B11.

- Advantages associated with these samples:
  - Multiple tracers (CFCs, SF_6, and $^3H/^3He$, as well as major dissolved gases).
  - Unused wells that no longer exist so low pumping stress.
  - Very short open intervals, ranging from 0.31 to 2.31 feet, so mixing minimized.
  - Median penetration of center of open interval into water table was 13.5 feet (sampling close to the water table, potentially minimizes mixing).
- Disadvantages associated with these samples:
  - Only two CFC samples and they are degraded. All of the $^3H/^3He$ samples are affected by fractionation.
- Depth to water (can affect tracer transport to water table):
  - Median: 4.99 feet
  - Mean: 5.55 feet
  - Min: 1.79 feet
  - Max: 8.34 feet
- Brief analysis:
  - The SF_6-based age gradient for these sites is shown in figure B45. The age gradient has a great deal of scatter. These wells are part of an agricultural network for which irrigation practices may be responsible for the scatter and the relatively old ages at shallow depths.

The reconstructed ^3H plot for SF_6-based ages is shown in figure B46. There is excellent agreement between the ^3H input function and the reconstructed ages.

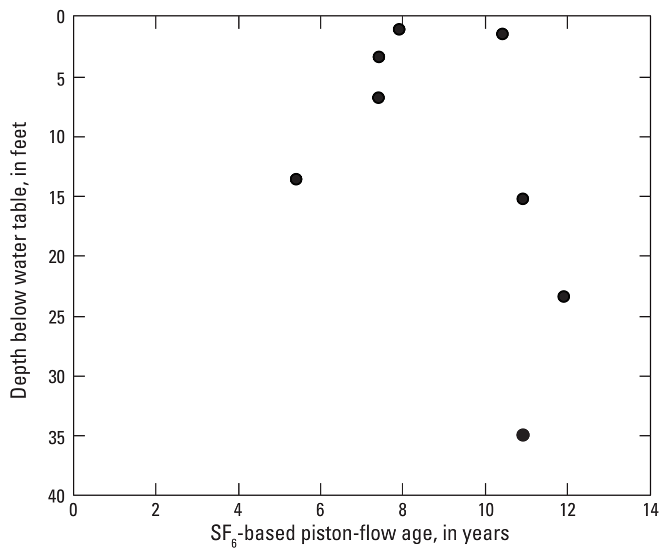

Figure B45. SF_6-based age gradient for dated sites from the FPSAG2 network, EIWA Study Unit.

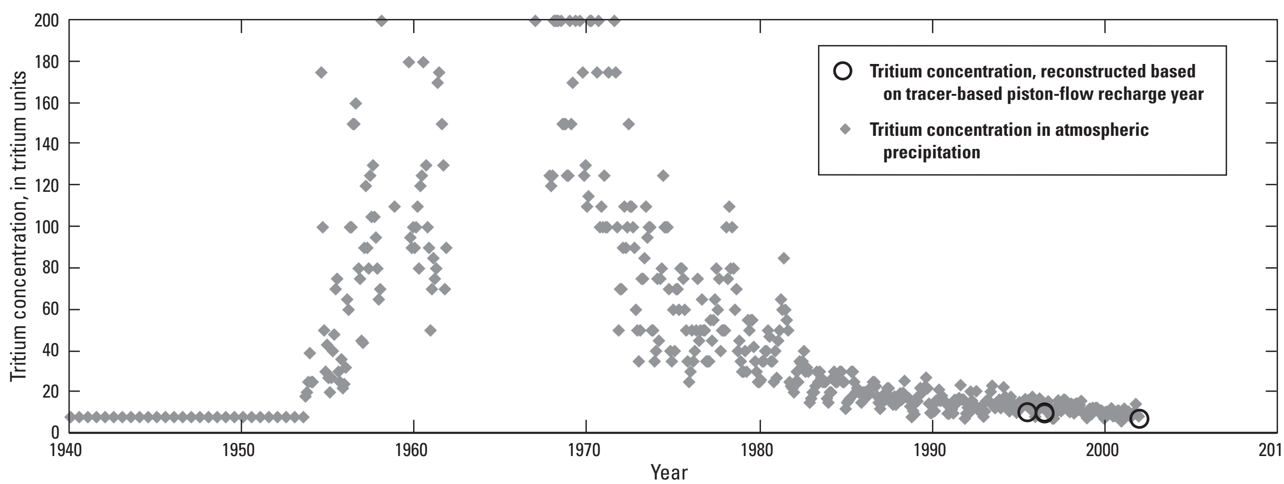

Figure B46. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, FPSAG2 network, EIWA Study Unit.

EIWA LUSCR1

Samples from three sites in the EIWA Study Unit were collected in 2007 for CFCs (networks and, in parentheses, number of sites):

- LUSCR1 (3)

The aquifer is composed of sands, gravel, silt, and clay, in a glaciated region.

Major dissolved-gas data were available for all three sites. Of these three sites, one was oxic and two were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites from this network as well as other nearby EIWA networks.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B12.

- Advantages associated with these samples:
  - CFCs, as well as major dissolved gases.
  - Monitoring wells so generally low pumping stress.
  - Short open intervals of 5 feet, so mixing minimized.
  - Median penetration of center of open interval into water table was 7.8 feet (sampling close to the water table, potentially minimizing mixing).
- Disadvantages associated with these samples:
  - Only 3 samples, and only 1 was datable.
- Depth to water (can affect tracer transport to water table):
  - Median: 3.90 feet
  - Mean: 3.88 feet
  - Min: 2.20 feet
  - Max: 5.55 feet
- Brief analysis:
  - With only one datable site, no age gradient or ^{3}H reconstruction was attempted.

EIWA SUS2

Samples from 23 sites in the EIWA Study Unit were collected in 2007 for CFCs (networks and, in parentheses, number of sites):

- SUS2 (CFCs, 23).

The aquifer is composed of glacial sands, gravel, and clay.

Major dissolved-gas data were available for 22 sites. Of these 22 sites, 7 were oxic and 15 were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B13.

- Advantages associated with these samples:
  - CFCs, as well as major dissolved gases.
  - Domestic wells so generally low pumping stress.
- Disadvantages associated with these samples:
  - Relatively large open intervals ranging from 4 to 177 feet, with many unknown, so mixing likely.
  - Median penetration of center of open interval into water table was 48.69 feet (not sampling close to the water table, potentially mixing).
- Depth to water (can affect tracer transport to water table):
  - Median: 10.60 feet
  - Mean: 19.64 feet
  - Min: 2.10 feet
  - Max: 80.70 feet
- Brief analysis:
  - In the EIWA network, in areas where clay and shale materials are present, it is common to find water recharged within the last 40 years that has not reached the deeper parts of the alluvial and bedrock aquifers. This could explain why there is an inverted age gradient for the SUS2 samples as shown in figure B47.

The reconstructed ^{3}H plot for CFC-based ages is shown in figure B48. There is good agreement between the ^{3}H input function and the reconstructed ages indicating that the samples represent relatively unmixed, piston-flow transport, with some samples showing effects of dispersion.

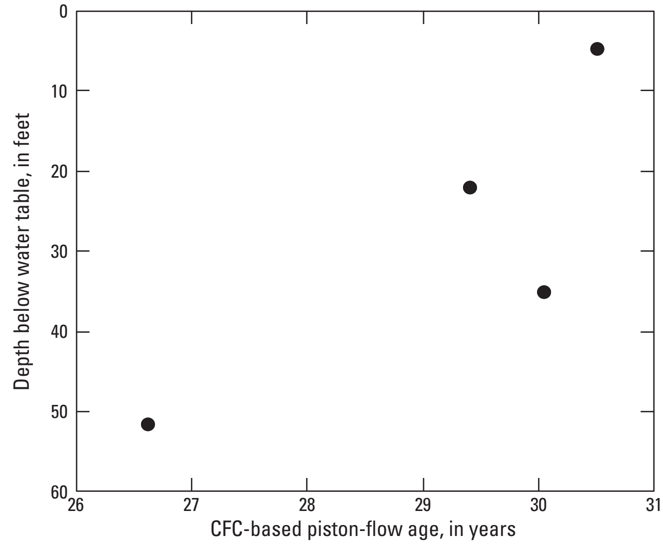

Figure B47. CFC-based age gradient for dated sites from the SUS2 network, EIWA Study Unit.

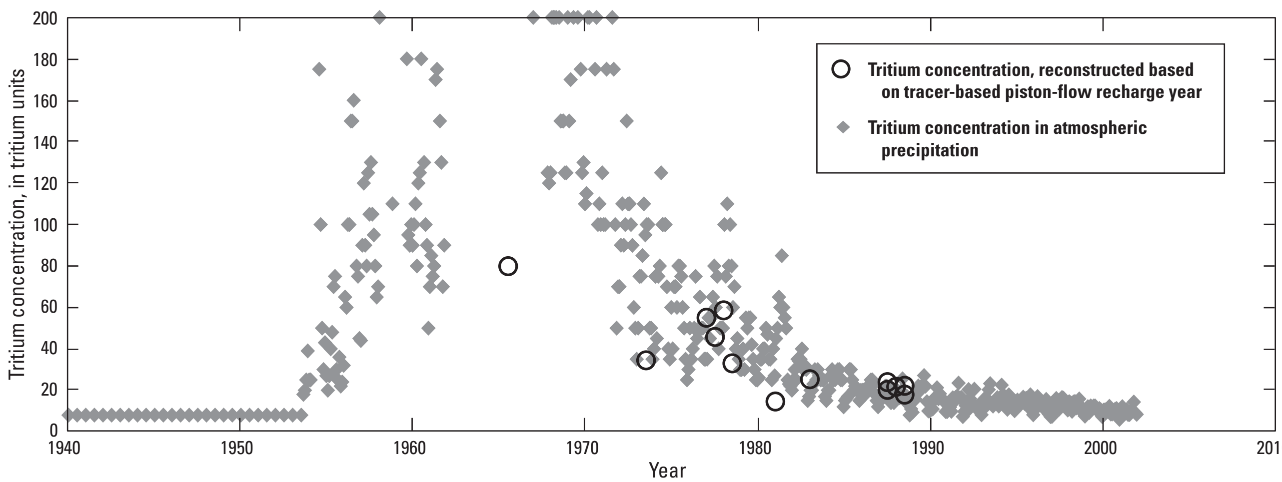

Figure B48. Reconstructed tritium concentrations (using CFC-based ages) and tritium in atmospheric precipitation, SUS2 network, EIWA Study Unit.

GRSL SUS1a, SUS1b, and LUSRC1

Samples from 10 sites in the GRSL Study Unit were collected in 2006 for CFCs, SF_6, and $^3H/^3He$ (networks and, in parentheses, number of sites):

- SUS1a (1)
- SUS1b (4)
- LUSRC1 (5)

The aquifer is composed of valley-fill deposits of sand and gravel.

Major dissolved-gas data were available for five sites. All five sites were oxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data. For the sites without major dissolved-gas data, age interpretations from tracer concentrations were made assuming that recharge temperature was equal to mean annual air temperature +1°C, and that excess air concentrations were 2 cc STP/kg because the samples with major dissolved-gas data, while consistent among duplicates, were quite variable from one site to the next.

$^3H/3He$ ages were calculated for eight sites (four of the eight sites required a correction for terrigenic helium), while samples from two sites were lost due to high pressure or other laboratory issues.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B14.

- Advantages associated with these samples:
  - Multiple tracers (CFCs, SF^6, and $^3H/^3He$, as well as major dissolved gases).
- Disadvantages associated with these samples:
  - Mixture of domestic, unused, irrigation, and commercial wells, so variable pumping rates.
  - Relatively large open intervals ranging from 10 to 94 feet so mixing likely.
  - Median penetration of center of open interval into water table was 56.74 feet (not sampling close to the water table, potentially mixing).
- Depth to water (can affect tracer transport to water table):
  - Median: 70.22 feet
  - Mean: 75.91 feet
  - Min: 21.60 feet
  - Max: 165.40 feet
- Brief analysis:
  - The CFC-, SF_6-, and $^3H/^3He$-based age gradients for these sites are shown in figures B49, B50, and B51. The age gradients show no clear trend, however, the $^3H/^3He$ ages are somewhat younger in the shallow wells indicating possible helium loss near the water table. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

The reconstructed ^3H plots for CFC-, SF_6-, and $^3H/^3He$-based ages are shown in figures B52, B53, and B54. The reconstructions show evidence of unmixed, piston-flow transport for some samples, and mixing for other samples, as would be expected for such a wide variety of well types and depths.

The $^3H/^3He$- versus SF_6-based age comparison for this network is shown in figure B55. The age comparison is limited by the fact that there are only three samples and only one same shows age agreement.

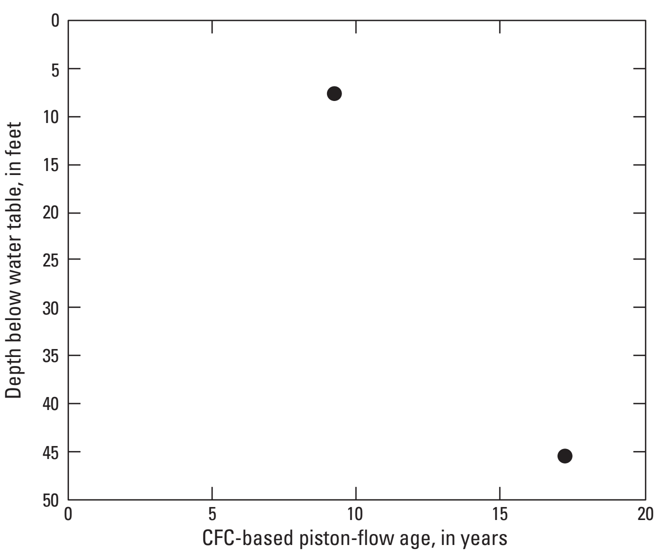

Figure B49. CFC-based age gradient for dated sites from the SUS1a, SUS1b, and LUSRC1 networks, GRSL Study Unit.

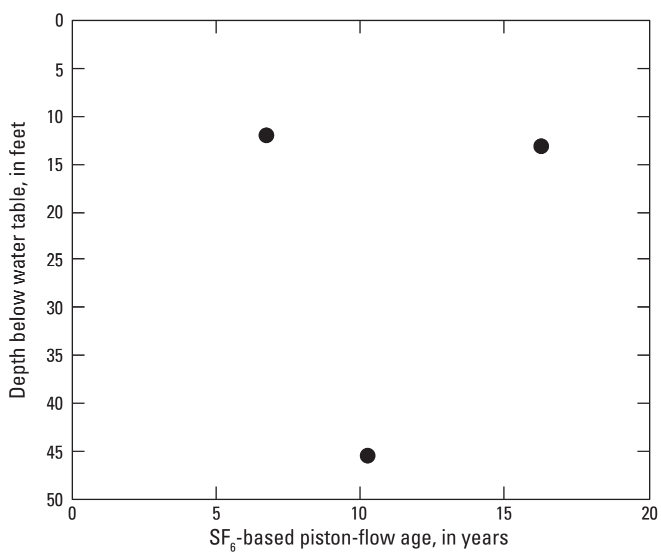

Figure B50. SF_6-based age gradient for dated sites from the SUS1a, SUS1b, and LUSRC1 networks, GRSL Study Unit.

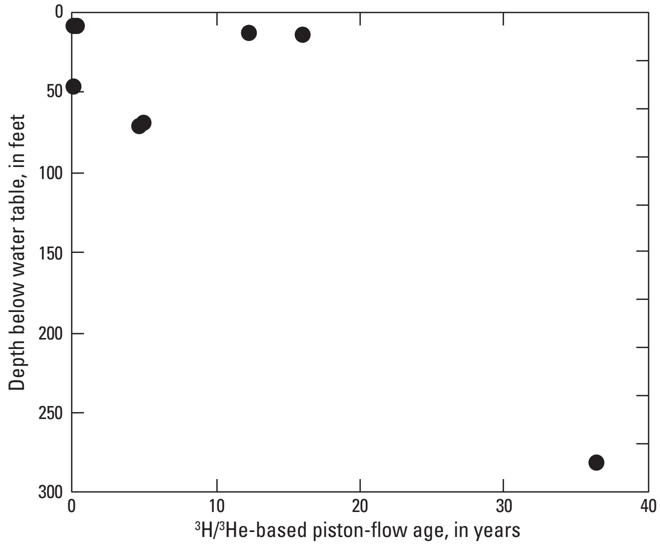

Figure B51. $^3H/^3He$-based age gradient for dated sites from the SUS1a, SUS1b, and LUSRC1 networks, GRSL Study Unit.

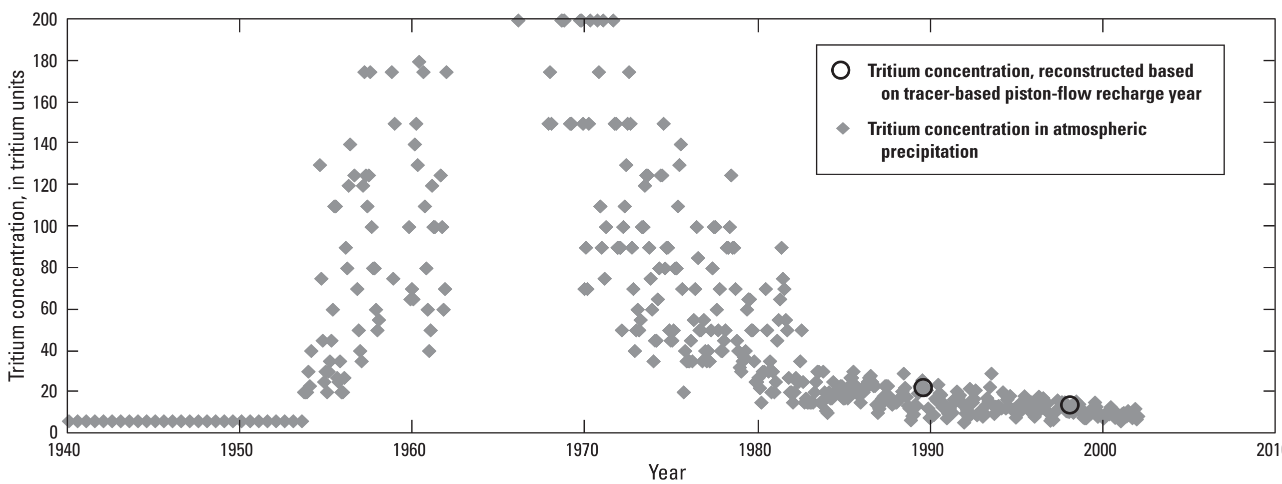

Figure B52. Reconstructed tritium concentrations (using CFC-based ages) and tritium in atmospheric precipitation, SUS1a, SUS1b, and LUSRC1 networks, GRSL Study Unit.

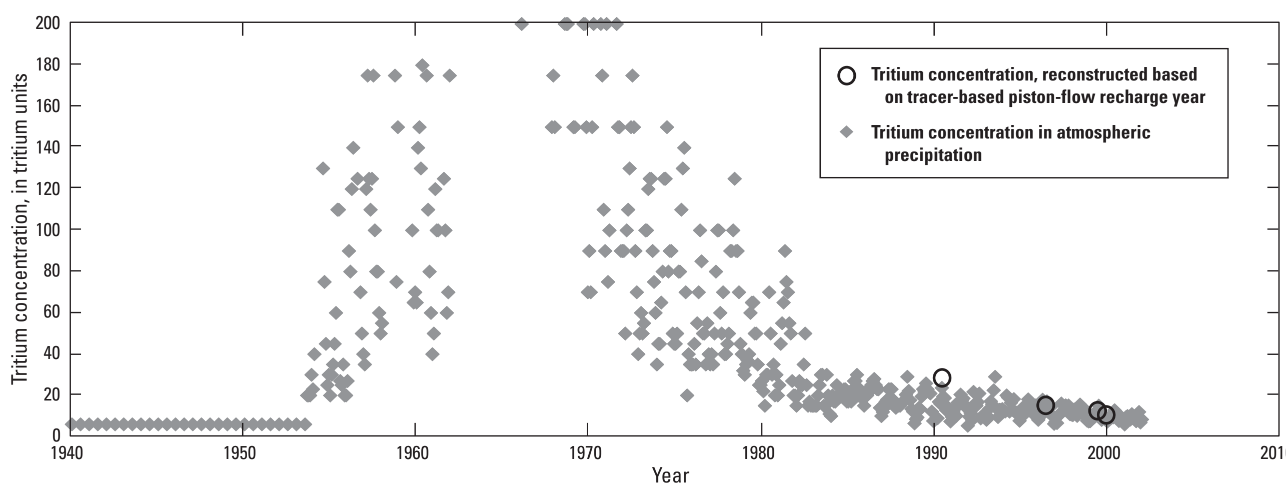

Figure B53. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, SUS1a, SUS1b, and LUSRC1 networks, GRSL Study Unit.

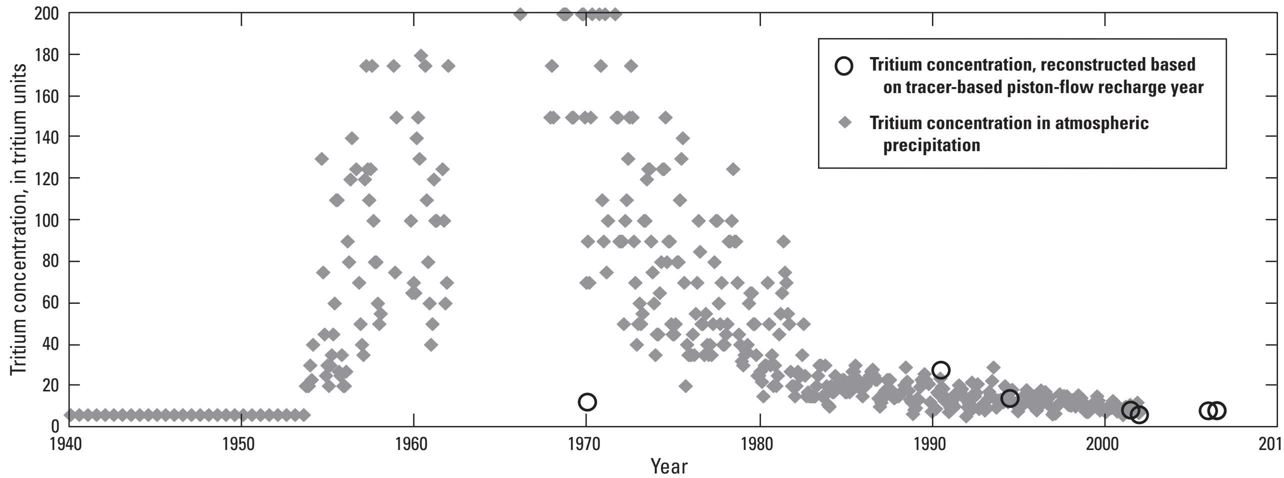

Figure B54. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, SUS1a, SUS1b, and LUSRC1 networks, GRSL Study Unit.

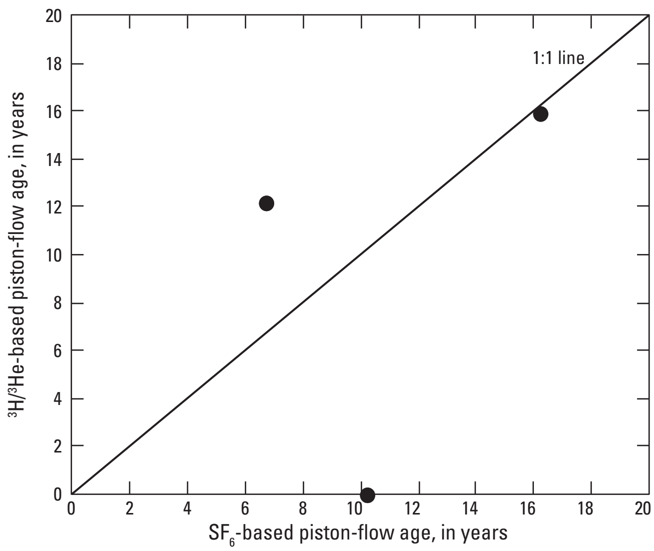

Figure B55. $^3H/^3He$- versus SF_6-based age comparison, SUS1a, SUS1b, and LUSRC1 networks, GRSL Study Unit.

GRSL SUS1a, SUS1b, SUS2, and SUS3

Samples from 36 sites in the GRSL Study Unit were collected in 2008 for CFCs, SF_6, and $^3H/^3He$ (networks and, in parentheses, number of sites):

- SUS1a (7)
- SUS1b (7)
- SUS2 (8)
- SUS3 (14)

The aquifer is composed of Basin and Range basin-fill sands, gravel, and clay.

Major dissolved-gas data were available for all 36 sites. Of these 36 sites, 30 were oxic and 6 were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites.

$^3H/^3He$ ages were calculated for 20 sites (9 of the 20 sites required a correction for terrigenic helium), while 6 site were not datable because tritium concentrations were too low, 2 sites were not datable because of fractionation, and samples from 5 sites were lost due to high pressure or other laboratory issues. Site S10 had a tritium concentration from a sample taken in 1998, which was decayed to 2008 for use in the $^3H/^3He$ spreadsheet.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B15.

- Advantages associated with these samples:
  - Multiple tracers (CFCs, SF_6, and $^3H/^3He$, as well as major dissolved gases).
- Disadvantages associated with these samples:
  - Mixture of domestic, irrigation, commercial, and public supply wells, so variable pumping rates.
  - Relatively large open intervals ranging from 5 to 733 feet so mixing likely.
  - Median penetration of center of open interval into water table was 170.81 feet (not sampling close to the water table, potentially mixing).

. Depth to water (can affect tracer transport to water table):

. Median: 124.75 feet

. Mean: 143.67 feet

. Min: 10.83 feet

. Max: 430.00 feet

. Brief analysis:

. The CFC-, SF_6-, and $^3H/^3He$-based age gradients for these sites are shown in figures B56, B57, and B58. The age gradients do not show any particular structure. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

The reconstructed ^3H plots for SF_6- and $^3H/^3He$-based ages are shown in figures B59 and B60. The reconstructions show that most samples are of mixed-age water as would be expected for such a wide variety of well types and depths. The $^3H/^3He$-based reconstruction, however, shows evidence of capturing the period of time around the bomb peak, with numerous samples with ages in the 1950 and 1960s exhibiting elevated ^3H reconstructions.

The $^3H/^3He$- versus SF_6-based age comparison for this network is shown in figure B61. The age comparison shows significant disagreement among tracers suggesting groundwater is generally of mixed age.

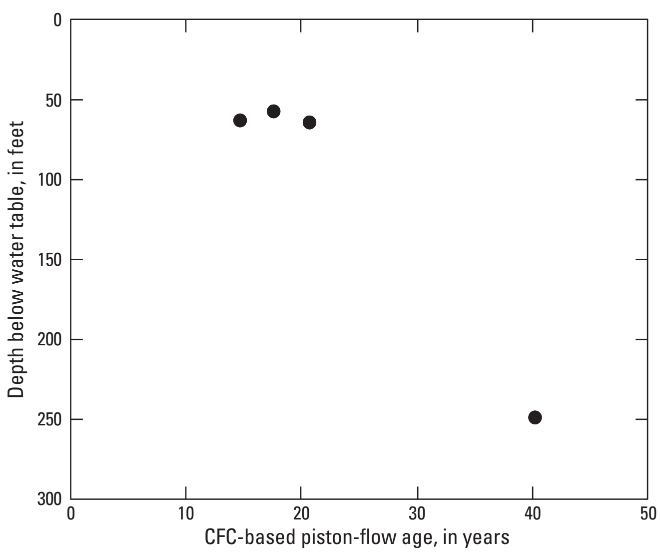

Figure B56. CFC-based age gradient for dated sites from the SUS1a, SUS1b, SUS2, and SUS3 networks, GRSL Study Unit.

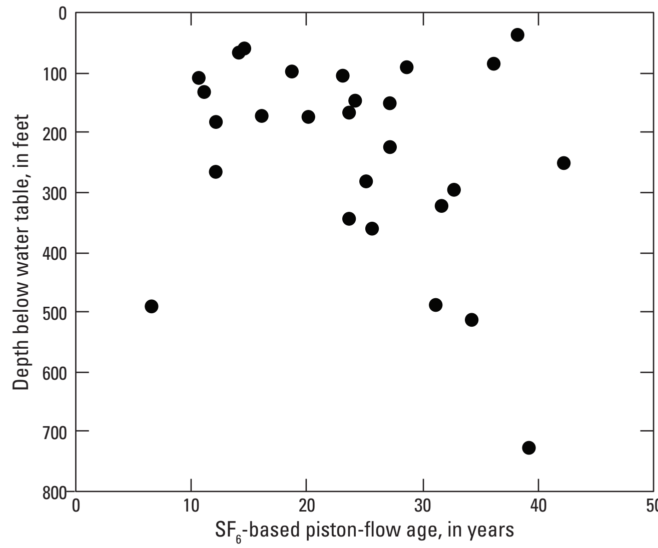

Figure B57. SF_6-based age gradient for dated sites from the SUS1a, SUS1b, SUS2, and SUS3 networks, GRSL Study Unit.

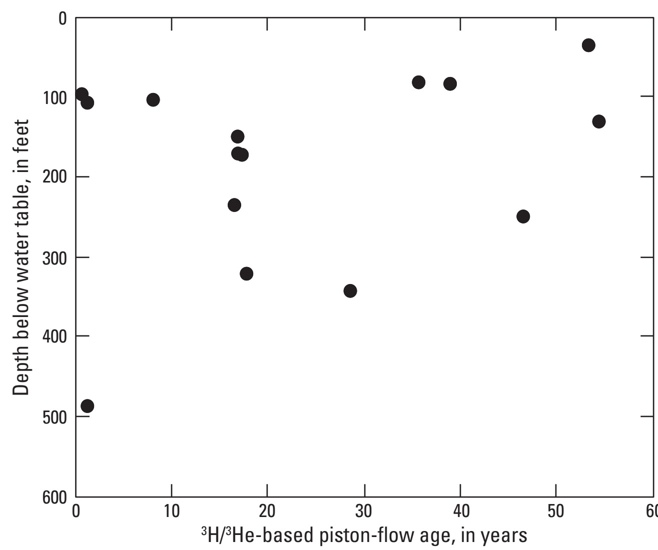

Figure B58. $^3H/^3He$-based age gradient for dated sites from the SUS1a, SUS1b, SUS2, and SUS3 networks, GRSL Study Unit.

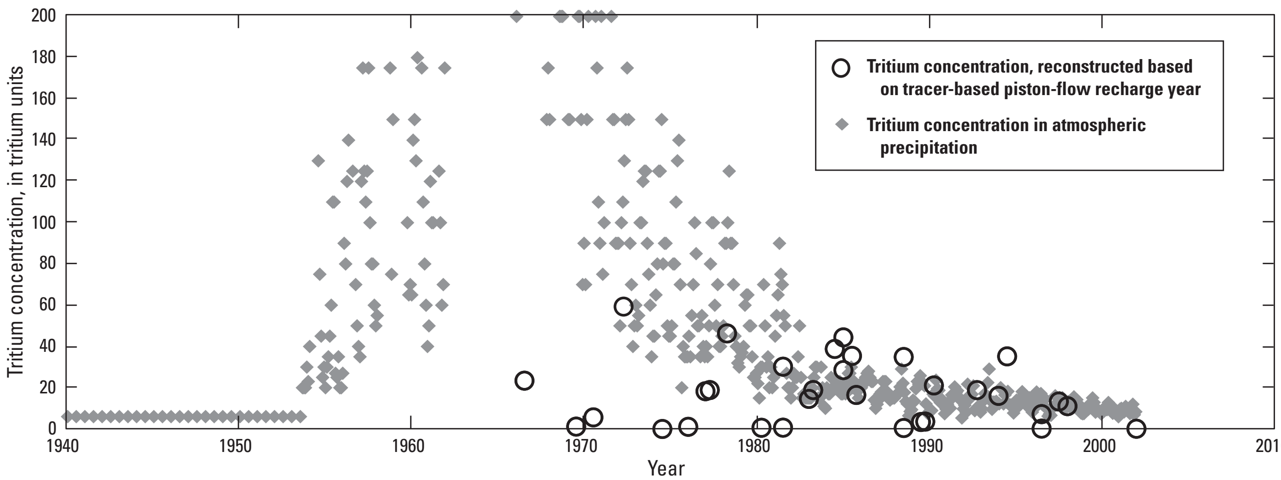

Figure B59. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, SUS1a, SUS1b, SUS2, and SUS3 networks, GRSL Study Unit.

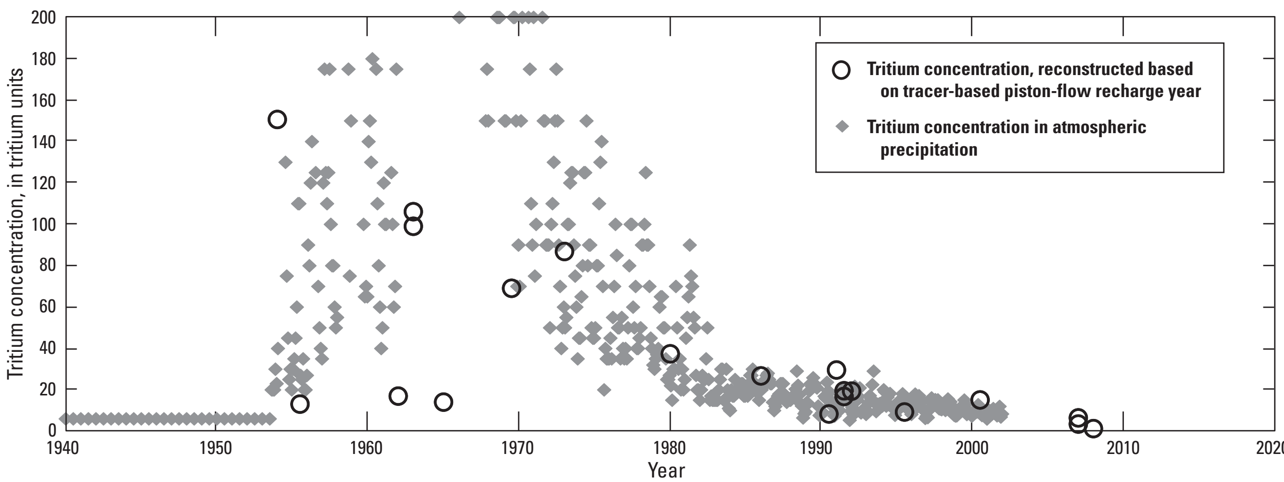

Figure B60. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, SUS1a, SUS1b, SUS2, and SUS3 networks, GRSL Study Unit.

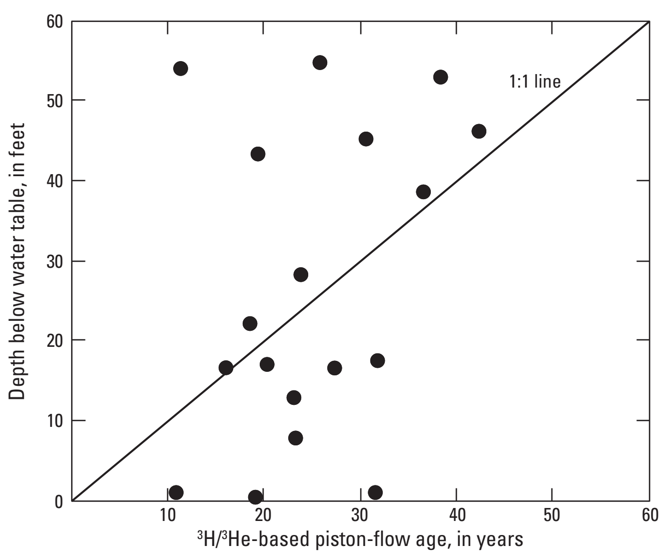

Figure B61. $^3H/^3He$- versus SF_6-based age comparison, SUS1a, SUS1b, SUS2, and SUS3 networks, GRSL Study Unit.

LERI FPSRC1

Samples from 19 sites in the LERI Study Unit were collected in 2008 for SF_6 (networks and, in parentheses, number of sites):

- FPSRC1 (19)

The aquifer is composed of outwash sand, silt, and gravel, with one well completed in the Mississippian Shale.

Major dissolved-gas data were available for 20 sites. Of these 20 sites, 7 were oxic and 13 were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B16.

- Advantages associated with these samples:
  - SF_6, as well as major dissolved gases.
  - Relatively short open intervals ranging from 2 to 5 feet so mixing likely minimized.
  - Median penetration of center of open interval into water table was 16.47 feet (sampling close to the water table, potentially minimizing mixing).
- Disadvantages associated with these samples:
  - Mixture of domestic, public supply, and monitoring wells, so variable pumping rates.
- Depth to water (can affect tracer transport to water table):
  - Median: 1.88 feet
  - Mean: 5.67 feet
  - Min: 0.25 feet
  - Max: 5.00 feet
- Brief analysis:
  - The SF_6-based age gradient for these sites is shown in figure B62. The age gradient shows a general trend of increasing age with depth. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth. For example, the sample with the young age for the deepest well is from a domestic well finished in a different aquifer than the rest of the wells.

The reconstructed ^3H plot for SF_6-based ages is shown in figure B63. The reconstruction shows evidence of unmixed, piston-flow transport for some samples, and mixing for other samples. Three of the four wells with reconstructed tritium values that plot well below the input curve are domestic or public supply wells with longer open intervals than the remaining unused monitoring wells. One of these wells, Well 4-205 is the well finished in shale.

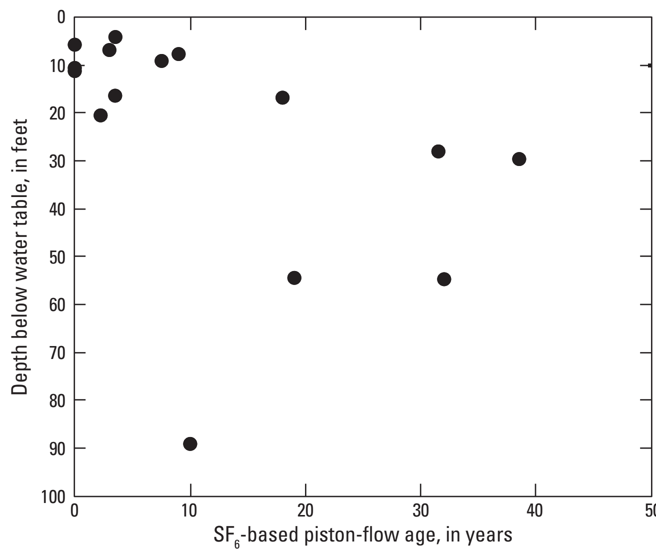

Figure B62. SF_6-based age gradient for dated sites from the FPSRC1 network, LERI Study Unit.

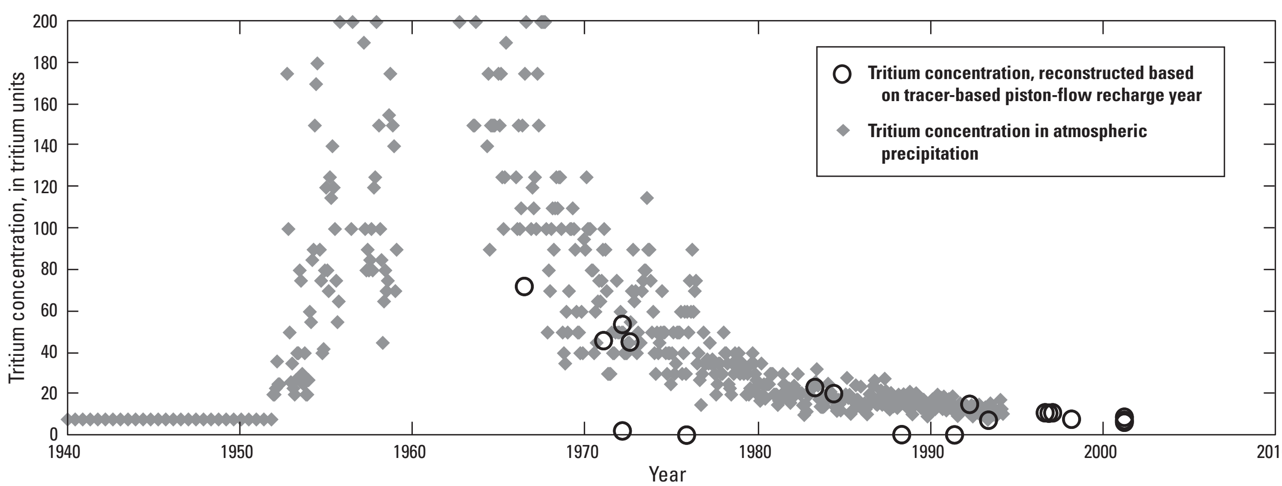

Figure B63. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, FPSRC1 network, LERI Study Unit.

LERI LUSRC1 and REFOT1

Samples from 25 sites in the LERI Study Unit were collected in 2007 for $^3H/^3He$ (networks and, in parentheses, number of sites):

- LUSRC1 (23)
- REFOT1 (2)

The aquifer is composed of outwash sands, silts, clays, and gravel.

Major dissolved-gas data were available for five sites. Of these five sites, four were oxic and one was suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites. For the one suboxic sample, no correction for denitrification was used because the recharge temperature would have been unreasonably low.

$^3H/^3He$ ages were calculated for 17 sites (4 of the 17 sites required a correction for terrigenic helium), while 6 sites were not datable because of fractionation, and samples from 2 sites were lost due to high pressure.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B17.

- Advantages associated with these samples:
  - $^3H/^3He$, as well as major dissolved gases.
  - Monitoring wells, so generally low pumping stress.
  - Relatively short open intervals ranging from 4.5 to 8.1 feet so mixing likely minimized.
  - Median penetration of center of open interval into water table was 9.21 feet (sampling close to the water table, potentially minimizing mixing).
- Disadvantages associated with these samples:
  - None.
- Depth to water (can affect tracer transport to water table):
  - Median: 12.27 feet
  - Mean: 16.07 feet
  - Min: 4.95 feet
  - Max: 58.65 feet
- Brief analysis:
  - The $^3H/^3He$-based age gradient for these sites is shown in figure B64. The age gradient shows a general increase in age with depth. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth. The zero age does not intercept at zero depth likely as a result of helium loss in the unsaturated zone, which ranges in depth from 5 to 60 feet below land surface.

The reconstructed ^3H plot for $^3H/^3He$-based ages is shown in figure B65. The reconstruction shows evidence of unmixed, piston-flow transport, which is consistent with the age gradient for this network.

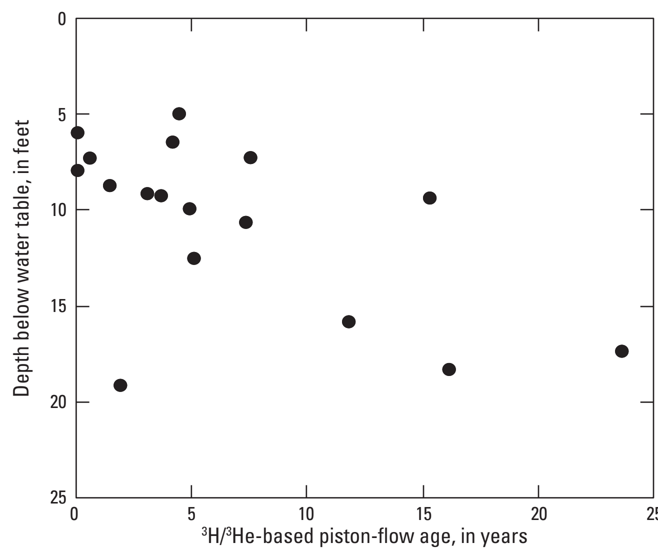

Figure B64. $^3H/^3He$-based age gradient for dated sites from the LUSRC1 and REFOT1 networks, LERI Study Unit.

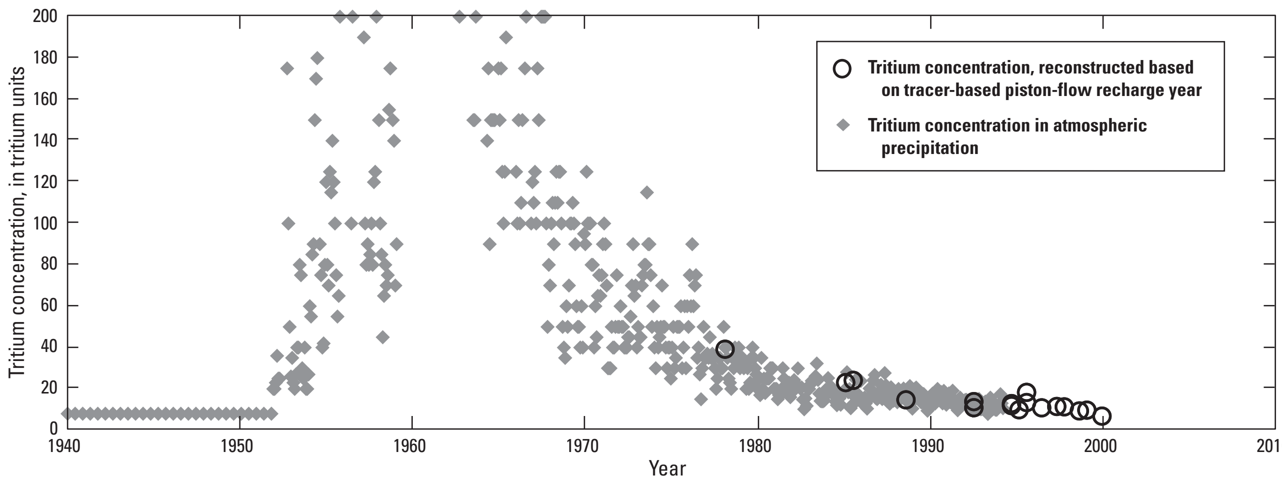

Figure B65. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, LUSRC1 and REFOT1 networks, LERI Study Unit.

LERI SUS1

Samples from 16 sites in the LERI Study Unit were collected in 2007 for CFCs (networks and, in parentheses, number of sites):

- SUS1 (16)

The aquifer is composed of sand and gravel.

Major dissolved-gas data were available for all 16 sites. Of these 16 sites, all 16 were suboxic and samples from three sites were degassed.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table, that recharge temperature was equal to the mean annual air temperature +1°C, and that excess air concentrations were 2 cc STP/kg.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B18.

- Advantages associated with these samples:
  - CFCs, as well as major dissolved gases.
  - Mixture of domestic and monitoring wells, so generally low pumping stress.
  - Relatively short open intervals ranging from 3 to 10 feet so mixing likely minimized.
- Disadvantages associated with these samples:
  - Median penetration of center of open interval into water table was 52.49 feet (not sampling close to the water table, potentially mixing).
  - The CFCs were degraded and no age-dating was possible for these sites because only CFC samples were taken.
- Depth to water (can affect tracer transport to water table):
  - Median: 22.79 feet
  - Mean: 26.84 feet
  - Min: 1.87 feet
  - Max: 69.65 feet
- Brief analysis:
  - No tracer interpretations could be made for this network as a result of the suboxic conditions.

LINJ LUSRC1, SUS2, REFFO1, and FPSOT3

Samples from 12 sites in the LINJ Study Unit were collected in 2007 for SF_6 (networks and, in parentheses, number of sites):

- LUSRC1 (4)
- SUS2 (5)
- REFFO1 (1)
- FPSOT3 (2)

The aquifer is composed of sand, clay, and gravel of the Cohansey Sand-Kirkwood Formation.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table, that recharge temperature was equal to the mean annual air temperature +1°C, and that excess air concentrations were 2 cc STP/kg.

The raw tracer data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B19.

- Advantages associated with these samples:
  - None.

. Disadvantages associated with these samples:

. No multiple tracers or major dissolved gases.

. Mixture of domestic, monitoring, commercial, and public supply wells, so variable pumping rates.

. Relatively large open intervals ranging from 2 to 34.25 feet so mixing likely.

. Median penetration of center of open interval into water table was 61.61 feet (not sampling close to the water table, potentially mixing).

. No tritium analyses.

. Depth to water (can affect tracer transport to water table):

. Median: 14.72 feet

. Mean: 25.90 feet

. Min: 8.85 feet

. Max: 51.39 feet

. Brief analysis:

. The SF_6-based age gradient for these sites is shown in figure B66. The age gradient shows a general trend of increasing age with depth. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

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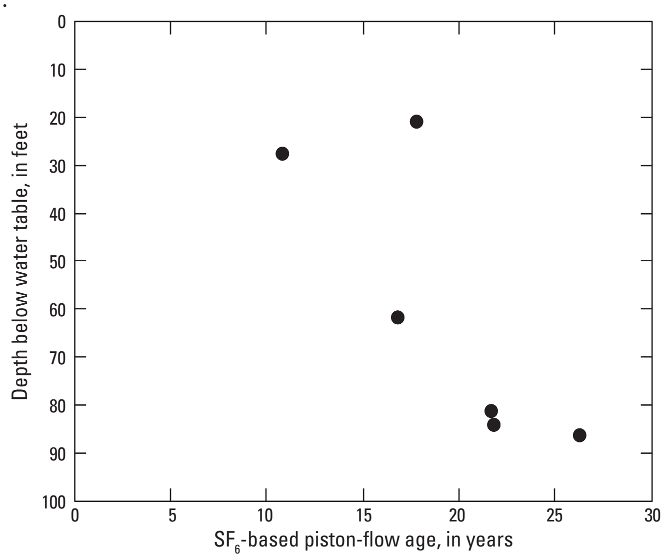

Figure B66. SF_6-based age gradient for dated sites from the LUSRC1, SUS2, REFFO1, and FPSOT3 networks, LINJ Study Unit.

LINJ LUSRC2

Samples from 27 sites in the LINJ Study Unit were collected in 2006 for SF_6 and $^3H/^3He$ (networks and, in parentheses, number of sites):

. LUSRC2 (SF_6, 26; $^3H/^3He$, 8)

The aquifer is composed of undifferentiated glacial deposits.

Major dissolved-gas data were available for nine sites. Of these nine sites, five were oxic and four were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites.

$^3H/^3He$ ages were calculated for four sites (three of the four sites required a correction for terrigenic helium), while one site was not datable because of fractionation, and samples from three sites were lost due to high pressure or other laboratory issues.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B20.

. Advantages associated with these samples:

. Multiple tracers (SF_6 and $^3H/^3He$, as well as major dissolved gases).

. Monitoring wells, so generally low pumping stress.

. Relatively short open intervals ranging from 3 to 10 feet so mixing likely minimized.

. Median penetration of center of open interval into water table was 19.57 feet (sampling close to the water table, potentially minimizing mixing).

. Disadvantages associated with these samples:

. No tritium analyses.

. Depth to water (can affect tracer transport to water table):

. Median: 25.61 feet

. Mean: 30.94 feet

. Min: 4.09 feet

. Max: 84.50 feet

- Brief analysis:
  - The SF_6- and $^3H/^3He$-based age gradients for these sites are shown in figure B67 and B68. Both age gradients show a general increase in age with depth. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

The $^3H/^3He$- versus SF_6-based age comparison for this network is shown in figure B69. The age comparison is limited by the low number of samples, but is at least consistent for two of the three samples.

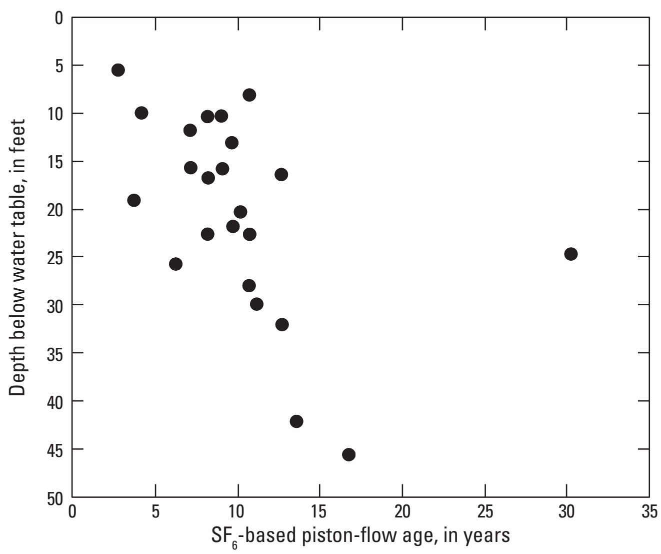

Figure B67. SF_6-based age gradient for dated sites from the LUSRC2 network, LINJ Study Unit.

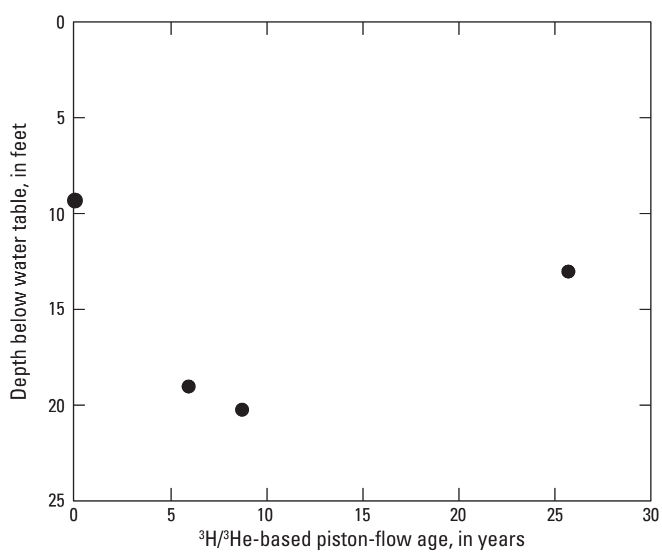

Figure B68. $^3H/^3He$-based age gradient for dated sites from the LUSRC2 network, LINJ Study Unit.

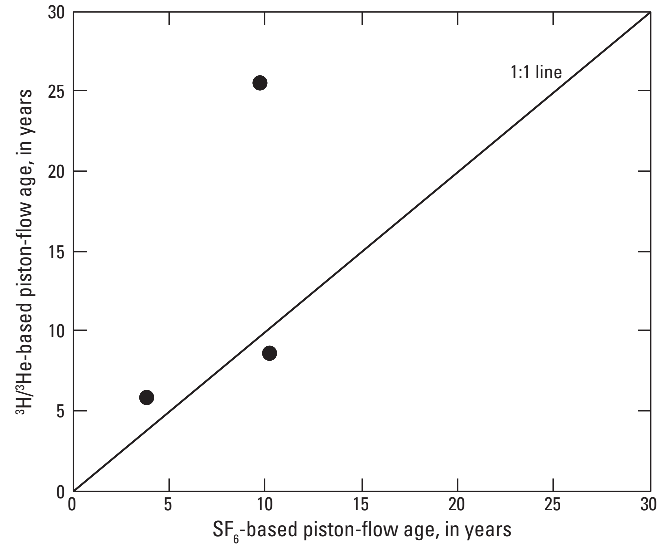

Figure B69. $^3H/^3He$- versus SF_6-based age comparison, LUSRC2 network, LINJ Study Unit.

LINJ SUS2

Samples from 11 sites in the LINJ Study Unit were collected in 2006 for SF_6 (networks and, in parentheses, number of sites):

- SUS2 (11)

The aquifer is composed of Basin and Range basin-fill sand, gravel, clay, and silt of the Cohansey Sand-Kirkwood Formation.

Major dissolved-gas data were available for nine sites. Of these nine sites, seven were oxic and two were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B21.

- Advantages associated with these samples:
  - SF_6, as well as major dissolved gases.
  - Relatively short open intervals of 10 feet so mixing likely minimized.
- Disadvantages associated with these samples:
  - Mixture of domestic and commercial wells, so variable pumping rates.
  - Median penetration of center of open interval into water table was 62.73 feet (not sampling close to the water table, potentially mixing).
  - No tritium analyses.

. Depth to water (can affect tracer transport to water table):

. Median: 13.39 feet

. Mean: 20.13 feet

. Min: 11.39 feet

. Max: 51.39 feet

. Brief analysis:

. The SF_6-based age gradient for these sites is shown in figure B70. The age gradient shows a general trend of increasing age with depth. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

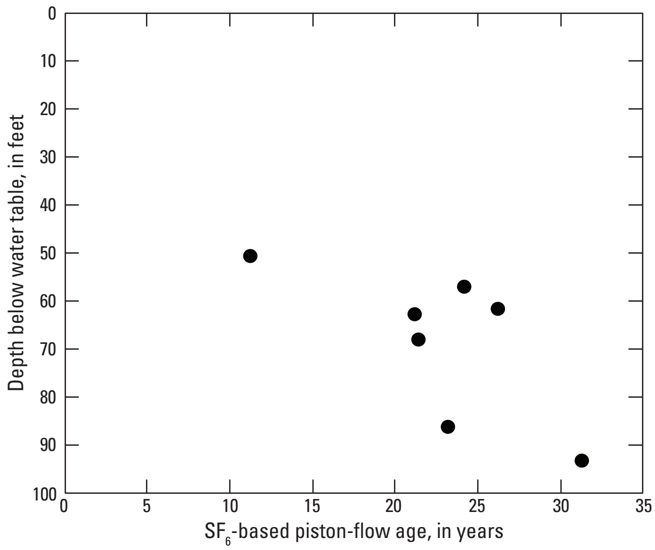

Figure B70. SF_6-based age gradient for dated sites from the SUS2 network, LINJ Study Unit.

MISE LUSRC1, LUSRC2, and REFOT1

Samples from 31 sites in the MISE Study Unit were collected in 2006 for SF_6 (networks and, in parentheses, number of sites):

. LUSRC1 (23)

. LUSRC2 (7)

. REFOT1 (1)

The aquifer is composed of sand, silt, gravel, and clay of the Memphis Sand and Terrace deposits.

Major dissolved-gas data were available for 30 sites. Of these 30 sites, 12 were oxic and 18 were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B22.

. Advantages associated with these samples:

. SF_6, as well as major dissolved gases.

. Monitoring wells, so generally low pumping stress.

. Relatively short open intervals ranging from 3.9 to 20 feet so mixing likely minimized.

. Median penetration of center of open interval into water table was 15.84 feet (sampling close to the water table, potentially minimizing mixing).

. Depth to water (can affect tracer transport to water table):

. Median: 32.39 feet

. Mean: 43.72 feet

. Min: 13.98 feet

. Max: 97.28 feet

. Brief analysis:

. The SF_6-based age gradient for these sites is shown in figure B71. The age gradient has a slight trend towards increasing age with depth. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

The reconstructed ^3H plot for SF_6-based ages is shown in figure B72. The reconstruction shows evidence of unmixed, piston-flow transport for some samples, and mixing for other samples.

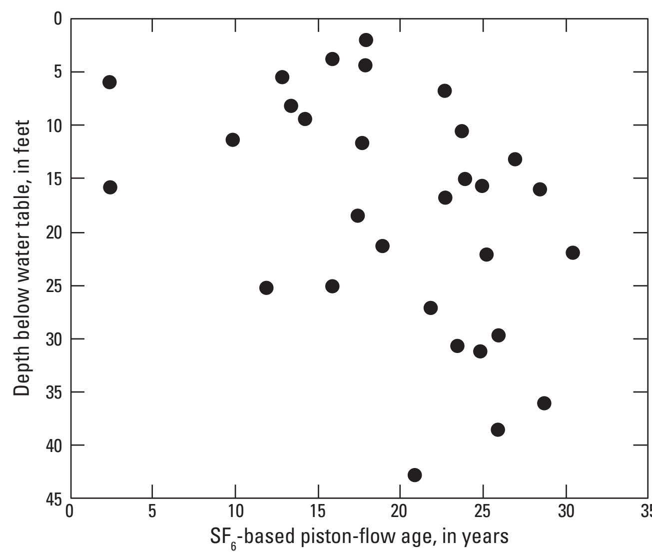

Figure B71. SF_6-based age gradient for dated sites from the LUSRC1, LUSRC2, and REFOT1 networks, MISE Study Unit.

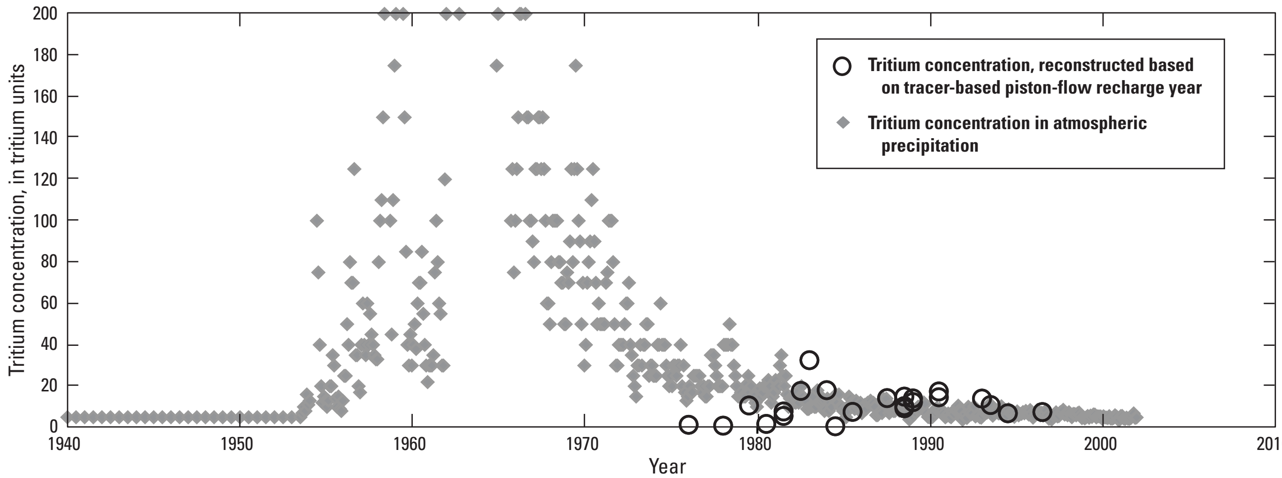

Figure B72. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, LUSRC1, LUSRC2, and REFOT1 networks, MISE Study Unit.

MISE SUS4

Samples from 16 sites in the MISE Study Unit were collected in 2007 for CFCs and $^3H/^3He$ (networks and, in parentheses, number of sites):

. SUS4 (16)

The aquifer is composed of sand of the Memphis and Sparta Sands.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table, that recharge temperature was equal to the mean annual air temperature +1°C, and that excess air concentrations were 2 cc STP/kg.

$^3H/^3He$ ages were calculated for two sites (these two sites did not require a correction for terrigenic He), while five sites were not datable because tritium concentrations were too low, four sites were not datable because of fractionation, and samples from five sites were lost due to high pressure.

The raw tracer data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B23.

. Advantages associated with these samples:

. Multiple tracers (CFCs and $^3H/^3He$).

. Disadvantages associated with these samples:

. No major dissolved gases.

. Mixture of domestic, irrigation, commercial, and public supply wells, so variable pumping rates.

. Relatively large open intervals ranging from 5 to 75 feet so mixing likely.

. Median penetration of center of open interval into water table was 178.18 feet (not sampling close to the water table, potentially mixing).

. Depth to water (can affect tracer transport to water table):

. Median: 35.87 feet

. Mean: 49.65 feet

. Min: 0.83 feet

. Max: 128.12 feet

. Brief analysis:

. The CFC-based age gradient for these sites is shown in figure B73. The age gradient is typical of samples that are affected by CFC-degradation, and/or are at the limit of CFC-based dating. Three of the samples with slightly younger ages come from wells with slightly more oxic water than the rest of the samples, which would be consistent with degradation, however, many of the samples have extremely low tritium values, which would indicate very old ages that would be beyond the range of dating successfully with CFCs.

The reconstructed ^3H plot for CFC-based ages is shown in figure B74. The reconstruction shows evidence of unmixed, piston-flow transport for the three more oxic samples noted above, mixing for other samples, and ages beyond the range of dating using CFCs for others samples.

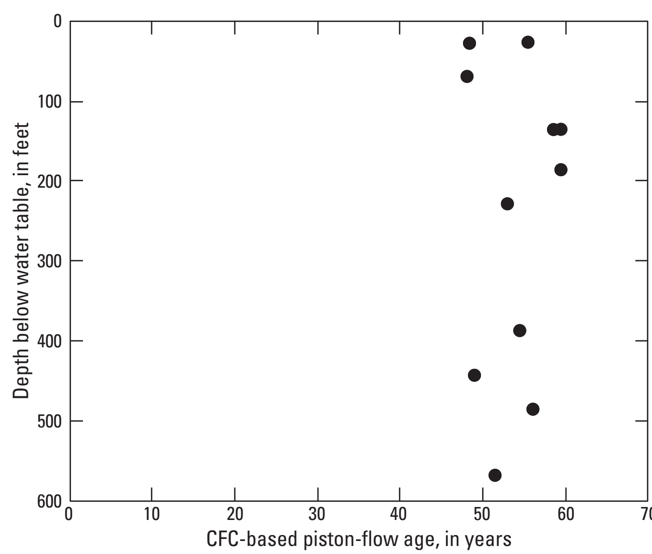

Figure B73. CFC-based age gradient for dated sites from the SUS4 network, MISE Study Unit.

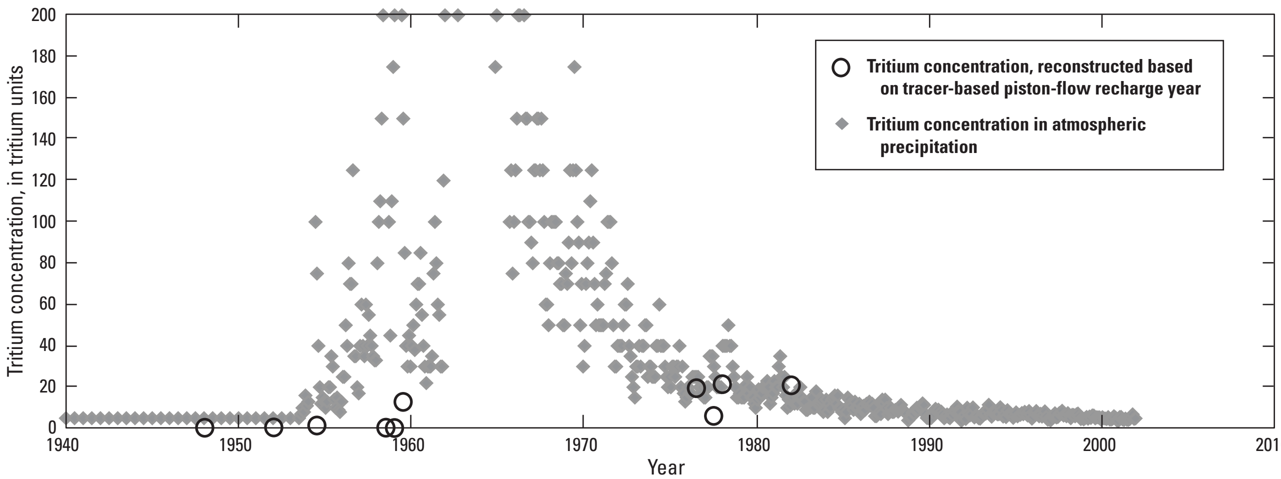

Figure B74. Reconstructed tritium concentrations (using CFC-based ages) and tritium in atmospheric precipitation, SUS4 network, MISE Study Unit.

NECB SUS3 and REFFO1

Samples from seven sites in the NECB Study Unit were collected in 2007 for CFCs (networks and, in parentheses, number of sites):

- SUS3 (5)
- REFFO1 (2)

The aquifer is composed of undifferentiated, stratified sand and gravel deposits.

Major dissolved-gas data were available for all seven sites. Of these seven sites, two were oxic and five were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B24.

- Advantages associated with these samples:
  - CFCs, as well as major dissolved gases.
  - Relatively short open intervals ranging from 1.3 to 20 feet so mixing likely minimized.
- Disadvantages associated with these samples:
  - Mixture of monitoring and public supply wells, so variable pumping rates.
  - Median penetration of center of open interval into water table was 47.04 feet (not sampling close to the water table, potentially mixing).
- Depth to water (can affect tracer transport to water table):
  - Median: 13.83 feet
  - Mean: 16.17 feet
  - Min: 1.85 feet
  - Max: 37.00 feet
- Brief analysis:
  - Due to the suboxic conditions in this network, age-dating was not possible using CFCs.

NVBR LUSRC1, REFOT1, and SUS2

Samples from 13 sites in the NVBR Study Unit were collected in 2008 for CFCs and $^3H/^3He$ (networks and, in parentheses, number of sites):

- LUSRC1 (6)
- REFOT1 (2)
- SUS2 (5)

The aquifer is composed of valley-fill sand, gravel, clay, and silt deposits.

Major dissolved-gas data were available for 13 sites. Of these 13 sites, 8 were oxic and 5 were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites.

$^3H/^3He$ ages were calculated for six sites (four of the six sites required a correction for terrigenic helium), while three sites were not datable because tritium concentrations were too low, and two sites were not datable because of fractionation.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B25.

- Advantages associated with these samples:
  - Multiple tracers (CFCs and $^3H/^3He$, as well as major dissolved gases).
- Disadvantages associated with these samples:
  - Mixture of monitoring and public supply wells, so variable pumping rates.
  - Relatively large open intervals ranging from 0 to 260 feet so mixing likely.
  - Median penetration of center of open interval into water table was 24.81 feet (not sampling close to the water table, potentially mixing).
- Depth to water (can affect tracer transport to water table):
  - Median: 44.73 feet
  - Mean: 56.05 feet
  - Min: 5.18 feet
  - Max: 140.81 feet
- Brief analysis:
  - The $^3H/^3He$-based age gradient for these sites is shown in figure B75. The age gradient shows a general increase in age with depth if the oldest sample is included, despite being beyond the dating range for $^3H/^3He$ dating. If this sample is excluded, the age gradient is more scattered, with old ages at very shallow depths in monitoring wells. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

The reconstructed ^3H plot for $^3H/^3He$-based ages is shown in figure B76. The reconstruction shows evidence of unmixed, piston-flow transport for samples recharged since 1980, and mixing of pre- and post-bomb water for the sample with a piston-flow age of about 1970. Most of the samples have very low tritium concentrations, some of which preclude using the $^3H/^3He$ technique for dating.

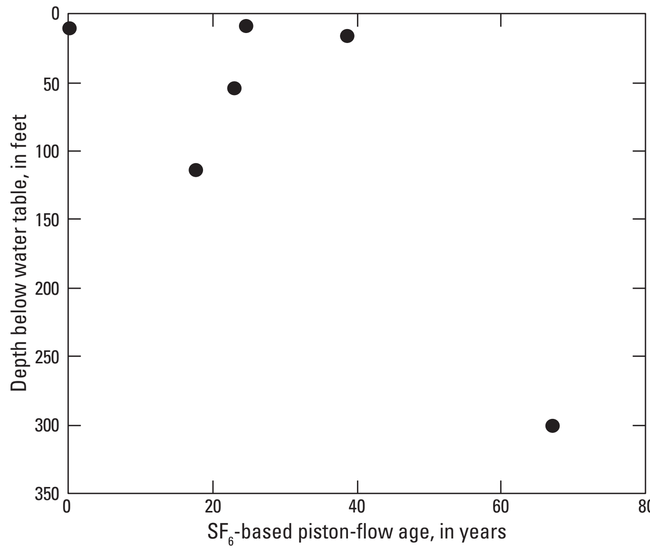

Figure B75. $^3H/^3He$-based age gradient for dated sites from the LUSRC1, REFOT1, and SUS2 networks, NVBR Study Unit.

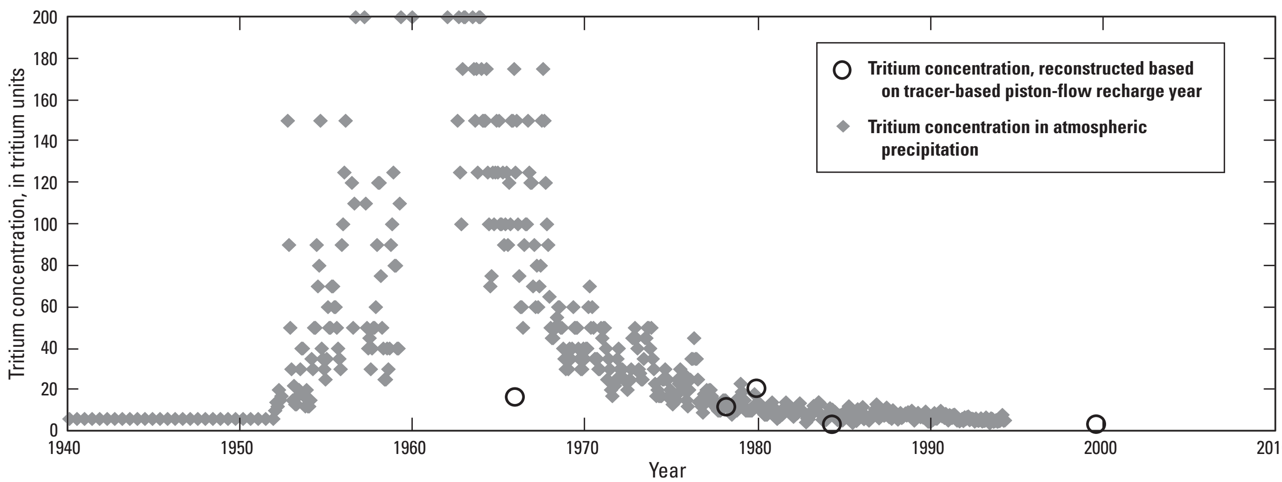

Figure B76. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, LUSRC1, REFOT1, and SUS2 networks, NVBR Study Unit.

PODL LUSRC1

Samples from six sites in the PODL Study Unit were collected in 2007 for SF_6 and $^3H/^3He$ (networks and, in parentheses, number of sites):

- LUSRC1 (5)

The aquifer is composed of fractured rock, with one well finished in limestone.

Major dissolved-gas data were available for five sites. Of these five sites, two were oxic and three were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data (PODL LUSRC1 and PODL REFFO1), with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites.

$^3H/^3He$ ages were calculated for three sites (two of the three sites required a correction for terrigenic helium), while two sites were not datable because of fractionation.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B26.

- Advantages associated with these samples:
  - Multiple tracers (SF_6 and $^3H/^3He$, as well as major dissolved gases).
  - Mostly monitoring wells, with one recreational well, so likely low pumping stress.
- Disadvantages associated with these samples:
  - Relatively large open intervals ranging from 24 to 102 feet so mixing likely.
  - Median penetration of center of open interval into water table was 29.62 feet (not sampling close to the water table, potentially mixing).
- Depth to water (can affect tracer transport to water table):
  - Median: 13.00 feet
  - Mean: 16.36 feet
  - Min: 6.83 feet
  - Max: 34.92 feet
- Brief analysis:
  - The SF_6- and $^3H/^3He$-based age gradients for these sites are shown in figures B77 and B78. The age gradients show a similar pattern for both SF_6 and $^3H/^3He$ samples, with somewhat younger ages for SF_6. The wells in this network are from fractured rock and are not from a single flowpath, so it would not be expected to have a clearly defined age gradient, particularly for so few wells.

The reconstructed ^3H plots for SF_6- and $^3H/^3He$-based ages are shown in figures B79 and B80. The reconstructions are similar and show evidence of unmixed, piston-flow transport.

The $^3H/^3He$- versus SF_6-based age comparison for this network is shown in figure B81. The age comparison is limited by the low number of samples and scattered values.

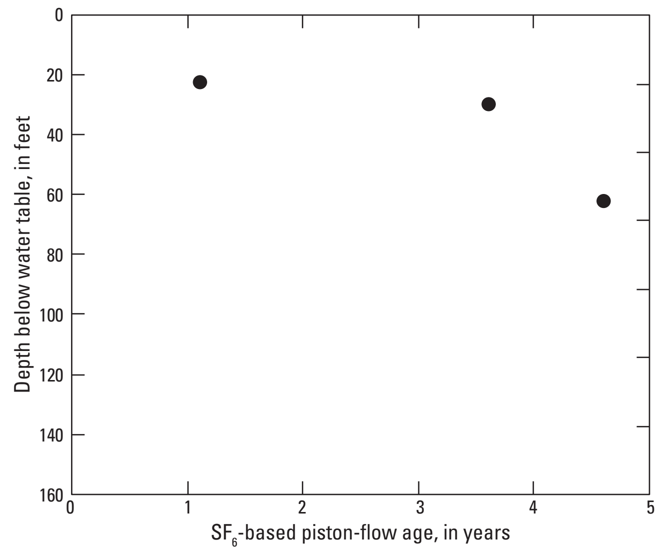

Figure B77. SF_6-based age gradient for dated sites from the LUSRC1 network, PODL Study Unit.

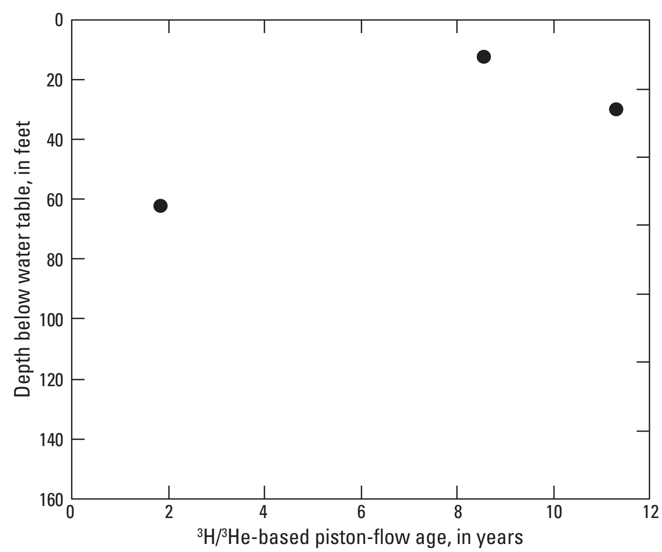

Figure B78. $^3H/^3He$-based age gradient for dated sites from the LUSRC1 network, PODL Study Unit.

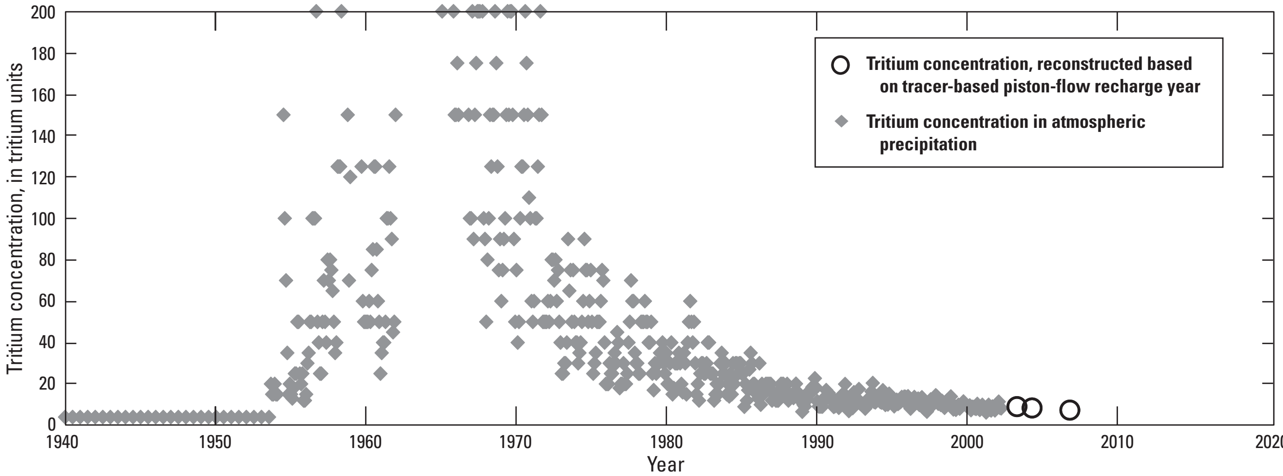

Figure B79. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, LUSRC1 network, PODL Study Unit.

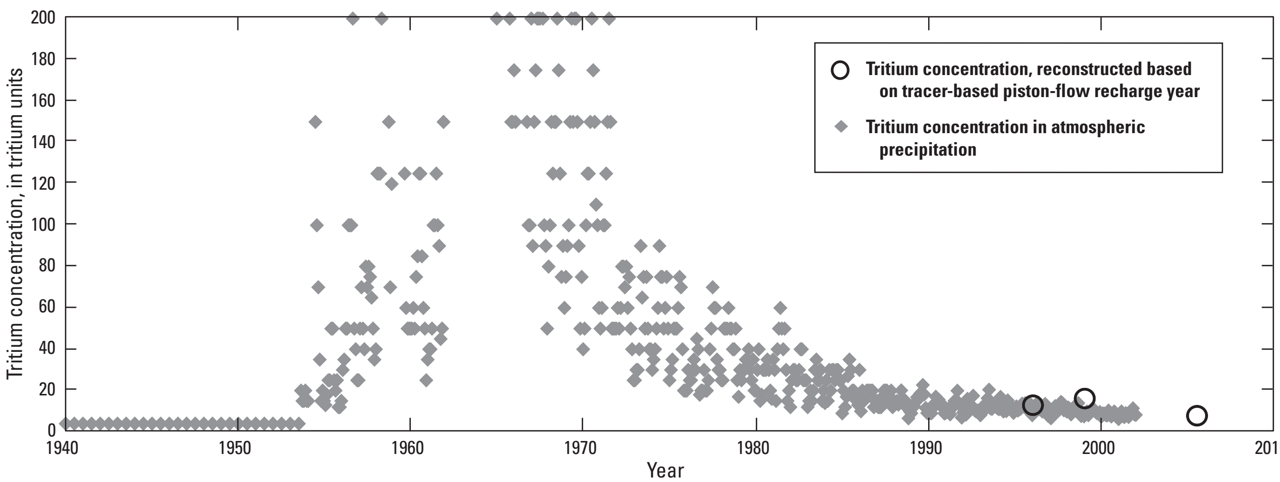

Figure B80. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, LUSRC1 network, PODL Study Unit.

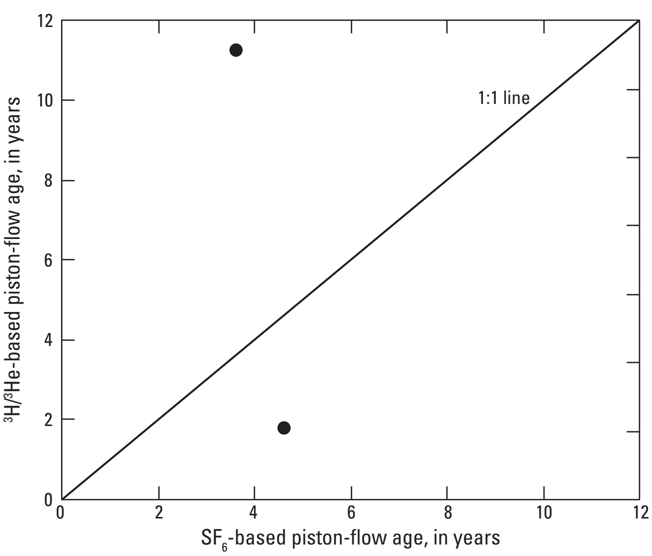

Figure B81. $^3H/^3He$- versus SF_6-based age comparison, LUSRC1 network, PODL Study Unit.

PODL POTOLUSAG1 and PODLREFFO1

Samples from six sites in the PODL Study Unit were collected in 2007 for SF_6 and $^3H/^3He$ (networks and, in parentheses, number of sites):

- POTOLUSAG1 (5)
- PODLREFFO1 (1)

The aquifer is composed of limestone and dolomite.

Major dissolved-gas data were available for six sites. Of these six sites, five were oxic and one was suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites.

$^3H/^3He$ ages were calculated for four sites (two of the four sites required a correction for terrigenic helium), while one site was lost due to high pressure.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B27.

- Advantages associated with these samples:
  - Multiple tracers (SF_6 and $^3H/^3He$, as well as major dissolved gases).
  - Mixture of domestic and recreation wells, so likely low pumping stress.
- Disadvantages associated with these samples:
  - Relatively large open intervals ranging from 17 to 109 feet so mixing likely.
  - Median penetration of center of open interval into water table was 62.86 feet (not sampling close to the water table, potentially mixing).
- Depth to water (can affect tracer transport to water table):
  - Median: 42.15 feet
  - Mean: 55.43 feet
  - Min: 29.50 feet
  - Max: 40.00 feet
- Brief analysis:
  - The SF_6- and $^3H/^3He$-based age gradients for these sites are shown in figures B82 and B83. The age gradients show a similar pattern for both SF_6 and $^3H/^3He$ samples, with somewhat younger ages for SF_6. The wells in this network are from karst and are not from a single flowpath, so it would not be expected to have a clearly defined age gradient, particularly for so few wells.

The reconstructed ^3H plots for SF_6- and $^3H/^3He$-based ages are shown in figures B84 and B85. The reconstructions are similar, which may simply be the result from the samples plotting in the relatively flat portion of the ^3H reconstruction.

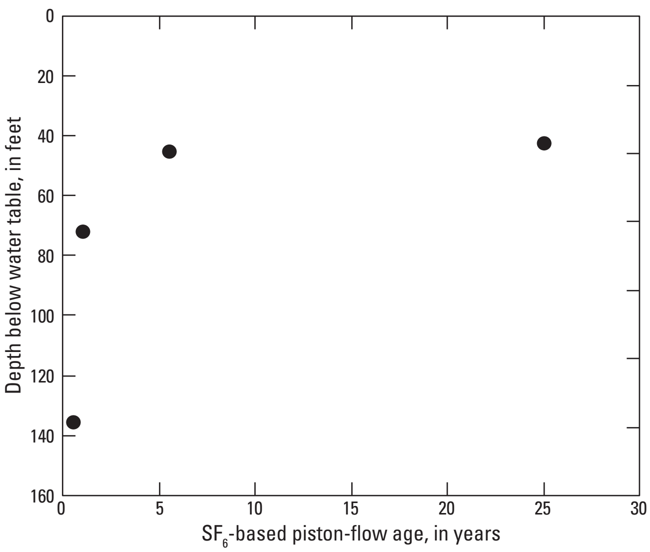

Figure B82. SF_6-based age gradient for dated sites from the POTOLUSAG1 and PODLREFF01 networks, PODL Study Unit.

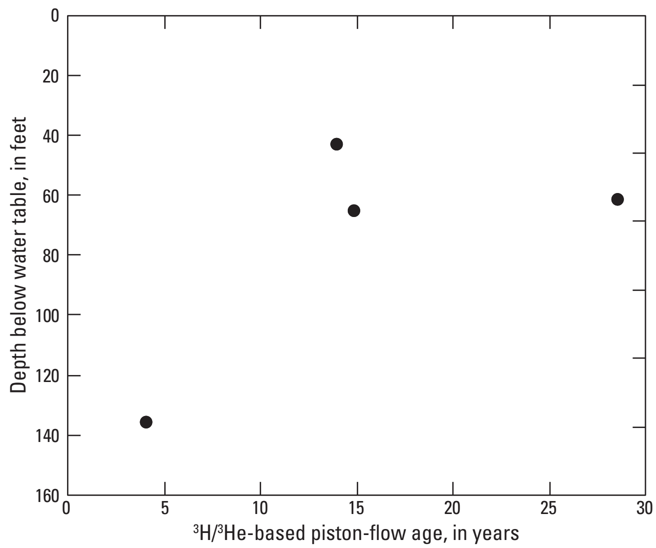

Figure B83. $^3H/^3He$-based age gradient for dated sites from the POTOLUSAG1 and PODLREFF01 networks, PODL Study Unit.

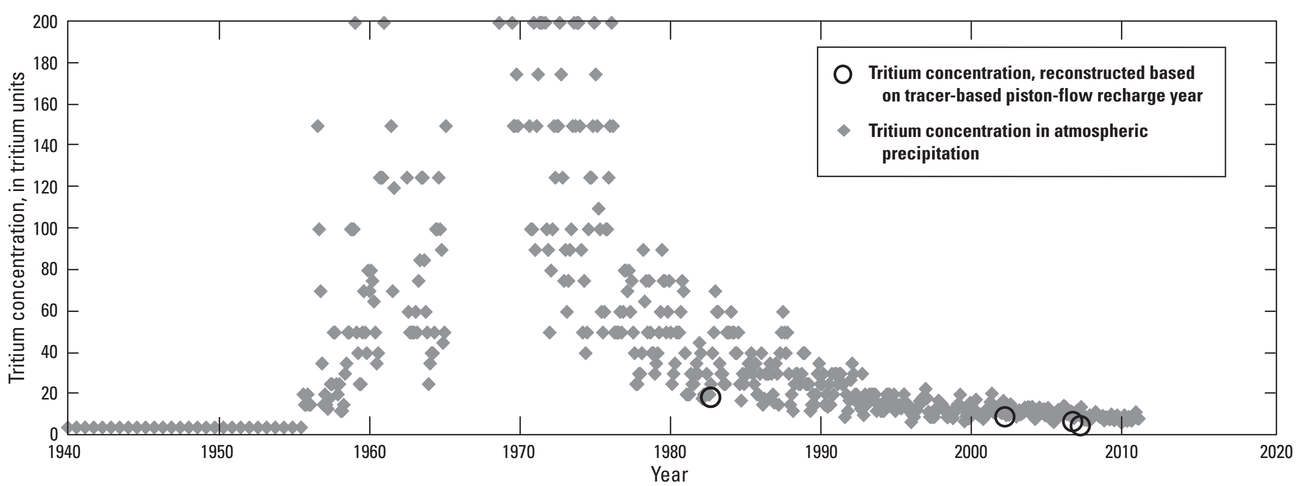

Figure B84. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, POTOLUSAG1 and PODLREFF01 networks, PODL Study Unit.

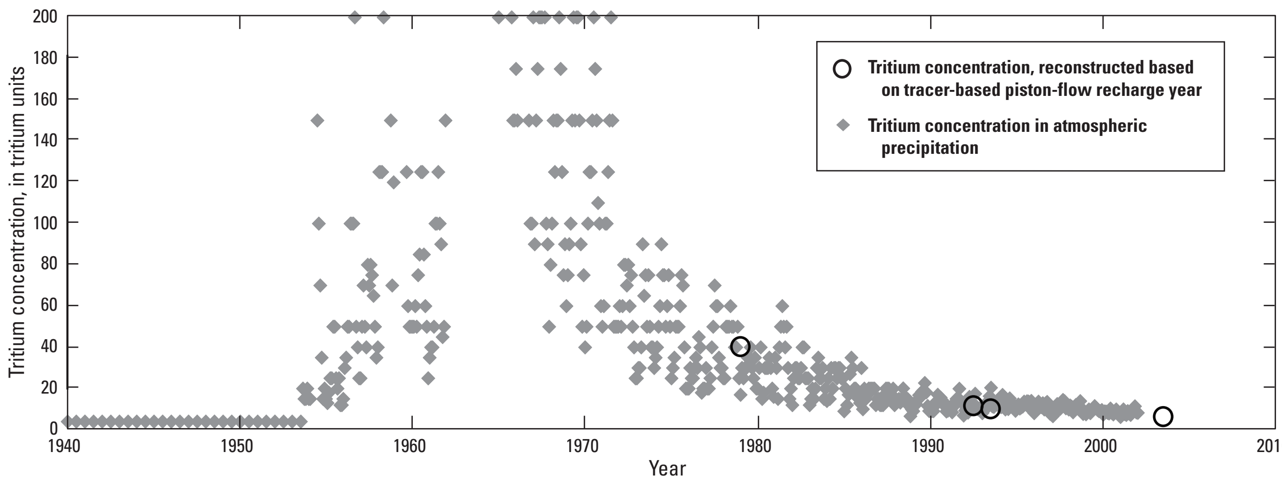

Figure B85. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, POTOLUSAG1 and PODLREFFO1 networks, PODL Study Unit.

PUGT FPSCR1 and LUSCR1

Samples from 20 sites in the PUGT Study Unit were collected in 2007 for SF_6 and $^3H/^3He$ (networks and, in parentheses, number of sites):

- FPSCR1 (11)
- LUSCR1 (9)

The aquifer is composed of glacial sands, gravel, and clay.

Major dissolved-gas data were available for 20 sites. Of these 20 sites, 7 were oxic and 13 were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites.

$^3H/^3He$ ages were calculated for eight sites (only one of the eight sites required a correction for terrigenic helium).

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B28.

- Advantages associated with these samples:
  - SF_6 and $^3H/^3He$, as well as major dissolved gases.
  - Monitoring wells, so low pumping stress.
  - Relatively short open intervals ranging from 1.98 to 54.08 feet so mixing likely minimized.
  - Median penetration of center of open interval into water table was 22.97 feet (sampling close to the water table, potentially minimizing mixing).
- Disadvantages associated with these samples:
  - Suboxic conditions.
- Depth to water (can affect tracer transport to water table):
  - Median: 9.42 feet
  - Mean: 8.93 feet
  - Min: 3.95 feet
  - Max: 18.32 feet
- Brief analysis:
  - The SF_6- and $^3H/^3He$-based age gradients for these sites are shown in figures B86 and B87. The SF_6-based age gradient shows a great deal of scatter, which may be the result of gas stripping due to the suboxic conditions. The $^3H/^3He$-based age gradient shows a general increase in age with depth. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

The reconstructed ^3H plots for SF_6- and $^3H/^3He$-based ages are shown in figures B88 and B89. The reconstructions show evidence of unmixed, piston-flow transport for most samples, and mixing or dispersion for other samples in the SF_6 reconstruction. Some of these samples may have been affected by gas stripping due to elevated methane (3 of the 4 samples have measurable methane). For those samples, the SF_6 ages would in fact be younger and would fall on the reconstructed tritium input curve.

The $^3H/^3He$- versus SF_6-based age comparison for this network is shown in figure B90. Several samples may be affected by gas stripping and SF_6 loss, which could explain the discrepancy in ages.

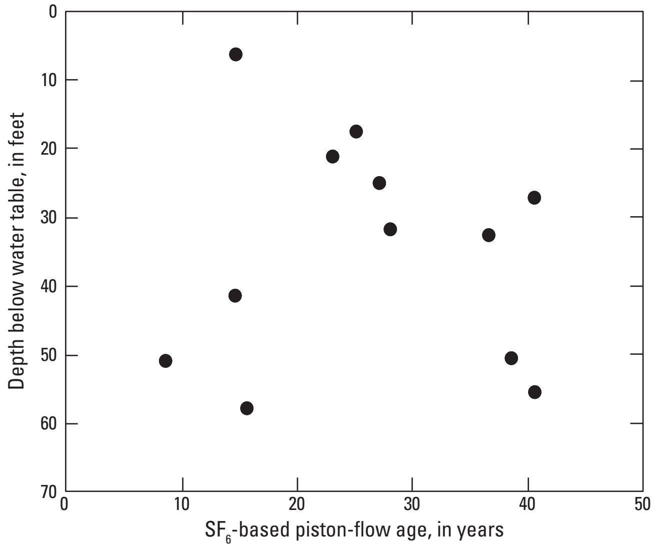

Figure B86. SF_6-based age gradient for dated sites from the FPSCR1 and LUSCR1 networks, PUGT Study Unit.

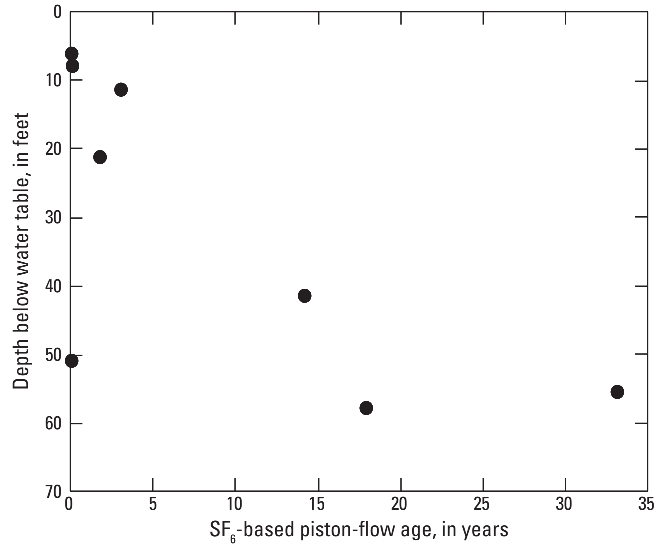

Figure B87. $^3H/^3He$-based age gradient for dated sites from the FPSCR1 and LUSCR1 networks, PUGT Study Unit.

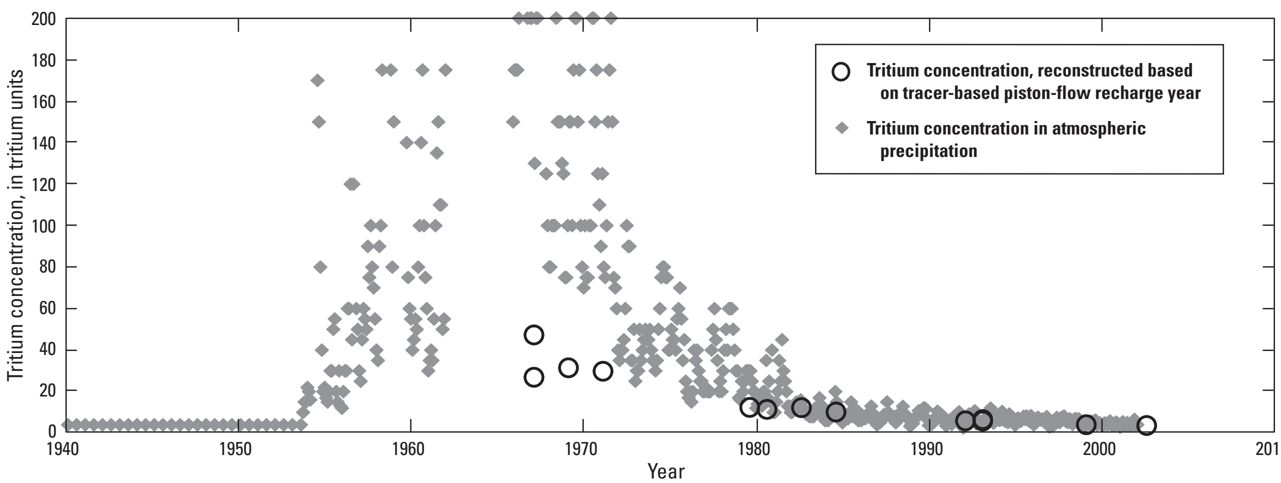

Figure B88. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, FPSCR1 and LUSCR1 networks, PUGT Study Unit.

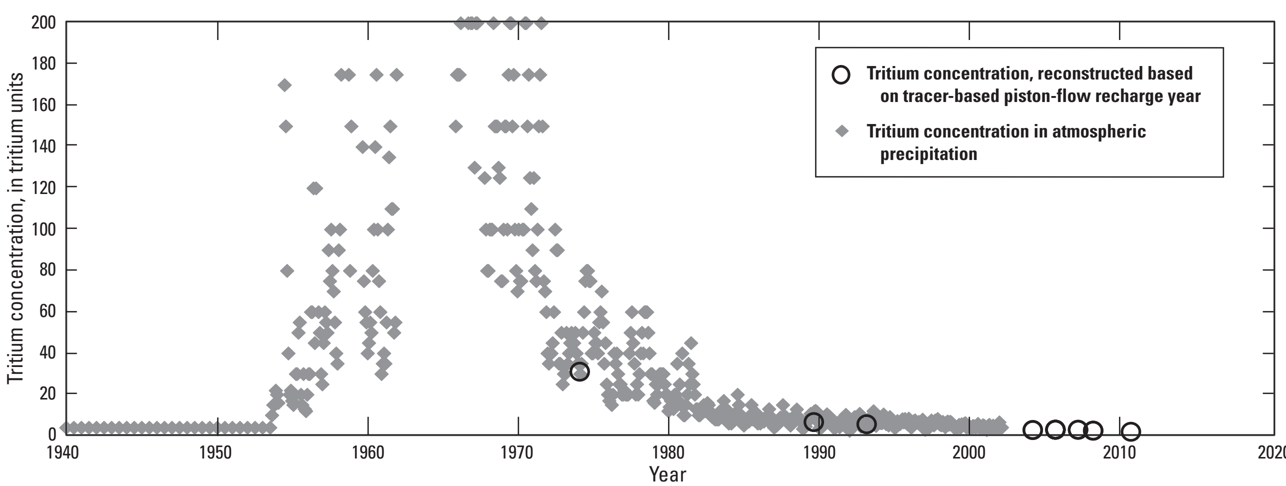

Figure B89. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, FPSCR1 and LUSCR1 networks, PUGT Study Unit.

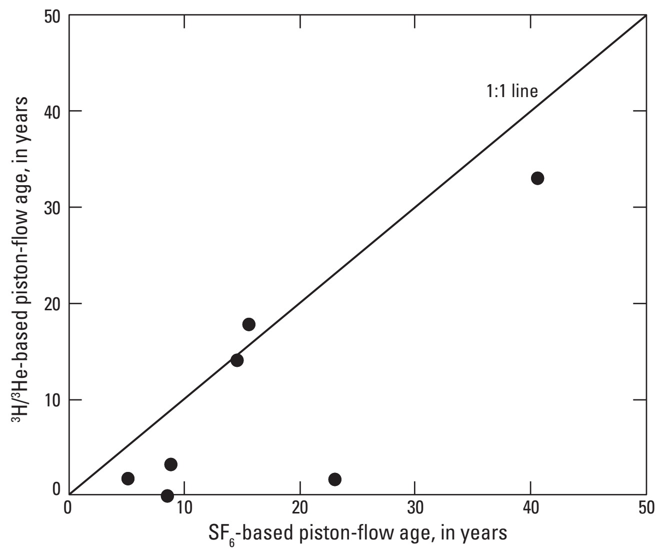

Figure B90. $^3H/^3He$- versus SF_6-based age comparison, FPSCR1, and LUSCR1 networks, PUGT Study Unit.

RIOG LUSAG1

Samples from 30 sites in the RIOG Study Unit were collected in 2006 for CFCs and 5 sites were repeated in 2008 for $^3H/^3He$ (network and, in parentheses, number of sites):

. LUSAG1 (CFCs, 30; $^3H/^3He$, 5)

The aquifer is composed of alluvial sand and silt.

Major dissolved-gas data were available for 22 sites from the 2006 sampling. Of these 22 sites, 1 was oxic and 21 were suboxic, and 3 were degassed. Excess air concentrations were elevated and difficult to constrain. Recharge temperatures ranged from 11.2 to 25.5°C and bracketed the 17.7°C determined from MAAT +1°C.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table, that recharge temperature was equal to mean annual air temperature +1°C, and that excess air concentrations were 2 cc STP/kg.

$^3H/^3He$ age was calculated for only one site (this one site did not require a correction for terrigenic He), while three sites were not datable because of fractionation, and the sample from one site was lost due to high pressure.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B29.

. Advantages associated with these samples:

. Multiple tracers (CFCs and $^3H/^3He$, as well as major dissolved gases).

. Monitoring wells, therefore low pumping stress.

. Relatively short open intervals ranging from 3.34 to 10 feet so mixing likely minimized.

. Median penetration of center of open interval into water table was 3.76 feet (sampling close to the water table, potentially minimizes mixing).

. Disadvantages associated with these samples:

. Suboxic conditions and degassing.

. Only five tritium values.

. Depth to water (can affect tracer transport to water table):

. Median: 11.68 feet

. Mean: 12.01 feet

. Min: 3.10 feet

. Max: 18.22 feet

. Brief analysis:

. The CFC-based age gradient for these sites is shown in figure B91. The age gradient shows a great deal of scatter and a shift toward older ages for very shallow depths as would be expected for a network with suboxic conditions and CFC degradation. In fact, most of the CFC samples plotted in figure B79 do not have methane measurements and were therefore left as fixed ages, when in fact, they likely have elevated methane concentrations and should simply be bracketed in terms of ages as was done for all of the other samples. The CFC data for this network provide an excellent example of the effects of degradation processes on CFC concentrations. Table B29 shows a consistent pattern of CFC-11 ages being the oldest (most degraded), CFC-113 ages being older than (or similar to) CFC-12 ages, and CFC-12 ages being the youngest.

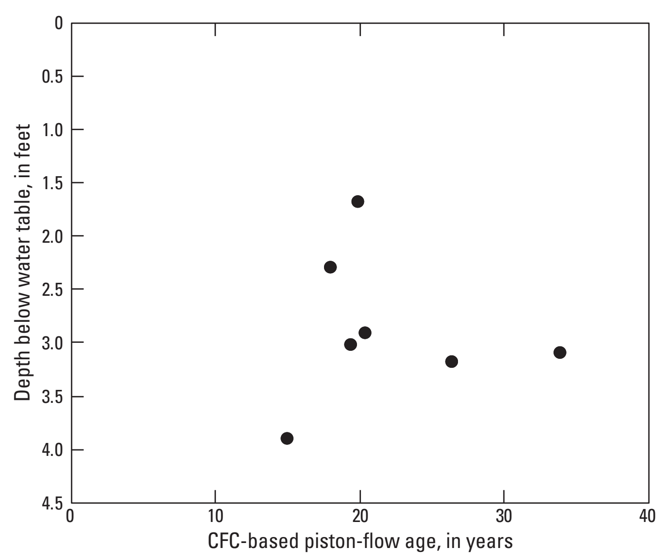

Figure B91. CFC-based age gradient for dated sites from the LUSAG1 network, RIOG Study Unit.

RIOG LUSCR1

Samples from 58 sites in the RIOG Study Unit were collected in 2007 and 2008 for CFCs and $^3H/^3He$ (networks and, in parentheses, number of sites):

- LUSCR1 (CFCs, 58; $^3H/^3He$, 29)

The aquifer is composed of sand, gravel, and silt of the Rio Grande aquifer system.

Major dissolved-gas data were available for 16 sites. Of these 16 sites, 13 were oxic, and one of the suboxic sites had excess air concentrations below the average of the oxic sites and therefore did not require any corrections. The dissolved-gas recharge temperatures were clustered in two groups with one group having temperatures significantly above the other dissolved-gas samples or the MAAT +1°C estimates.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table, that recharge temperature was equal to mean annual air temperature +1°C, and that excess air concentrations were 2 cc STP/kg.

$^3H/^3He$ ages were calculated for 15 sites (only 2 of the 15 sites required a correction for terrigenic helium), while 5 sites were not datable because of fractionation, and samples from 9 sites were lost due to high pressure.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B30.

- Advantages associated with these samples:
  - Multiple tracers (CFCs and $^3H/^3He$, as well as major dissolved gases).
  - Monitoring wells, therefore low pumping stress.
  - Relatively short open intervals ranging from 2.46 to 10 feet so mixing likely minimized.
  - Median penetration of center of open interval into water table was 11.45 feet (sampling close to the water table, potentially minimizing mixing).
- Disadvantages associated with these samples:
  - None.
- Depth to water (can affect tracer transport to water table):
  - Median: 18.68 feet
  - Mean: 18.84 feet
  - Min: 3.64 feet
  - Max: 61.11 feet
- Brief analysis:
  - The CFC- and $^3H/^3He$-based age gradients for these sites are shown in figures B92 and B93. The age gradients show a great deal of scatter with a shift toward older ages for the CFC-based age gradient. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

The reconstructed ^3H plots for CFC- and $^3H/^3He$-based ages are shown in figures B94 and B95. The reconstructions show evidence of unmixed, piston-flow transport for most samples. The one old sample in the $^3H/^3He$ reconstruction has a very low tritium concentration and is likely affected by mixing of pre- and post-bomb water.

The $^3H/^3He$- versus CFC-based age comparison for this network is shown in figure B96. The age comparison shows the shift in CFC-based ages toward older ages as compared to the $^3H/^3He$-based ages.

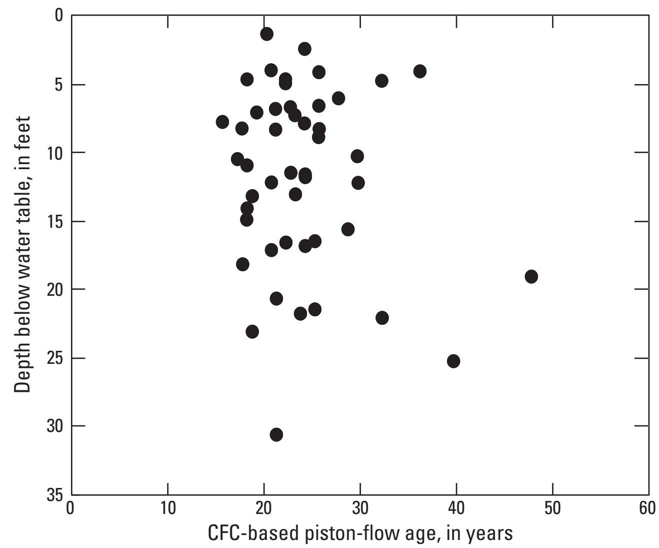

Figure B92. CFC-based age gradient for dated sites from the LUSCR1 network, RIOG Study Unit.

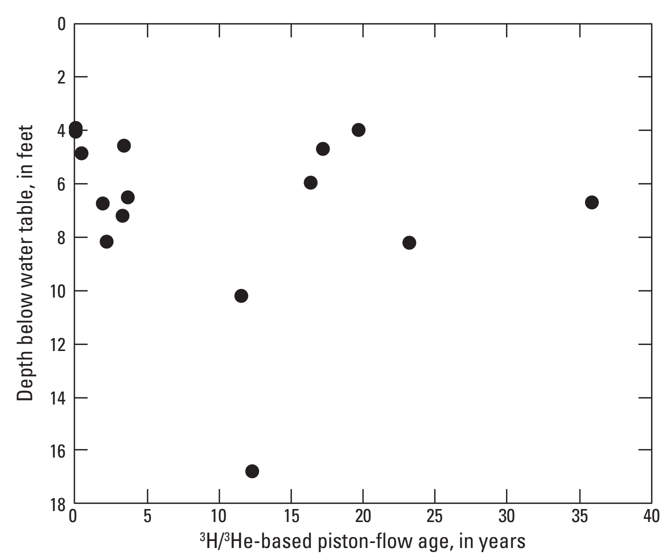

Figure B93. $^3H/^3He$-based age gradient for dated sites from the LUSCR1 network, RIOG Study Unit.

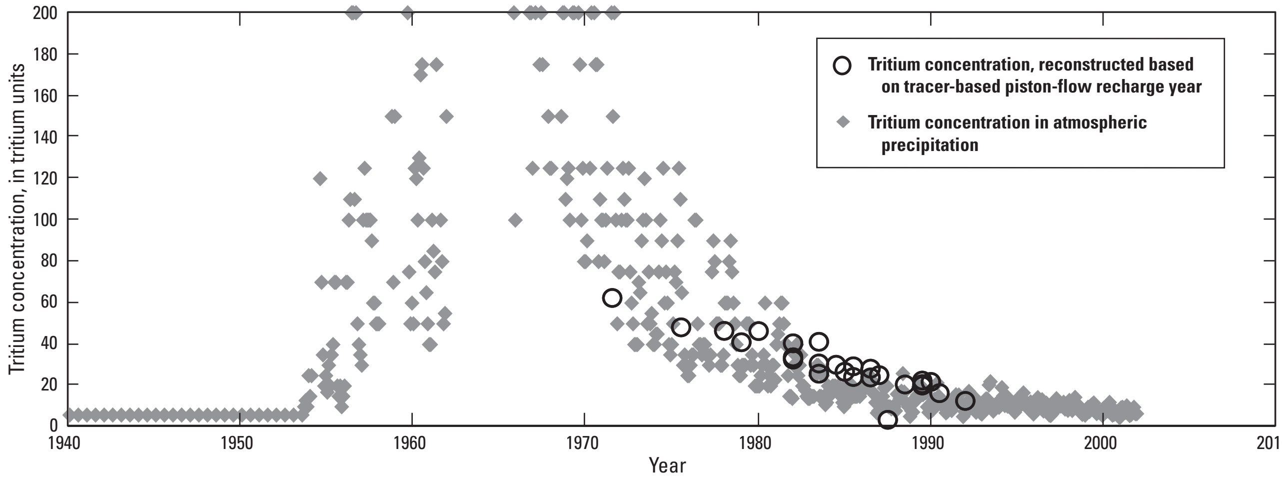

Figure B94. Reconstructed tritium concentrations (using CFC-based ages) and tritium in atmospheric precipitation, LUSCR1 network, RIOG Study Unit.

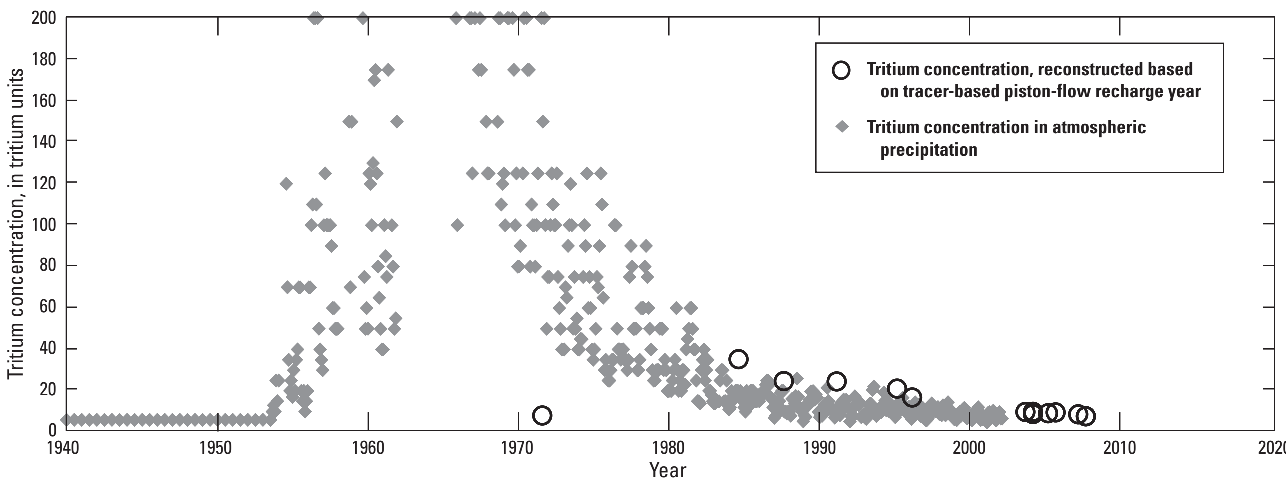

Figure B95. Reconstructed tritium concentrations (using $^{3}H/^{3}He$-based ages) and tritium in atmospheric precipitation, LUSCR1 network, RIOG Study Unit.

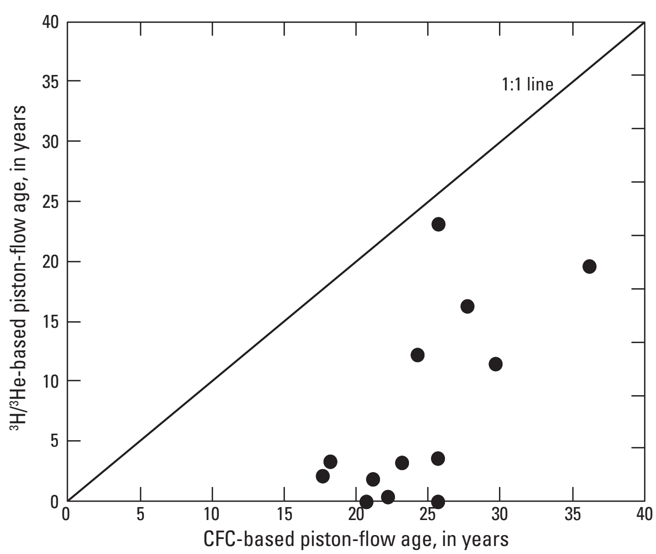

Figure B96. $^{3}H/^{3}He$- versus CFC-based age comparison, LUSCR1 network, RIOG Study Unit.

RIOG LUSRC1

Samples from seven sites in the RIOG Study Unit were collected in 2008 for $^3H/^3He$ (networks and, in parentheses, number of sites):

. LUSRC1 (7)

The aquifer is composed of sands of the Rio Grande aquifer system.

Major dissolved-gas data were available for seven sites. Of these seven sites, two were oxic and five were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table, that recharge temperature was equal to mean annual air temperature +1°C, and that excess air concentrations were 2 cc STP/kg.

$^3H/^3He$ ages were calculated for five sites (two of the five sites required a correction for terrigenic helium), while two sites were not datable because of fractionation.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B31.

. Advantages associated with these samples:

. $^3H/^3He$, as well as major dissolved gases.

. Monitoring wells, therefore low pumping stress.

. Relatively short open intervals ranging from 4.14 to 10 feet so mixing likely minimized.

. Median penetration of center of open interval into water table was 4.81 feet (sampling close to the water table, potentially minimizing mixing).

. Disadvantages associated with these samples:

. Suboxic conditions.

. Depth to water (can affect tracer transport to water table):

. Median: 8.18 feet

. Mean: 12.26 feet

. Min: 4.18 feet

. Max: 23.86 feet

. Brief analysis:

. The $^3H/^3He$-based age gradient for these sites is shown in figure B97. The age gradient shows little structure, likely as a result of the narrow range in depths for these wells.

The reconstructed ^3H plot for $^3H/^3He$-based ages is shown in figure B98. The reconstruction shows evidence of unmixed, piston-flow transport.

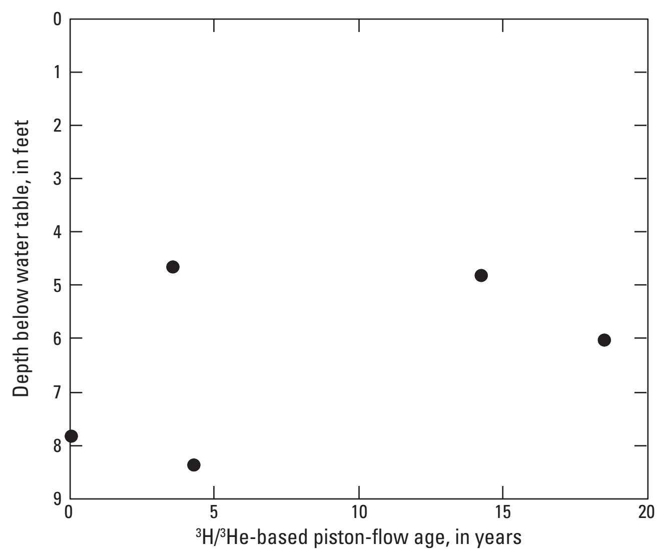

Figure B97. $^3H/^3He$-based age gradient for dated sites from the LUSRC1 network, RIOG Study Unit.

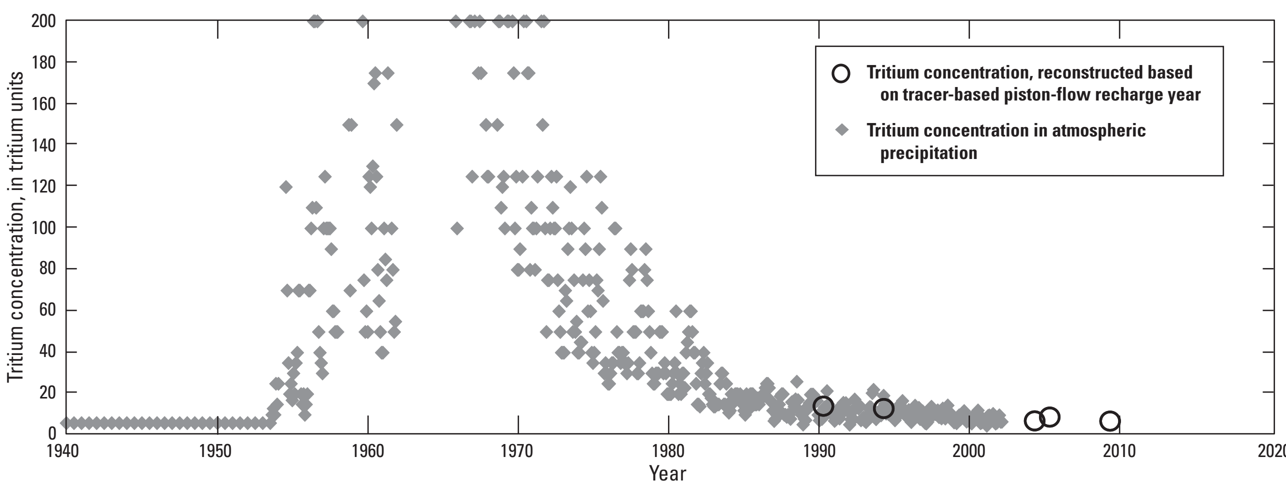

Figure B98. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, LUSRC1 network, RIOG Study Unit.

SACR LUSCR1

Samples from 5 sites in the SACR Study Unit were collected in 2006 for CFCs and SF_6 (networks and, in parentheses, number of sites):

- LUSCR1 (5)

The aquifer is composed of alluvial sand, gravel, silt and clay of the Central Valley aquifer system.

Major dissolved-gas data were available for all five sites. Of these five sites, one was oxic and four were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table, that recharge temperature was equal to mean annual air temperature +1°C, and that excess air concentrations were 2 cc STP/kg.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B32.

- Advantages associated with these samples:
  - Multiple tracers (CFCs and SF_6, as well as major dissolved gases).
  - Monitoring wells, therefore low pumping stress.
  - Relatively short open intervals ranging from 5 to 10 feet so mixing likely minimized.
- Disadvantages associated with these samples:
  - Median penetration of center of open interval into water table was 26.04 feet (sampling close to the water table, potentially minimizing mixing).
- Depth to water (can affect tracer transport to water table):
  - Median: 3.73 feet
  - Mean: 5.05 feet
  - Min: 1.67 feet
  - Max: 13.05 feet
- Brief analysis:
  - The SF_6-based age gradient for these sites is shown in figure B99. The age gradient shows little structure, likely as a result of the narrow range in depths for these wells.

The reconstructed ^3H plot for $^3H/^3He$-based ages is shown in figure B100. The samples generally plot above the ^3H reconstruction suggesting that the samples may be of mixed age resulting from heterogeneity of aquifer sediments.

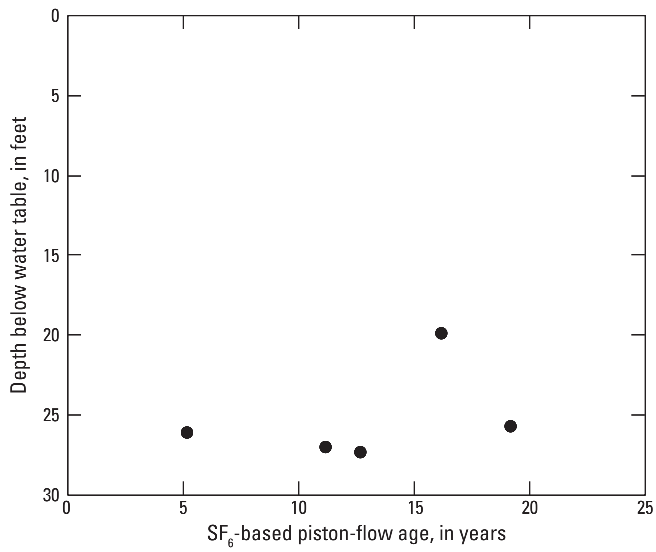

Figure B99. SF_6-based age gradient for dated sites from the LUSRC1 network, SACR Study Unit.

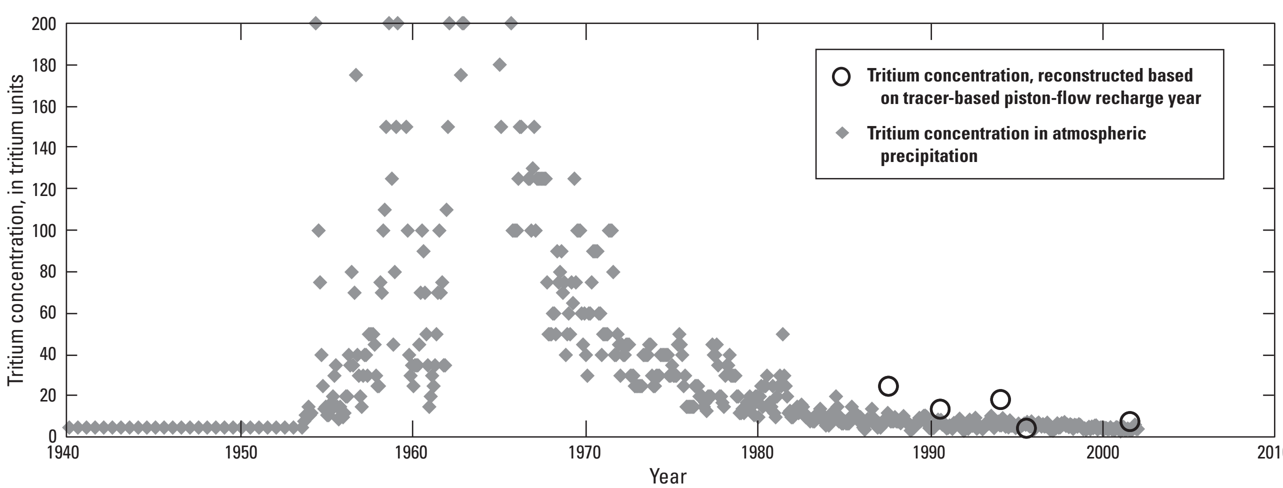

Figure B100. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, LUSRC1 network, SACR Study Unit.

SACR LUSRC1

Samples from five sites in the SACR Study Unit were collected in 2006 for CFCs and SF_6 (networks and, in parentheses, number of sites):

LUSRC1 (CFCs, 5; SF_6, 4)

The aquifer is composed of alluvial sand, gravel, silt and clay of the Central Valley aquifer system.

Major dissolved-gas data were available for all five sites. Of these five sites, three were oxic and two were suboxic, and one was degassed.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B33.

. Advantages associated with these samples:

. Multiple tracers (CFCs and SF_6, as well as major dissolved gases).

. Monitoring wells, therefore low pumping stress.

. Relatively short open intervals of 10 feet so mixing likely minimized.

. Median penetration of center of open interval into water table was 18.88 feet (sampling close to the water table, potentially minimizing mixing).

. Disadvantages associated with these samples:

. No tritium analyses.

. Depth to water (can affect tracer transport to water table):

. Median: 19.53 feet

. Mean: 42.11 feet

. Min: 4.22 feet

. Max: 138.15 feet

. Brief analysis:

. The SF_6-based age gradient for these sites is shown in figure B101. It is difficult to ascertain the age structure for this study unit with only four samples, but the shallow wells were all younger than the deepest. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

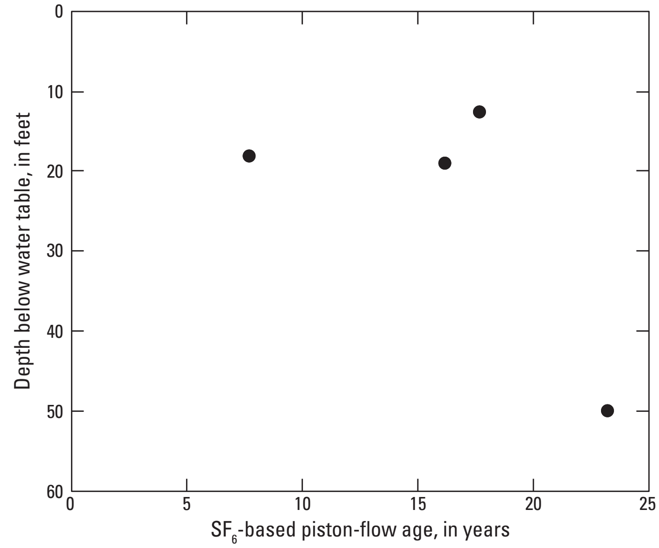

Figure B101. SF_6-based age gradient for dated sites from the LUSRC1 network, SACR Study Unit.

SACR SUS1

Samples from 26 sites in the SACR Study Unit were collected in 2008 for CFCs, SF_6, and $^3H/^3He$ (networks and, in parentheses, number of sites):

. SUS1 (CFCs, 26; SF_6, 26; $^3H/^3He$, 21)

The aquifer is composed of alluvial sand, gravel, silt and clay of the Central Valley aquifer system.

Major dissolved-gas data were available for 26 sites. Of these 26 sites, 18 were oxic and 8 were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites.

$^3H/^3He$ ages were calculated for twelve sites (5 of the 12 sites required a correction for terrigenic helium), while 1 site was not datable because tritium was too low, 2 sites were not datable because of fractionation, and samples from 6 sites were lost due to high pressure.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B34.

. Advantages associated with these samples:

. Multiple tracers (CFCs, SF_6, and $^3H/^3He$, as well as major dissolved gases).

. Disadvantages associated with these samples:

. Mixture of domestic and irrigation wells, so variable pumping rates.

. Relatively large open intervals ranging from 11 to 133 feet so mixing likely.

. Median penetration of center of open interval into water table was 68.19 feet (not sampling close to the water table, potentially mixing).

. Depth to water (can affect tracer transport to water table):

. Median: 29.43 feet

. Mean: 43.78 feet

. Min: 3.34 feet

. Max: 158.26 feet

. Brief analysis:

. The CFC-, SF_6-, and $^3H/^3He$-based age gradients for these sites are shown in figures B102, B103, and B104. The age gradients do not show any particular structure. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

The reconstructed ^3H plots for CFC-, SF_6- and $^3H/^3He$-based ages are shown in figures B105, B106, and B107. Most of the samples indicate a mixed groundwater age. The $^3H/^3He$-based reconstruction shows evidence of capturing the period of time around the bomb peak, with samples affected by dispersion.

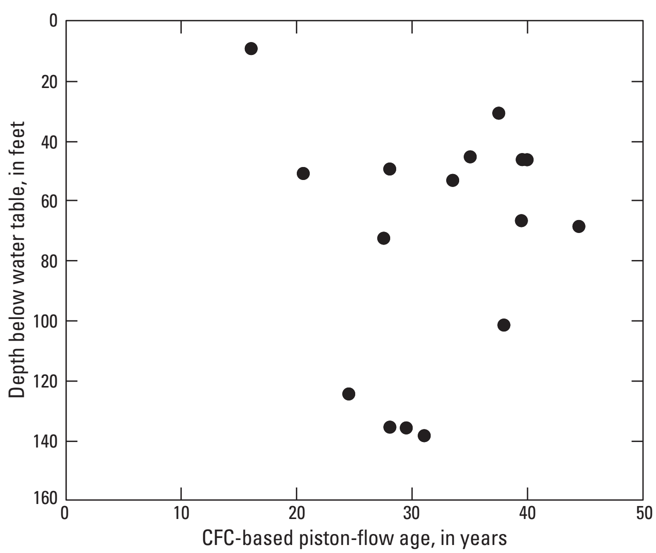

Figure B102. CFC-based age gradient for dated sites from the SUS1 network, SACR Study Unit.

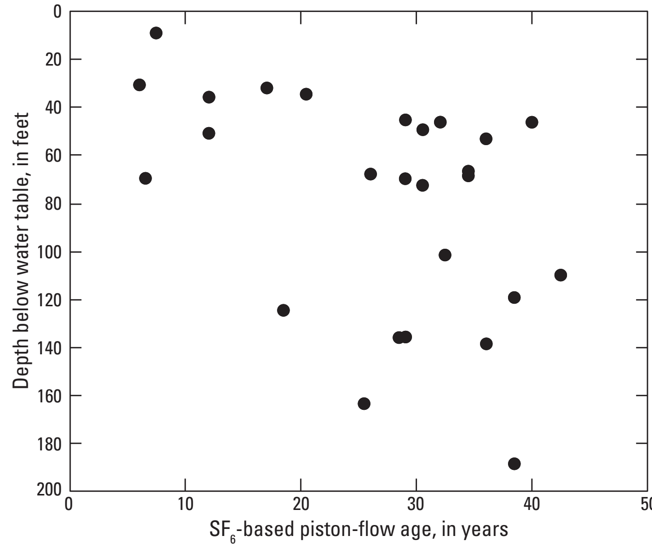

Figure B103. SF_6-based age gradient for dated sites from the SUS1 network, SACR Study Unit.

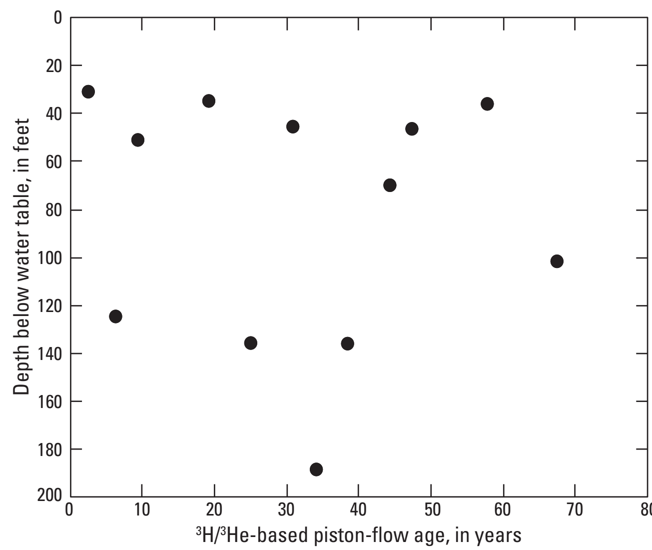

Figure B104. $^3H/^3He$-based age gradient for dated sites from the SUS1 network, SACR Study Unit.

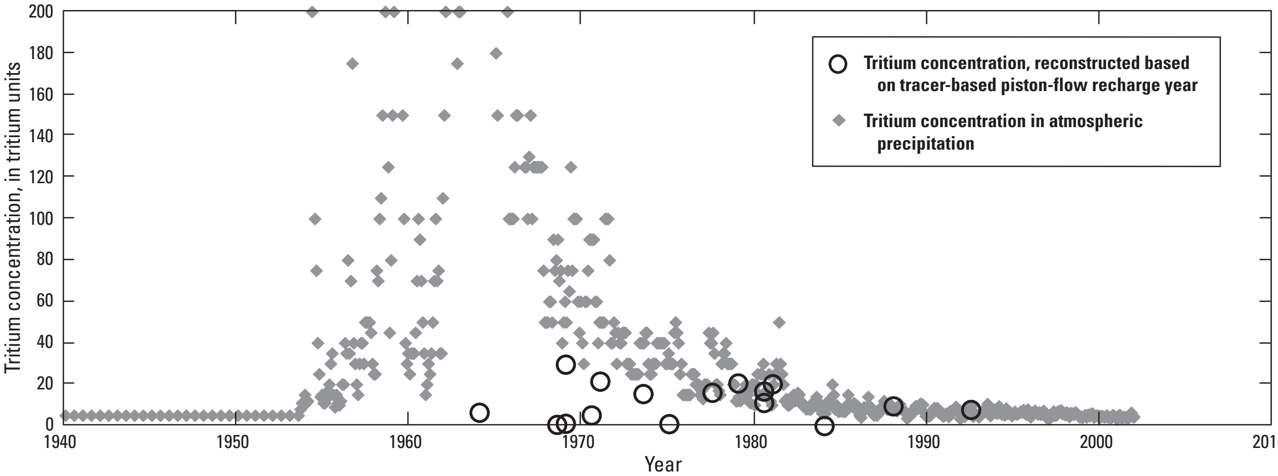

Figure B105. Reconstructed tritium concentrations (using CFC-based ages) and tritium in atmospheric precipitation, SUS1 network, SACR Study Unit.

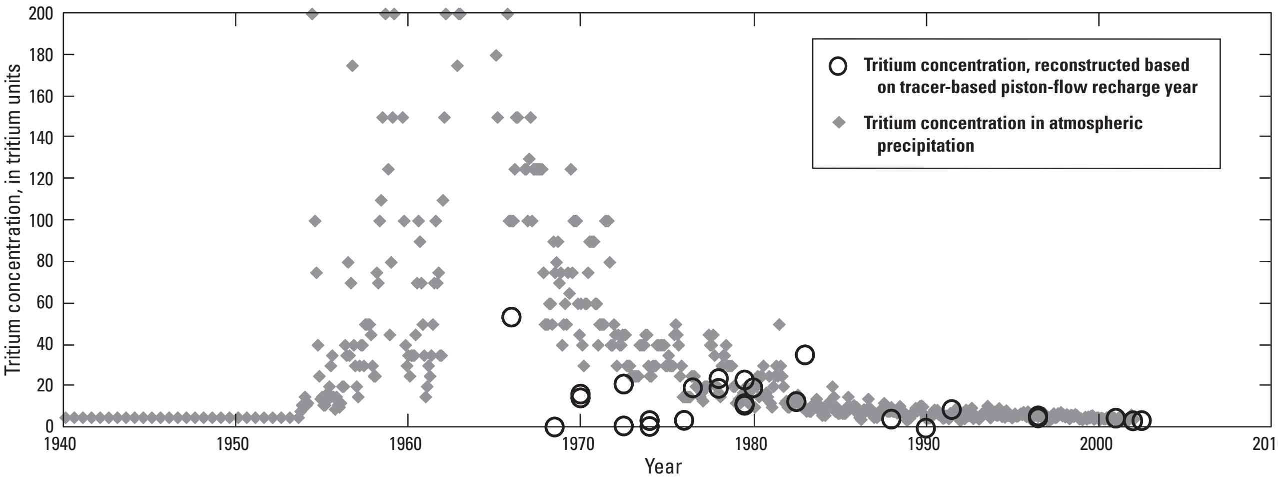

Figure B106. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, SUS1 network, SACR Study Unit.

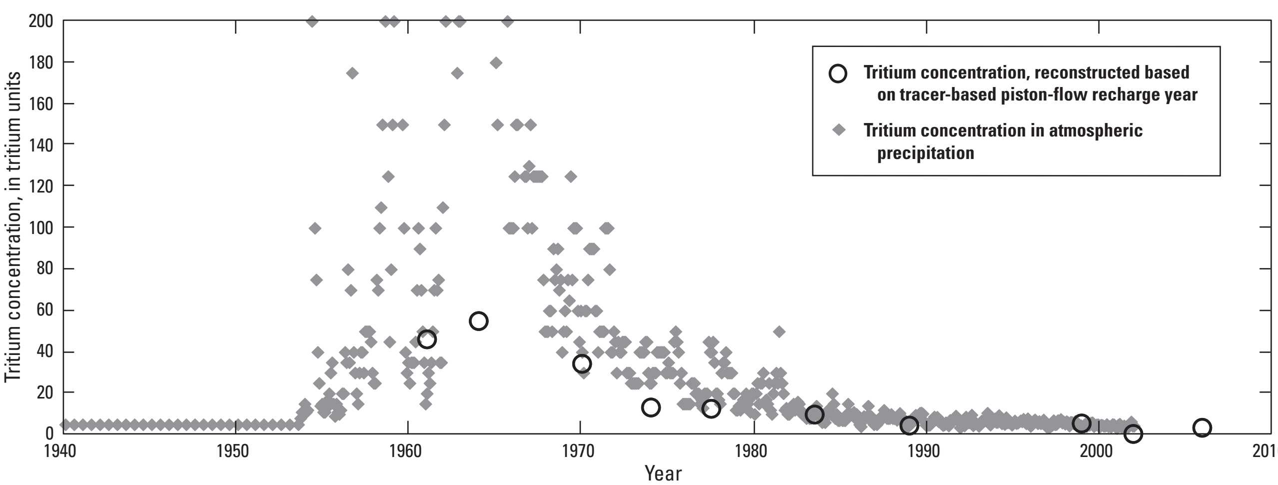

Figure B107. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, SUS1 network, SACR Study Unit.

The SF_6- versus CFC-based age comparison, the $^3H/^3He$-versus CFC-based age comparison, and the $^3H/^3He$-versus SF_6-based age comparison for this network are shown in figures B108, B109, and B110. The age comparison between CFC- and SF_6-based ages is reasonably good, while the comparison between $^3H/^3He$- and CFC-based ages is poor. The comparison between $^3H/^3He$- and SF_6-based ages shows good agreement to the point where the limits of SF_6-based dating is useful, at which point the $^3H/^3He$-based ages continue to get older while the SF_6-based ages do not.

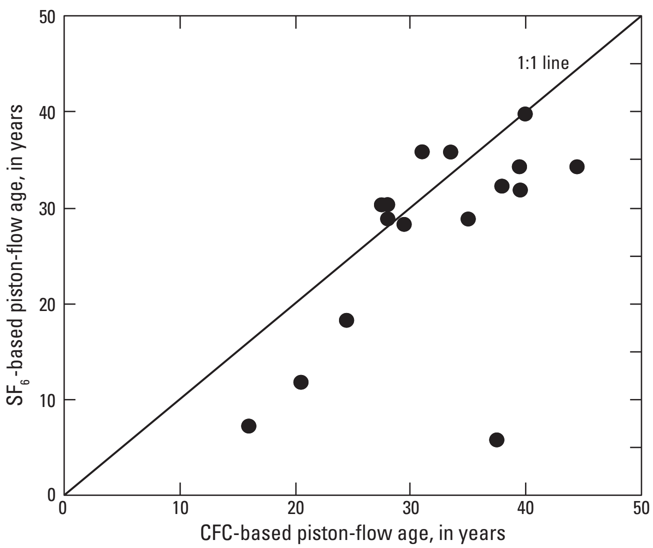

Figure B108. SF_6- versus CFC-based age comparison, SUS1 network, SACR Study Unit.

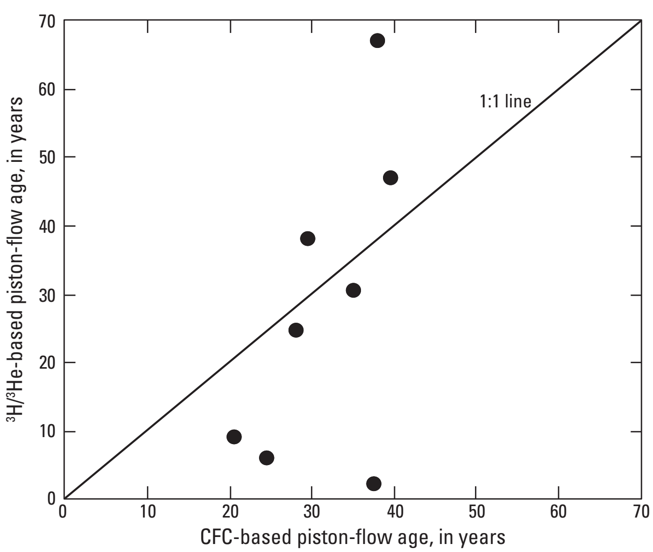

Figure B109. $^3H/^3He$- versus CFC-based age comparison, SUS1 network, SACR Study Unit.

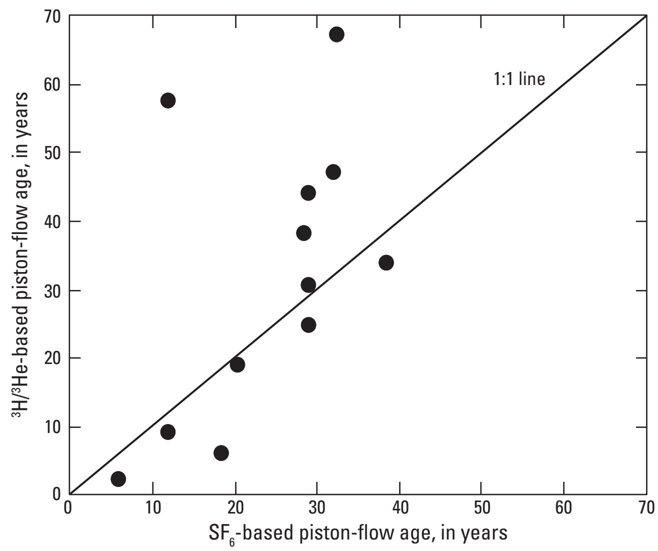

Figure B110. $^3H/^3He$- versus SF_6-based age comparison, SUS1 network, SACR Study Unit.

SANJ LUSCR1a

Samples from five sites in the SANJ Study Unit were collected in 2008 for CFCs, SF_6, and $^3H/^3He$ (networks and, in parentheses, number of sites):

- LUSCR1a (CFCs and SF_6, 5; $^3H/^3He$, 4)

The aquifer is composed of alluvial sand, gravel, silt and clay of the Central Valley aquifer system.

Major dissolved-gas data were available for all five sites. Of these five sites, four were oxic and one was suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites.

$^3H/^3He$ ages were calculated for four sites (all four sites did not require a correction for terrigenic He).

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B35.

- Advantages associated with these samples:
  - Multiple tracers (CFCs, SF_6, and $^3H/^3He$, as well as major dissolved gases).
  - Domestic wells so likely low pumping stress.
- Disadvantages associated with these samples:
  - Relatively large open intervals ranging from 20 to 40 feet so mixing likely.

- Median penetration of center of open interval into water table was 58.52 feet (not sampling close to the water table, potentially mixing).
- Depth to water (can affect tracer transport to water table):
  - Median: 82.42 feet
  - Mean: 64.97 feet
  - Min: 6.80 feet
  - Max: 111.87 feet
- Brief analysis:
  - The CFC-, SF_6-, and $^3H/^3He$-based age gradients for these sites are shown in figures B111, B112, and B113. The age gradients show a great deal of scatter as would be expected for samples taken from wells with large open intervals and a relatively deep unsaturated zone. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth. The $^3H/^3He$-based ages are significantly younger as would be expected since helium would be lost in the unsaturated zone until recharge occurs.

The reconstructed ^3H plots for CFC-, SF_6-, and $^3H/^3He$-based ages are shown in figures B114, B115, and B116. The reconstructions show a similar pattern to the age gradients above in that the CFC- and SF_6-based ages are similar, and the $^3H/^3He$-based ages are very young. The samples generally plot along the tritium reconstructions, with minor offsets that likely result from sampling large open intervals with deep unsaturated zones.

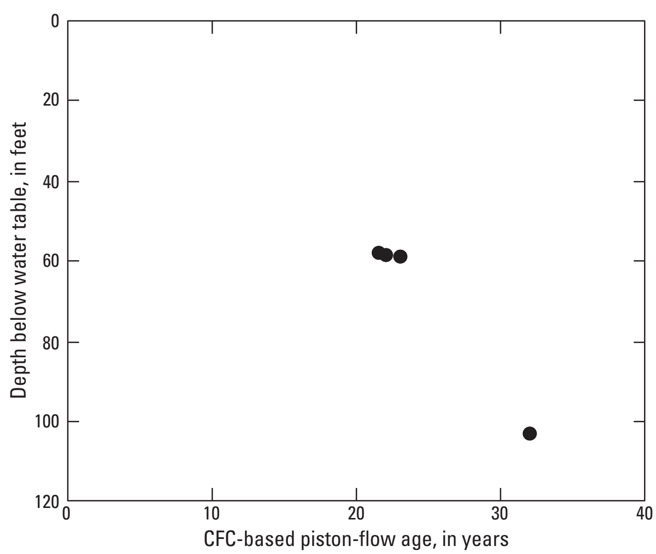

Figure B111. CFC-based age gradient for dated sites from the LUSCR1a network, SANJ Study Unit.

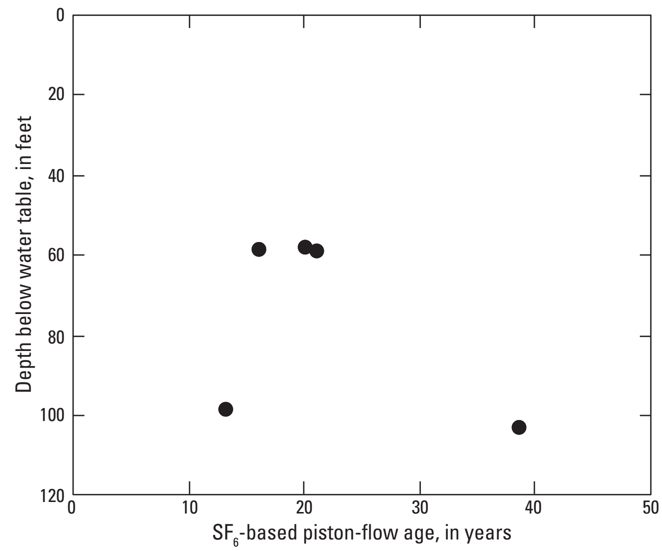

Figure B112. SF_6-based age gradient for dated sites from the LUSCR1a network, SANJ Study Unit.

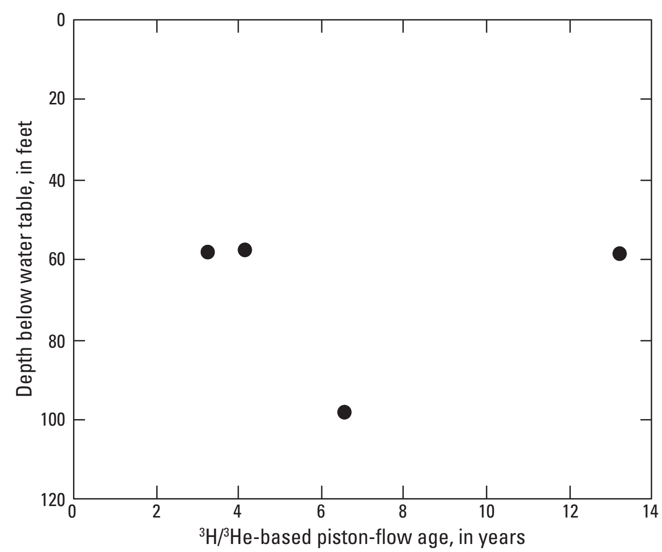

Figure B113. $^3H/^3He$-based age gradient for dated sites from the LUSCR1a network, SANJ Study Unit.

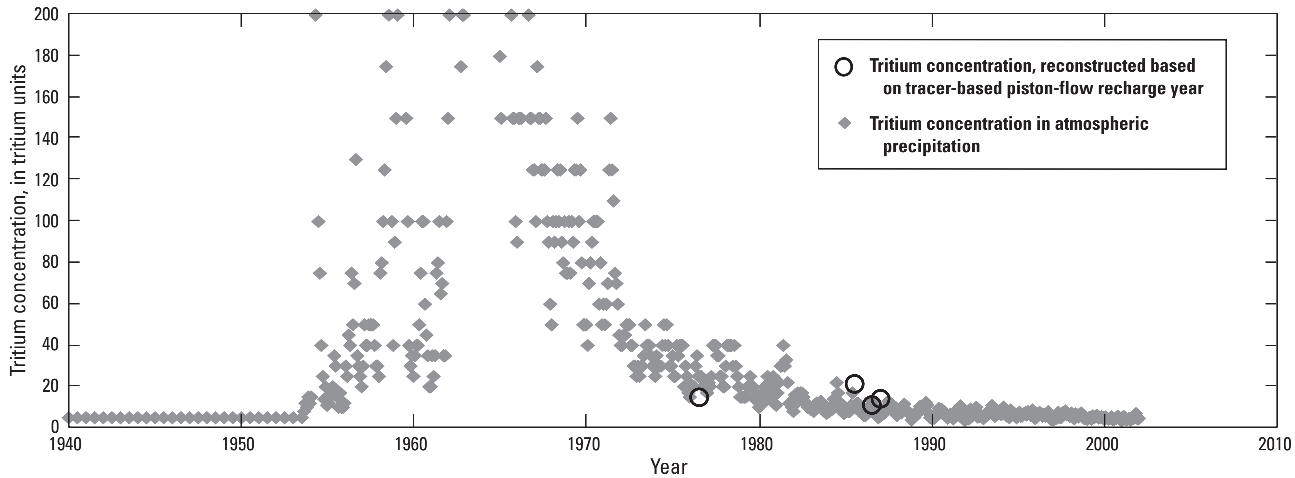

Figure B114. Reconstructed tritium concentrations (using CFC-based ages) and tritium in atmospheric precipitation, LUSCR1a network, SANJ Study Unit.

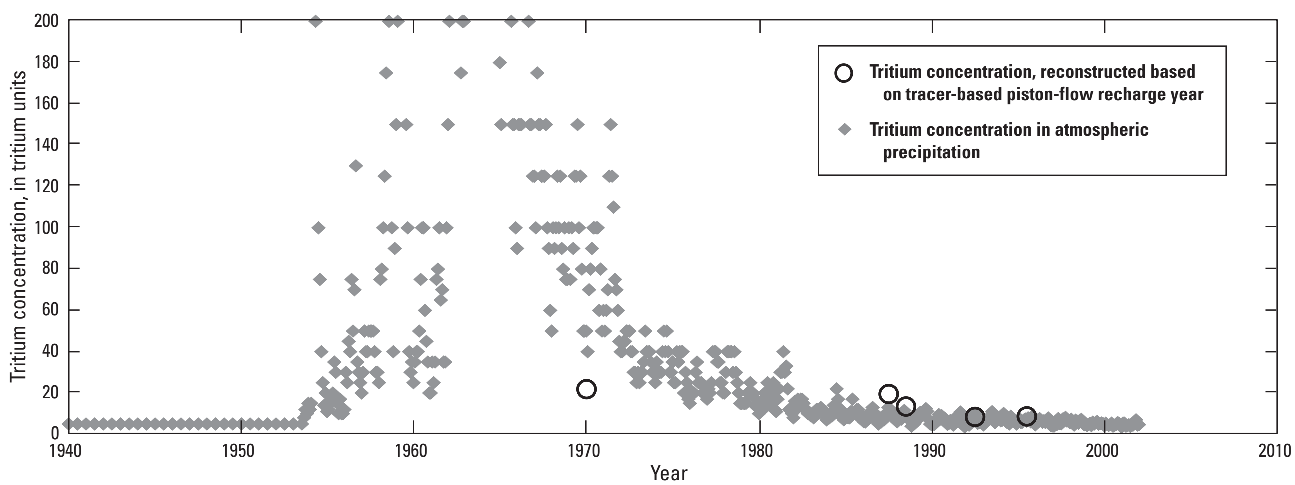

Figure B115. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, LUSCR1a network, SANJ Study Unit.

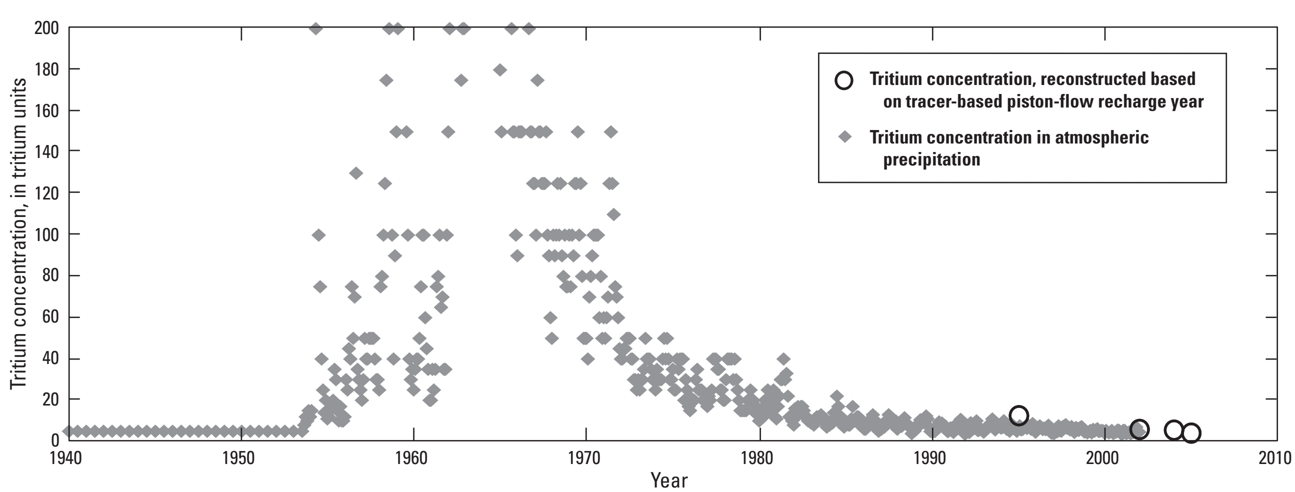

Figure B116. Reconstructed tritium concentrations (using $^{3}H/^{3}He$-based ages) and tritium in atmospheric precipitation, LUSCR1a network, SANJ Study Unit.

The SF_6- versus CFC-based age comparison, the $^3H/^3He$- versus CFC-based age comparison, and the $^3H/^3He$- versus SF_6-based age comparison for this network are shown in figures B117, B118, and B119. The age comparisons show reasonable agreement for CFC- and SF_6-based ages, and a bias toward younger ages for $^3H/^3He$-based ages as would be expected for samples taken from wells with a deep unsaturated zone.

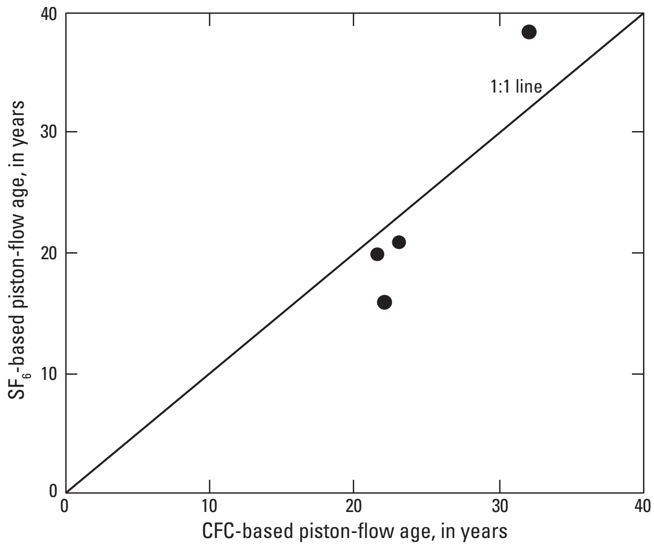

Figure B117. SF_6- versus CFC-based age comparison, LUSCR1a network, SANJ Study Unit.

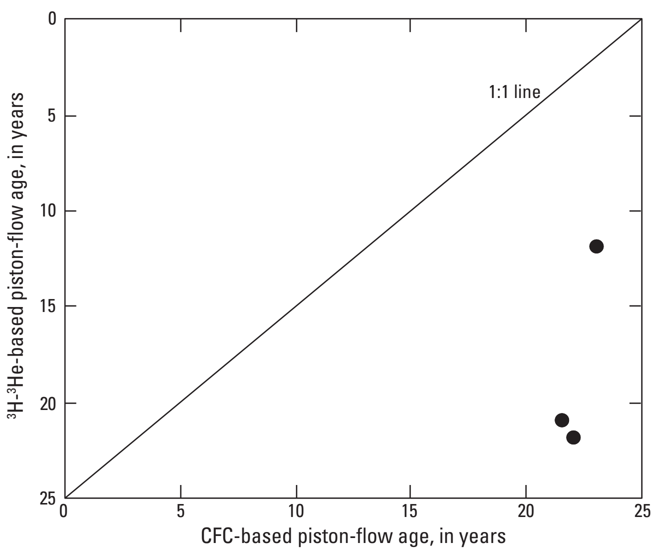

Figure B118. $^3H/^3He$- versus CFC-based age comparison, LUSCR1a network, SANJ Study Unit.

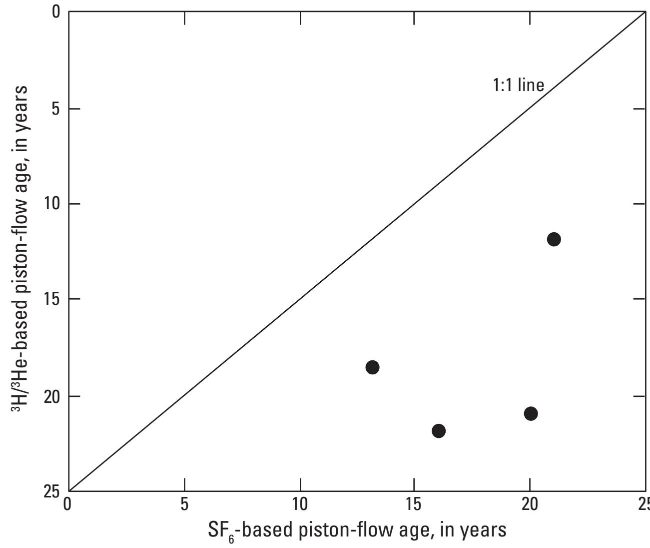

Figure B119. $^3H/^3He$- versus SF_6-based age comparison, LUSCR1a network, SANJ Study Unit.

SANJ LUSOR1a

Samples from five sites in the SANJ Study Unit were collected in 2006 for CFCs and SF_6, and from one site for $^3H/^3He$ in 2008 (networks and, in parentheses, number of sites):

. LUSOR1a (CFCs and SF_6, 5 in 2006; $^3H/^3He$, 1 in 2008)

The aquifer is composed of alluvial sand, gravel, silt and clay of the Central Valley aquifer system.

Major dissolved-gas data were available for all five sites. Of these five sites, all five were oxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data.

$^3H/^3He$ age was calculated for only one site and it did not require a correction for terrigenic He.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B36.

. Advantages associated with these samples:

. Multiple tracers (CFCs, SF_6, and $^3H/^3He$, as well as major dissolved gases).

. Domestic wells so likely low pumping stress.

. Disadvantages associated with these samples:

. Relatively large open intervals ranging from 14 to 50 feet so mixing likely.

- Median penetration of center of open interval into water table was 74.08 feet (not sampling close to the water table, potentially mixing).
- Depth to water (can affect tracer transport to water table):
  - Median: 43.73 feet
  - Mean: 43.29 feet
  - Min: 34.64 feet
  - Max: 51.87 feet
- Brief analysis:
  - The CFC- and SF_6-based age gradients for these sites are shown in figures B120 and B121. The age gradients show little structure, but are similar for both CFC- and SF_6-based dating. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

The reconstructed ^3H plots for CFC- and SF_6-based ages are shown in figures B122 and B123. The reconstructions are similar and show evidence of relatively unmixed, piston-flow transport.

The SF_6- versus CFC-based age comparison for this network is shown in figure B124. The age comparison shows consistency between CFC- and SF_6-based ages.

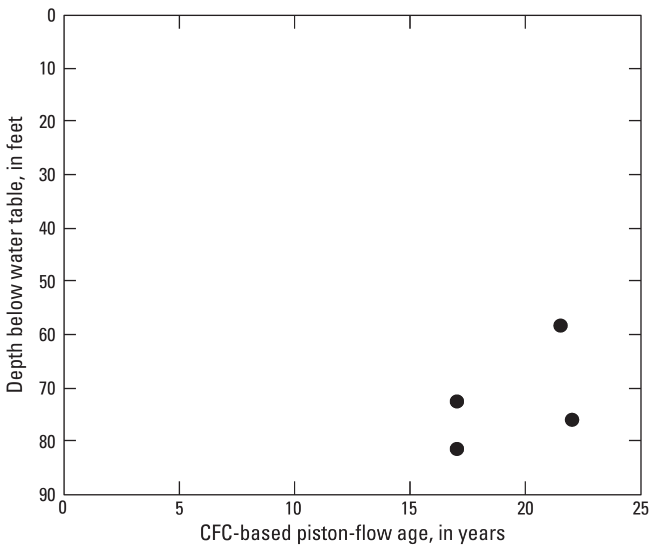

Figure B120. CFC-based age gradient for dated sites from the LUSOR1a network. SANJ Study Unit.

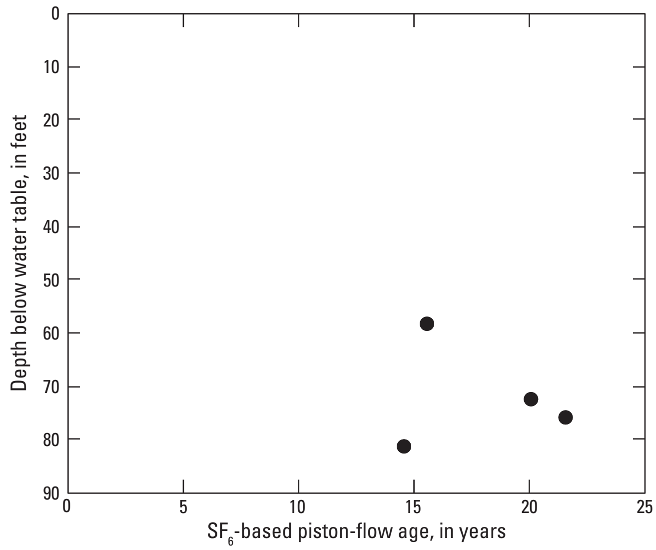

Figure B121. SF_6-based age gradient for dated sites from the LUSOR1a network, SANJ Study Unit.

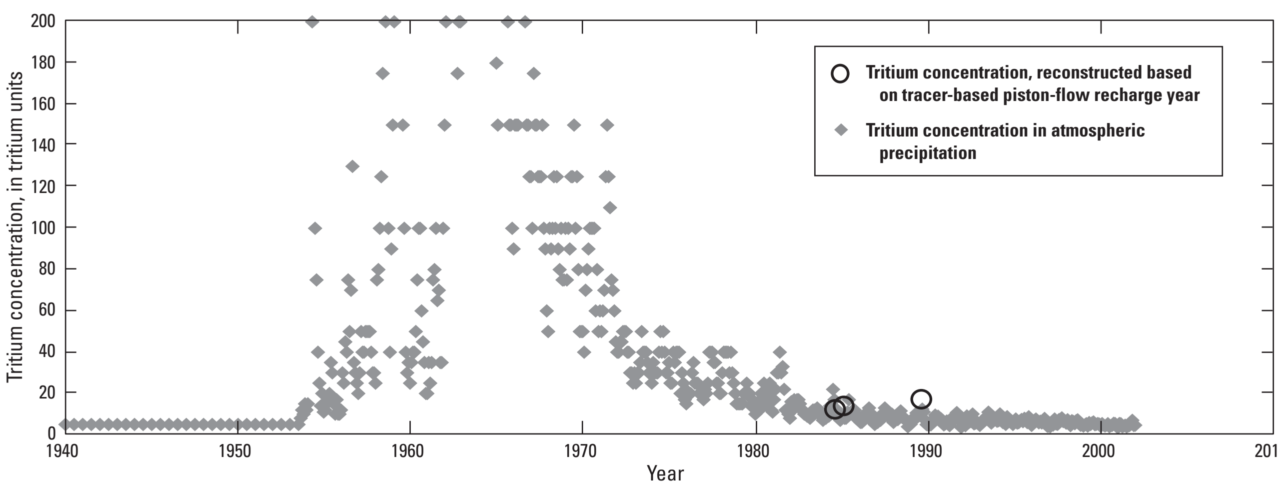

Figure B122. Reconstructed tritium concentrations (using CFC-based ages) and tritium in atmospheric precipitation, LUSOR1a network, SANJ Study Unit.

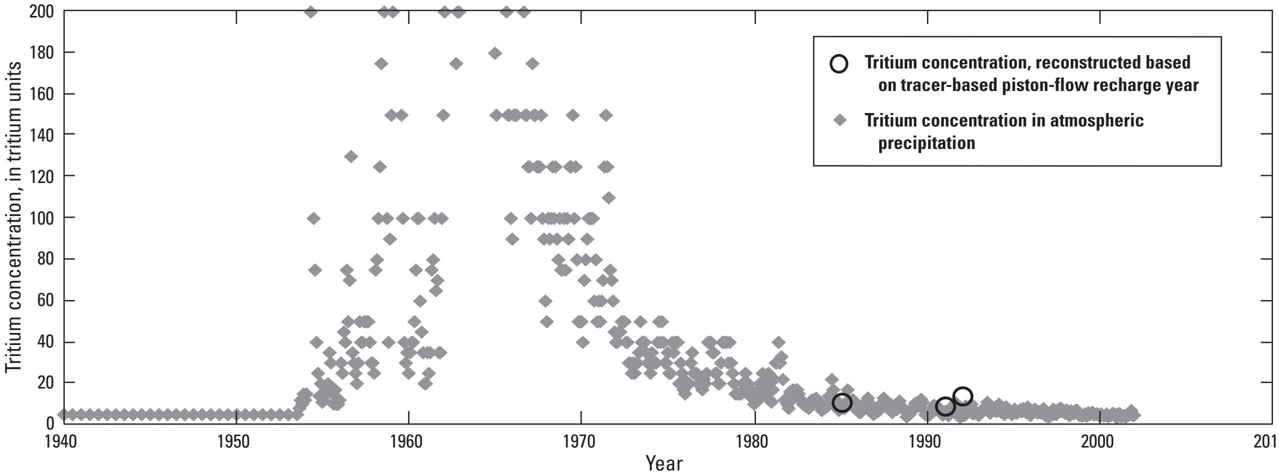

Figure B123. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, LUSOR1a network, SANJ Study Unit.

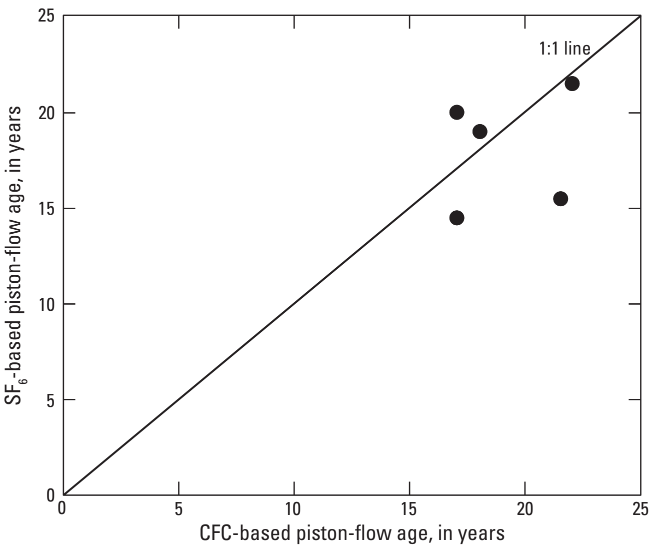

Figure B124. SF_6- versus CFC-based age comparison, LUSOR1a network, SANJ Study Unit.

SANJ LUSOR2a

Samples from five sites in the SANJ Study Unit were collected in 2006 for CFCs and SF_6, and from two sites in 2008 for $^3H/^3He$ (networks and, in parentheses, number of sites):

- LUSOR2a (CFCs and SF_6, 5; $^3H/^3He$, 2)

The aquifer is composed of alluvial sand, gravel, silt, and clay of the Central Valley aquifer system.

Major dissolved-gas data were available for all five sites in 2006 and two sites in 2008. Of these five sites, four were oxic and one was suboxic in 2006, and both sites were oxic in 2008.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites.

$^3H/^3He$ ages were calculated for two sites (only one site required a correction for terrigenic helium).

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B37.

- Advantages associated with these samples:
  - Multiple tracers (CFCs, SF_6, and $^3H/^3He$, as well as major dissolved gases).
  - Domestic wells so likely low pumping stress.
  - Disadvantages associated with these samples:
  - Open intervals ranging from 10 to 20 feet so some mixing likely.
  - Median penetration of center of open interval into water table was 138.89 feet (not sampling close to the water table, potentially mixing).
- Depth to water (can affect tracer transport to water table):
  - Median: 61.00 feet
  - Mean: 53.13 feet
  - Min: 8.46 feet
  - Max: 82.93 feet
- Brief analysis:
  - The SF_6-based age gradient for these sites is shown in figure B125. The age gradient shows no real structure. Differences in screen length, recharge source/strength,

aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth. The CFC- and $^3H/^3He$-based age gradients are not shown because there were only two samples to plot in each case.

The reconstructed ^3H plots for CFC-, SF_6- and $^3H/^3He$-based ages are shown in figures B126, B127, and B128. Numerous samples plot above the ^3H reconstruction as might be expected for samples taken from sites with large open intervals and relatively deep unsaturated zones. The $^3H/^3He$-based reconstruction, though only two samples, is excellent.

The SF_6- versus CFC-based age comparison for this network is shown in figure B129. The age comparison is limited due to the low number of samples, but is consistent between CFC- and SF_6-based ages.

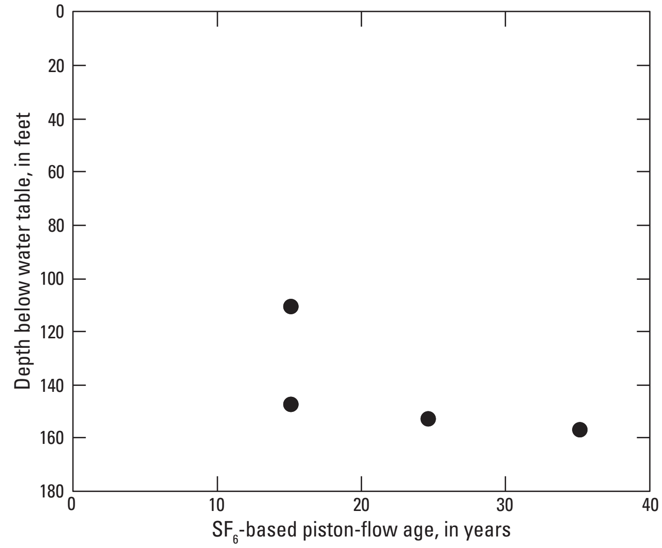

Figure B125. SF_6-based age gradient for dated sites from the LUSOR2a network, SANJ Study Unit.

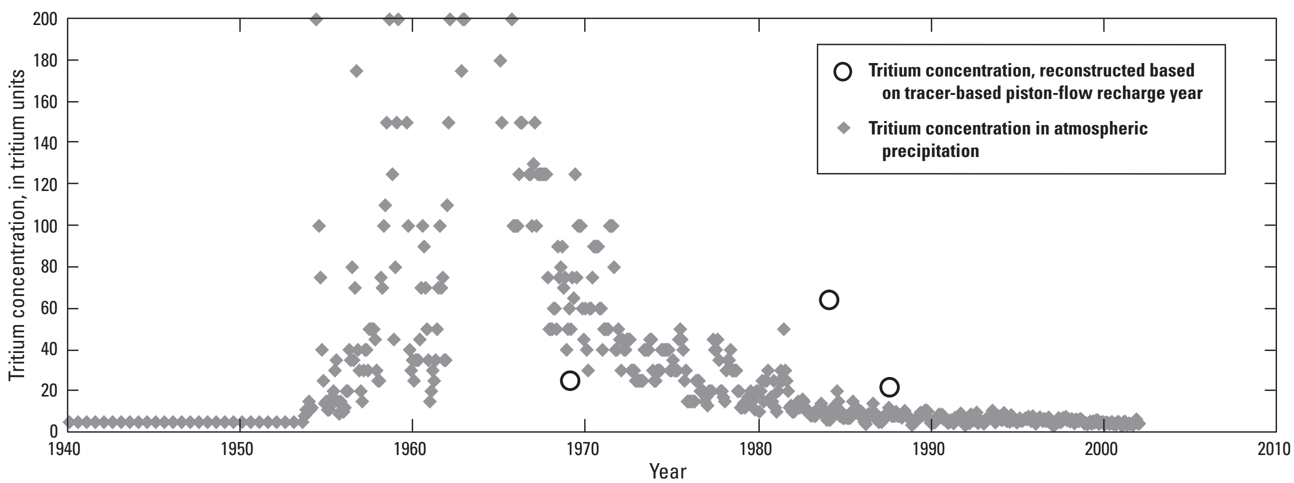

Figure B126. Reconstructed tritium concentrations (using CFC-based ages) and tritium in atmospheric precipitation, LUSOR2a network, SANJ Study Unit.

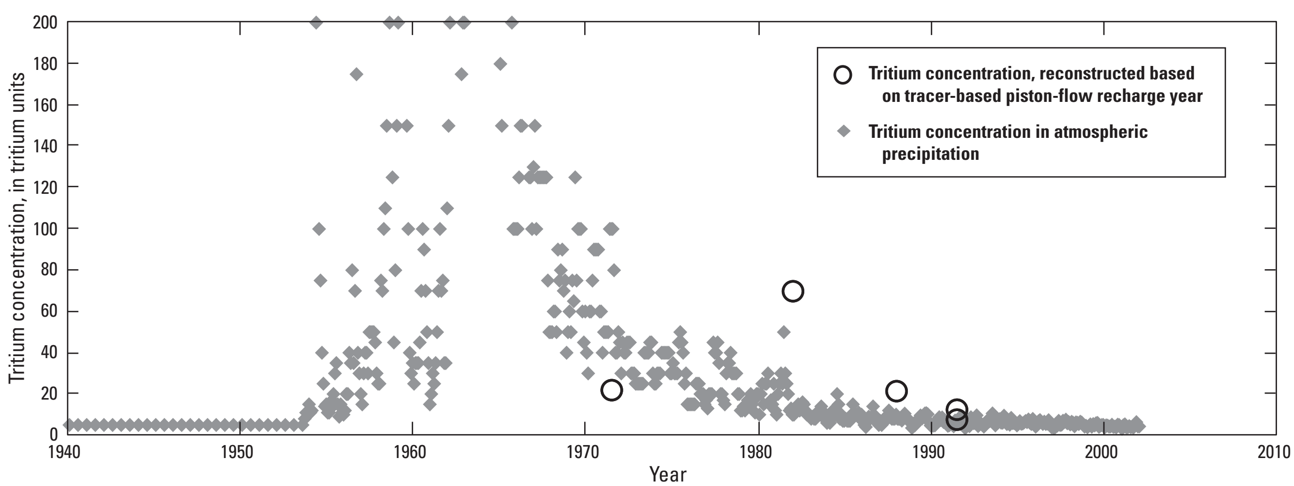

Figure B127. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, LUSOR2a network, SANJ Study Unit.

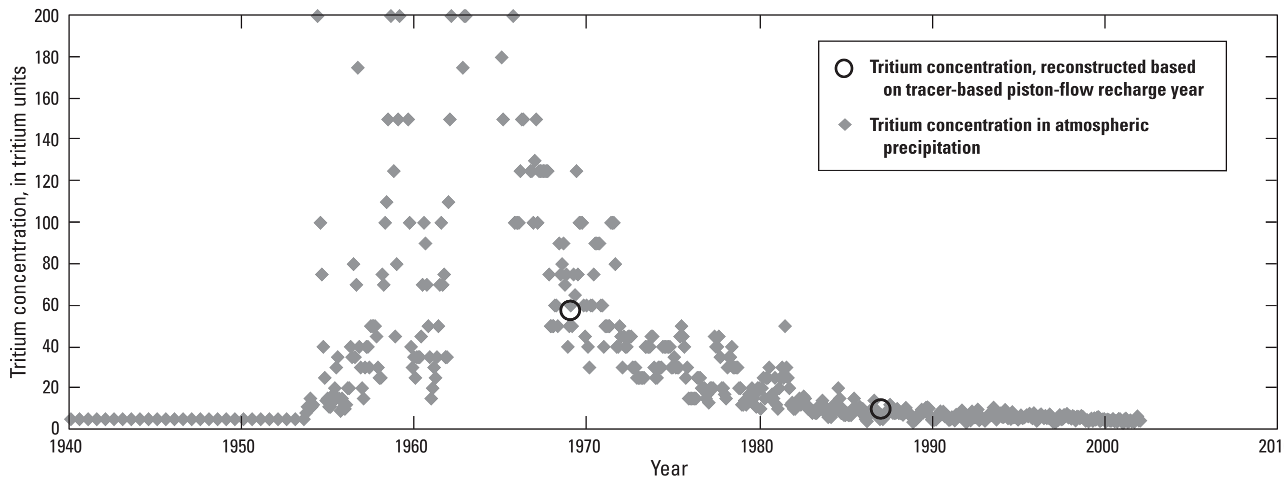

Figure B128. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, LUSOR2a network, SANJ Study Unit.

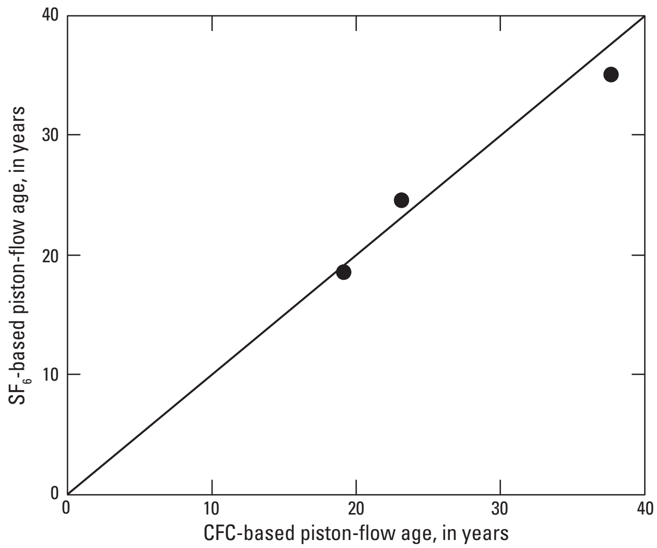

Figure B129. SF_6- versus CFC-based age comparison, LUSOR2a network, SANJ Study Unit.

SANJ SUS1

Samples from five sites in the SANJ Study Unit were collected in 2008 for CFCs, SF_6, and $^3H/^3He$ (networks and, in parentheses, number of sites):

- SUS1 (CFCs and SF_6, 5; $^3H/^3He$, 4)

The aquifer is composed of alluvial sand, gravel, silt and clay of the Central Valley aquifer system.

Major dissolved-gas data were available for all five sites. Of these five sites, all five were oxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data.

$^3H/^3He$ ages were calculated for four sites (all four sites did not require a correction for terrigenic He).

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B38.

- Advantages associated with these samples:
  - Multiple tracers (CFCs, SF^6, and $^3H/^3He$, as well as major dissolved gases).
  - Domestic wells so likely low pumping stress.
- Disadvantages associated with these samples:
  - Relatively large open intervals ranging from 18 to 100 feet so mixing likely.
  - Median penetration of center of open interval into water table was 66.87 feet (not sampling close to the water table, potentially mixing).
- Depth to water (can affect tracer transport to water table):
  - Median: 63.60 feet
  - Mean: 88.74 feet
  - Min: 34.13 feet
  - Max: 145.34 feet
- Brief analysis:
  - The CFC-, SF_6-, and $^3H/^3He$-based age gradients for these sites are shown in figures B130, B131, and B132. The age gradients show a general increase in age with depth. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

The reconstructed ^3H plots for CFC-, SF_6-, and $^3H/^3He$-based ages are shown in figures B133, B134, and B135. The reconstructions show evidence of relatively unmixed, piston-flow transport.

The SF_6- versus CFC-based age comparison, the $^3H/^3He$- versus CFC-based age comparison, and the $^3H/^3He$- versus SF_6-based age comparison for this network are shown in figures B136, B137, and B138. All three age comparisons show a general consistency, but some dispersive effects also are apparent.

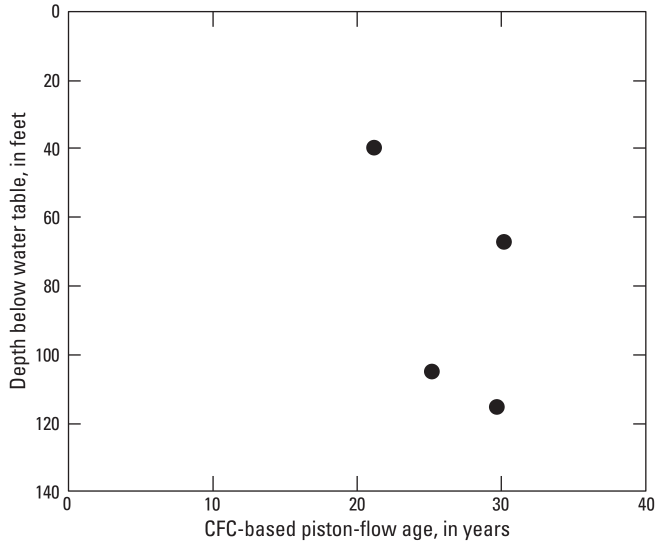

Figure B130. CFC-based age gradient for dated sites from the SUS1 network, SANJ Study Unit.

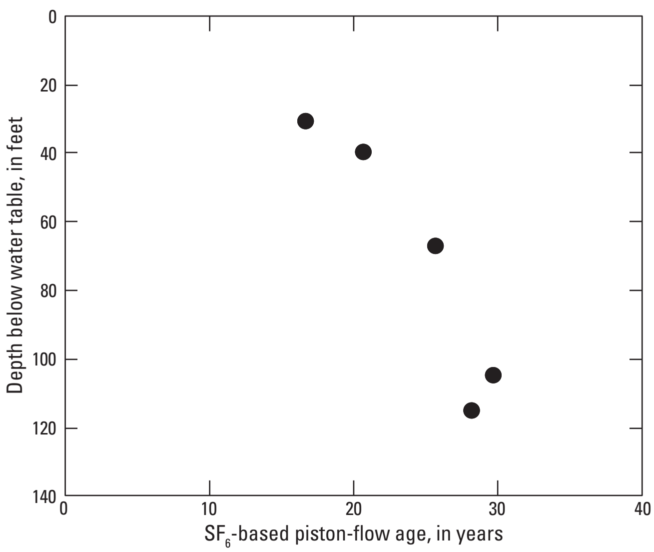

Figure B131. SF_6-based age gradient for dated sites from the SUS1 network, SANJ Study Unit.

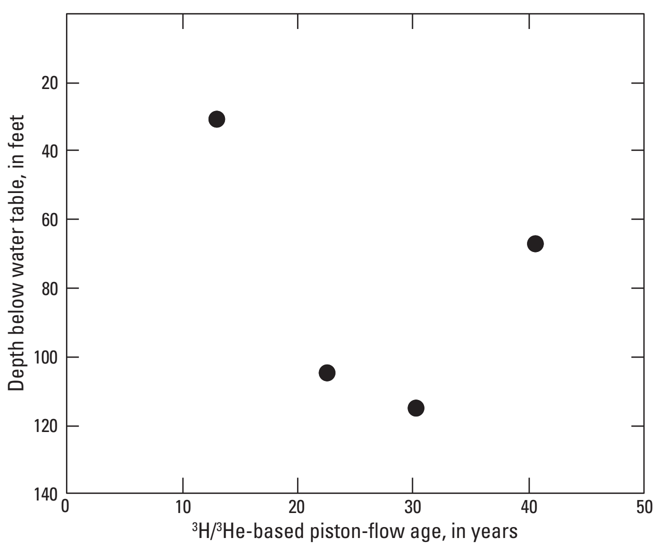

Figure B132. $^3H/^3He$-based age gradient for dated sites from the SUS1 network, SANJ Study Unit.

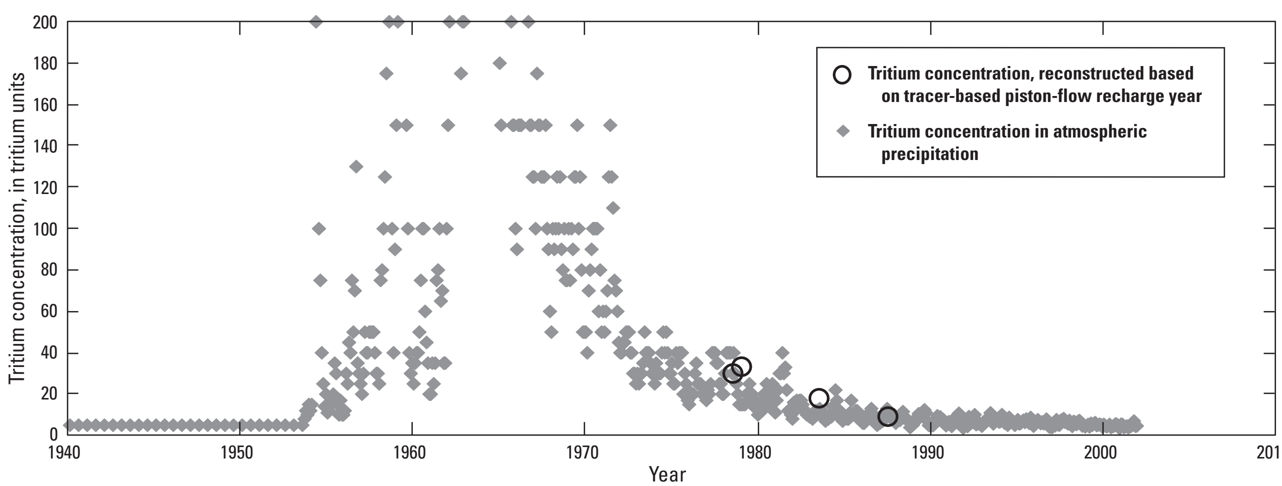

Figure B133. Reconstructed tritium concentrations (using CFC-based ages) and tritium in atmospheric precipitation, SUS1 network, SANJ Study Unit.

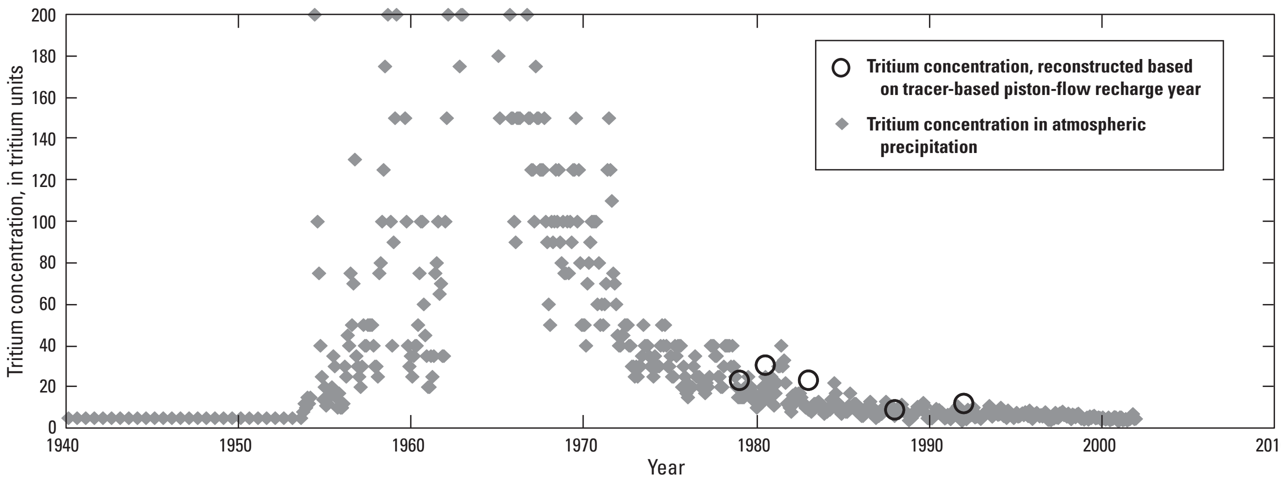

Figure B134. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, SUS1 network, SANJ Study Unit.

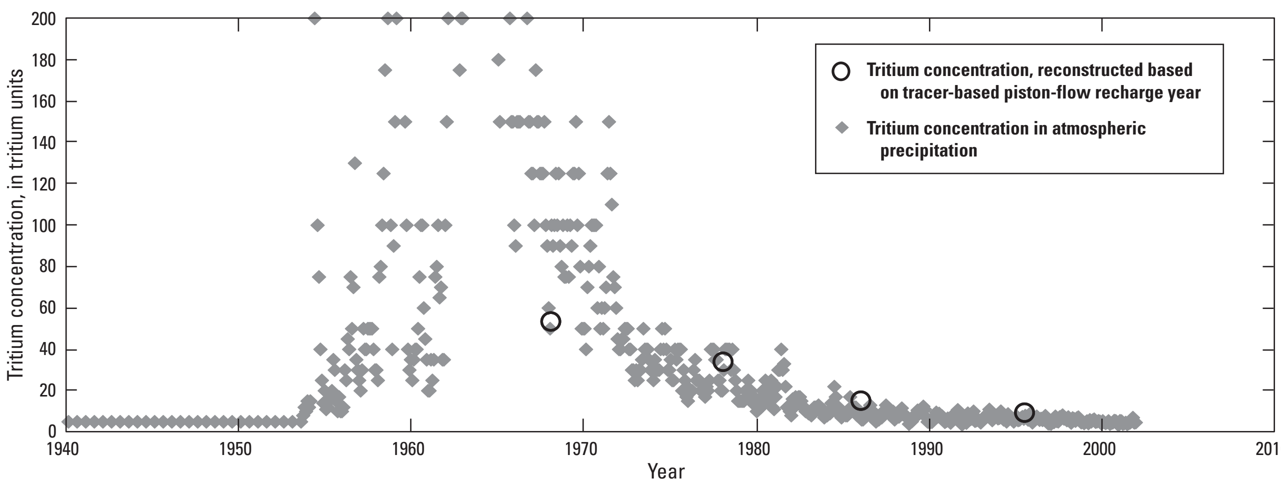

Figure B135. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, SUS1 network, SANJ Study Unit.

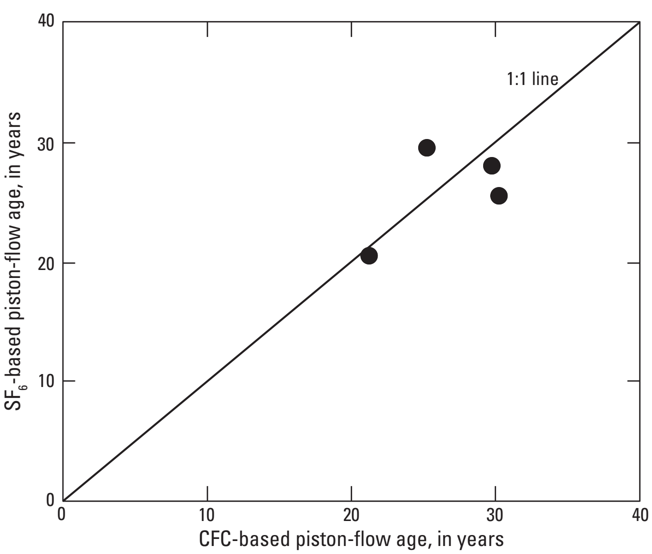

Figure B136. SF_6- versus CFC-based age comparison, SUS1 network, SANJ Study Unit.

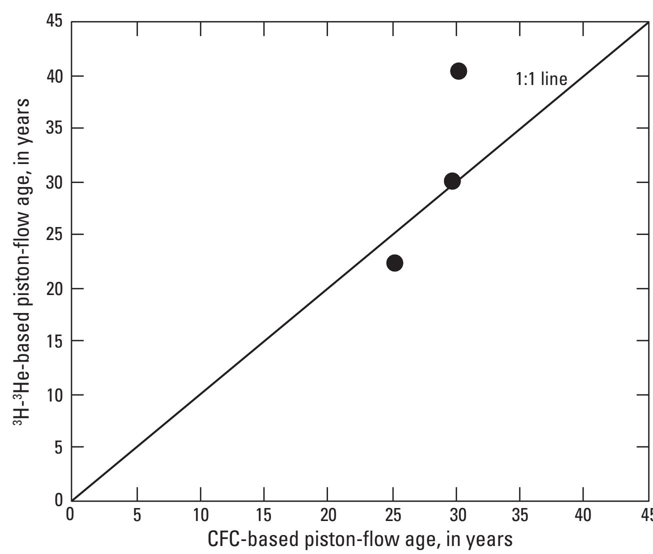

Figure B137. $^3H/^3He$- versus CFC-based age comparison, SUS1 network, SANJ Study Unit.

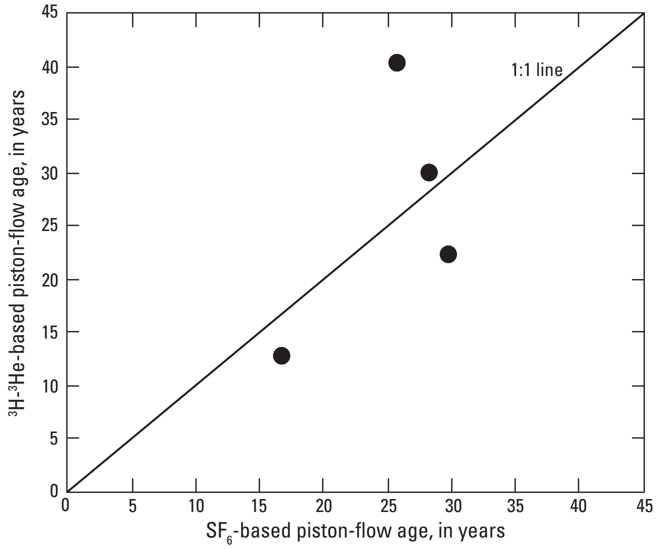

Figure B138. $^3H/^3He$- versus SF_6-based age comparison, SUS1 network, SANJ Study Unit.

SANT FPSAG1

Samples from 16 sites in the SANT Study Unit were collected in 2008 for CFCs and SF_6 (networks and, in parentheses, number of sites):

. FPSAG1 (CFCs, 16; SF_6, 1)

The aquifer is composed of sands, and clay with some sand. Two sites were finished in limestone.

Major dissolved-gas data were available for 16 sites. Of these 16 sites, 9 were oxic and 7 were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites. Using this approach, however, many of the sites with elevated methane concentrations had questionable dissolved-gas results. A comparison was done between results using MAAT+1°C and major dissolved-gas data, with similar results using both methods, but slightly older results using the MAAT+1°C for two sites.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B39.

. Advantages associated with these samples:

. Multiple tracers (CFCs and SF_6, as well as major dissolved gases).

. Monitoring wells, therefore low pumping stress.

. Short open intervals of 0.5 foot so mixing likely minimized.

. Median penetration of center of open interval into water table was 8.02 feet (sampling close to the water table, potentially minimizes mixing).

. Disadvantages associated with these samples:

. Suboxic conditions.

. Depth to water (can affect tracer transport to water table):

. Median: 6.96 feet

. Mean: 5.54 feet

. Min: -0.29 feet

. Max: 10.23 feet

. Brief analysis:

. The CFC-based age gradient for these sites is shown in figure B139. The age gradient shows a general increase in age with depth with the exception of two samples, both of which are located in surface-water bodies (stream channel and lake/swamp) indicating that they may be in discharge areas and would be expected to have older ages at shallow depths. The CFC-based ages also appear to be shifted toward older ages, which may be the result of suboxic conditions in numerous wells.

The reconstructed ^3H plot for CFC-based ages is shown in figure B140. Numerous samples plot above and/or to the right of the ^3H reconstruction, which may be the result of CFC-based ages being too old as a result of degradation. If the CFC-based ages were younger, the samples would shift down and to the right, however, the reconstructed tritium would still be somewhat elevated. The reason for the slightly elevated tritium in these samples is unknown.

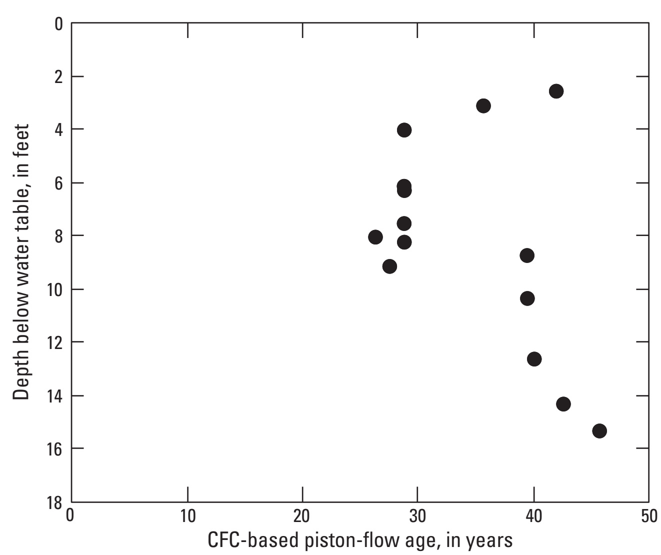

Figure B139. CFC-based age gradient for dated sites from the FPSAG1 network, SANT Study Unit.

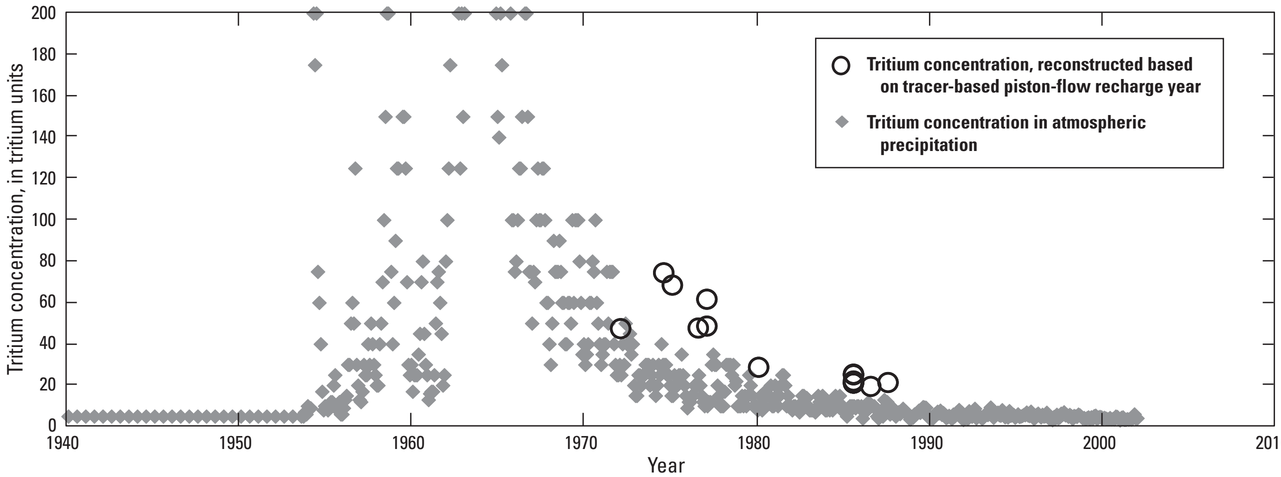

Figure B140. Reconstructed tritium concentrations (using CFC-based ages) and tritium in atmospheric precipitation, FPSAG1 network, SANT Study Unit.

SANT LUSRC1

Samples from 19 sites in the SANT Study Unit were collected in 2006 for CFCs and SF_6 (networks and, in parentheses, number of sites):

- LUSRC1 (CFCs, 19; SF_6, 4)

The aquifer is composed of clay with some sand of the Southeastern Coastal Plain aquifer system.

Major dissolved-gas data were available for 19 sites. Of these 19 sites, 10 were oxic and 9 were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites. Using this approach was problematic and the MAAT+1°C, which was similar, was used instead.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B40.

- Advantages associated with these samples:
  - Multiple tracers (CFCs and SF_6, as well as major dissolved gases).
  - Monitoring wells, therefore low pumping stress.
  - Relatively short open intervals ranging from 2.32 to 5 feet so mixing likely minimized.
  - Median penetration of center of open interval into water table was 4.36 feet (sampling close to the water table, potentially minimizing mixing).
- Disadvantages associated with these samples:
  - Suboxic conditions.
  - No tritium.
- Depth to water (can affect tracer transport to water table):
  - Median: 9.70 feet
  - Mean: 13.21 feet
  - Min: 2.14 feet
  - Max: 47.69 feet
- Brief analysis:
  - The CFC-based age gradient for these sites is shown in figure B141. The age gradient shows a general increase in age with depth, however, the ages are shifted to older ages even at shallow depths. The relatively old ages at shallow depths may be the result of degradation of the CFCs in suboxic conditions. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

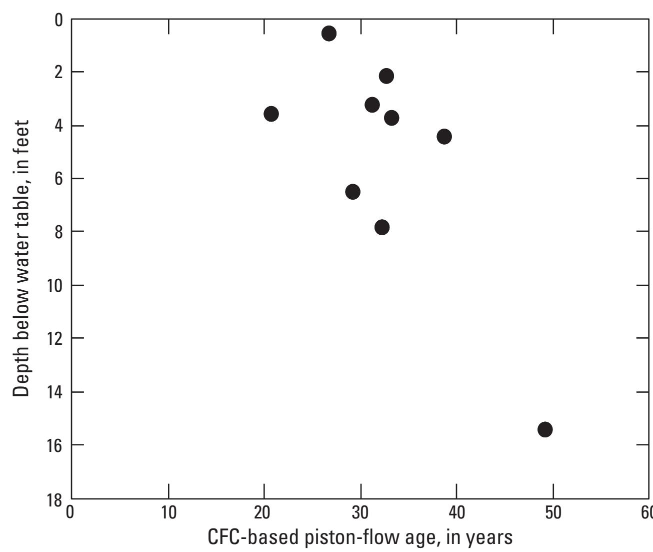

Figure B141. CFC-based age gradient for dated sites from the LUSRC1 network, SANT Study Unit.

SCTX LUSRC1

Samples from 22 sites in the SCTX Study Unit were collected in 2006 for CFCs and SF_6 (networks and, in parentheses, number of sites):

- LUSRC1 (22)

The aquifer is composed of limestone and dolomite of the Edwards-Trinity aquifer system.

Major dissolved-gas data were available for all 22 sites. Of these 22 sites, all 22 were oxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data. Using this approach, several sites had unreasonably high excess air, but if excess nitrogen was utilized, the recharge temperatures were too low. Also, four sites had unreasonably high recharge temperatures.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B41.

- Advantages associated with these samples:
  - Multiple tracers (CFCs and SF_6, as well as major dissolved gases).
  - Monitoring wells, therefore low pumping stress.
- Disadvantages associated with these samples:
  - Relatively large open intervals ranging from 34.2 to 84.96 feet so mixing likely.
  - Median penetration of center of open interval into water table was 25.92 feet (not sampling close to the water table, potentially mixing).
- Depth to water (can affect tracer transport to water table):
  - Median: 221.01 feet
  - Mean: 219.56 feet
  - Min: 153.09 feet
  - Max: 270.25 feet
- Brief analysis:
  - The CFC- and SF_6-based age gradients for these sites are shown in figures B142 and B143. The age gradients show a great deal of scatter as would be expected for samples taken from wells finished in karst with large open intervals.

The reconstructed ^3H plots for CFC- and SF_6-based ages are shown in figures B144 and B145. The samples appear to be relatively unmixed, they plot in a region where they could shift to older or younger ages and still plot on the ^3H input function and therefore could still be affected by mixing.

The SF_6- versus CFC-based age comparison for this network is shown in figure B146. The age comparison is very scattered as would be expected for a karst environment where mixing, and perhaps even degassing, is occurring.

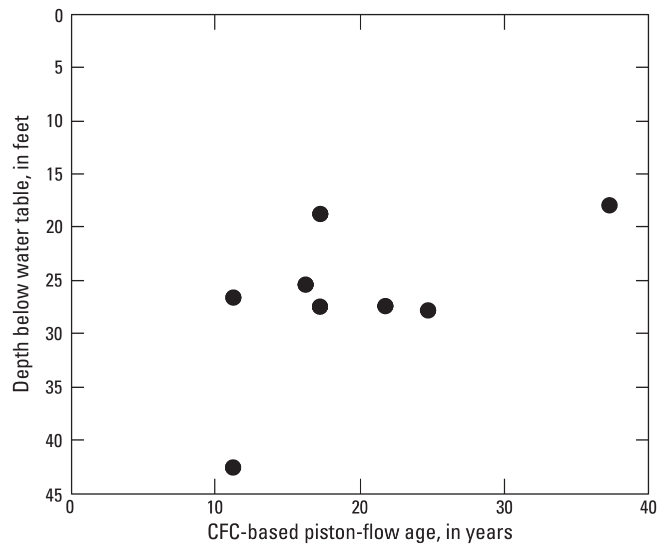

Figure B142. CFC-based age gradient for dated sites from the LUSRC1 network, SCTX Study Unit.

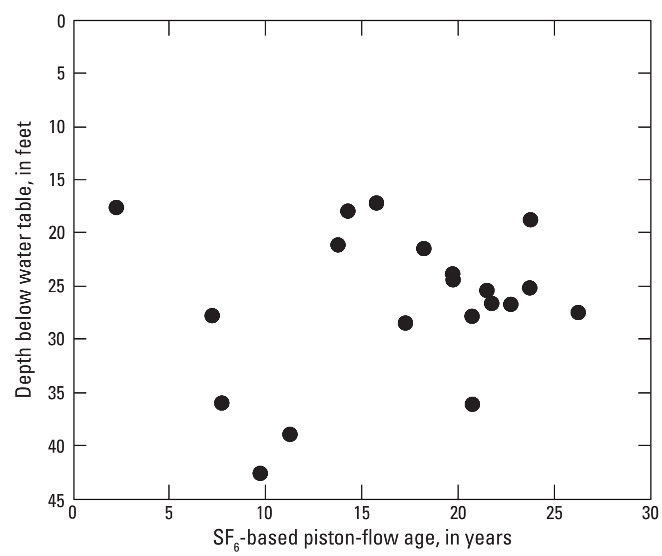

Figure B143. SF_6-based age gradient for dated sites from the LUSRC1 network, SCTX Study Unit.

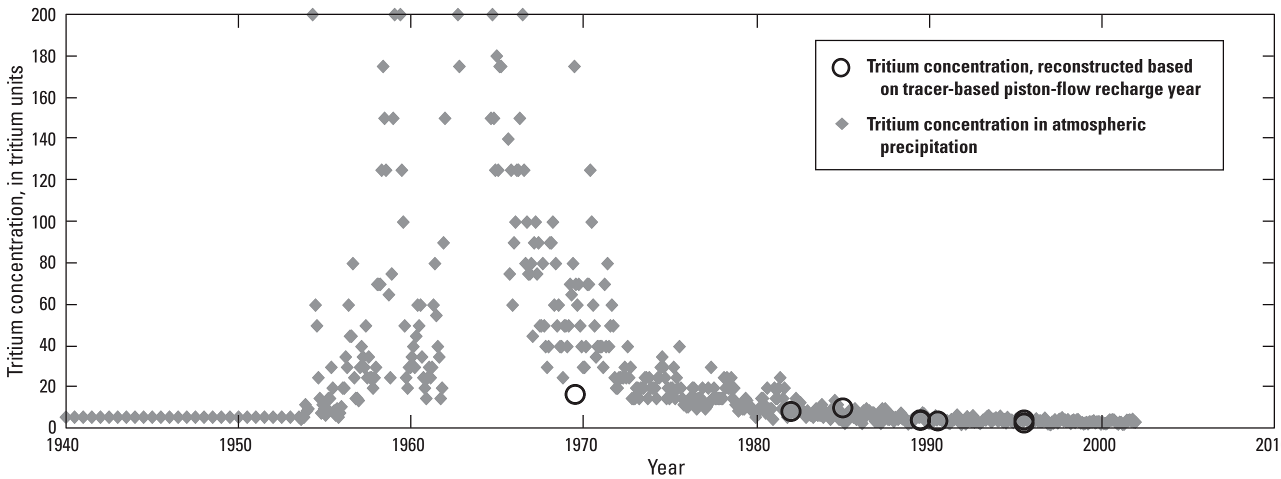

Figure B144. Reconstructed tritium concentrations (using CFC-based ages) and tritium in atmospheric precipitation, LUSRC1 network, SCTX Study Unit.

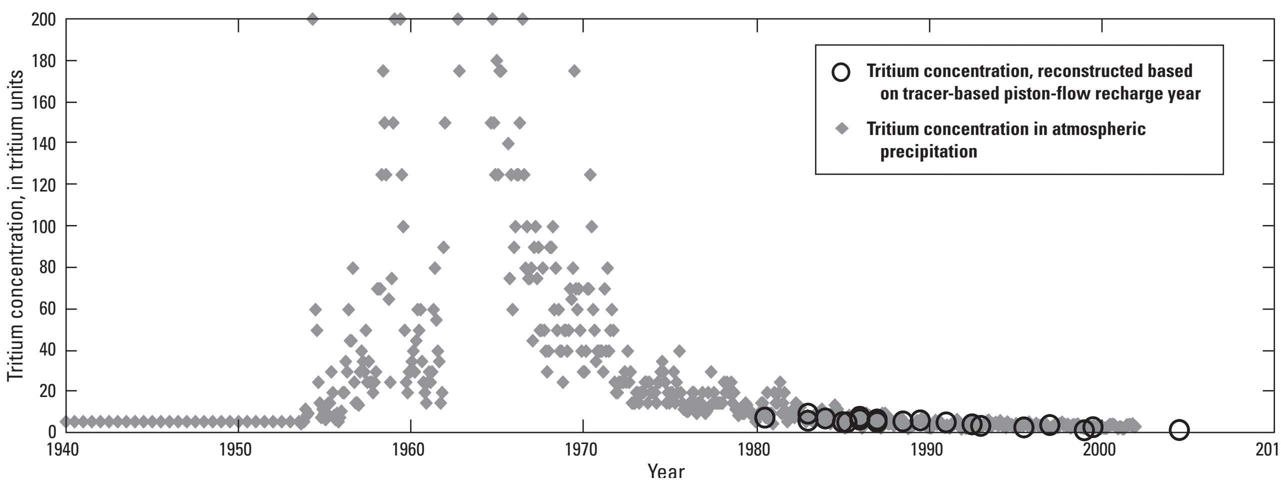

Figure B145. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, LUSRC1 network, SCTX Study Unit.

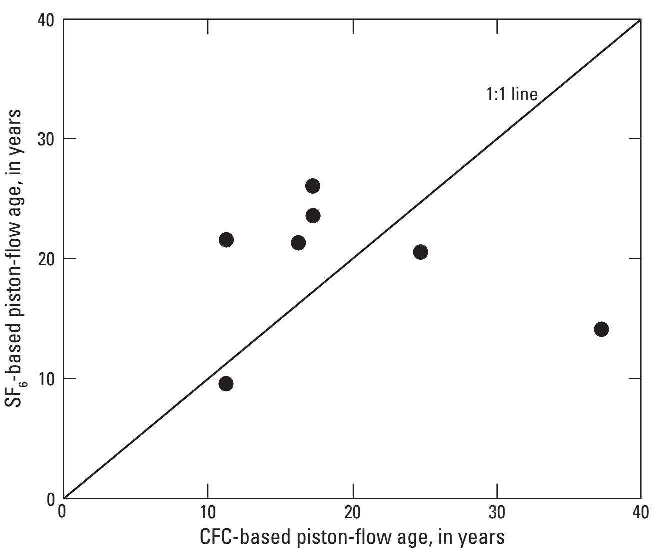

Figure B146. SF_6- versus CFC-based age comparison, LUSRC1 network, SCTX Study Unit.

SCTX LUSRC2 and REFRE2

Samples from 24 sites in the SCTX Study Unit were collected in 2008 for CFCs, SF_6, and $^3H/^3He$ (networks and, in parentheses, number of sites):

. LUSRC2 (23)

. REFRE2 (1)

The aquifer is composed of limestone of the Edwards-Trinity aquifer system.

Major dissolved-gas data were available for 24 sites. Of these 24 sites, 20 were oxic and 4 were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data. For the suboxic sites, if the oxic sites were used to constrain the excess sir, the recharge temperatures were too low, so used the median recharge temperature of the oxic sites for the suboxic sites.

$^3H/^3He$ ages were calculated for twelve sites (9 of the 12 sites required a correction for terrigenic helium), while 1 site was not datable because the tritium was too low, 7 sites were not datable because of fractionation, and samples from 4 sites were lost due to high pressure or damaged copper tubes.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B42.

. Advantages associated with these samples:

. Multiple tracers (CFCs, SF_6, and $^3H/^3He$, as well as major dissolved gases).

. Mixture of monitoring wells and one irrigation well, so likely low pumping stress.

. Disadvantages associated with these samples:

. Relatively large open intervals ranging from 23.77-100 feet so mixing likely.

. Median penetration of center of open interval into water table was 33.95 feet (not sampling close to the water table, potentially mixing).

. Depth to water (can affect tracer transport to water table):

. Median: 67.89 feet

. Mean: 76.60 feet

. Min: 16.58 feet

. Max: 167.99 feet

. Brief analysis:

. The CFC-, SF_6-, and $^3H/^3He$-based age gradients for these sites are shown in figures B147, B148, and B149.

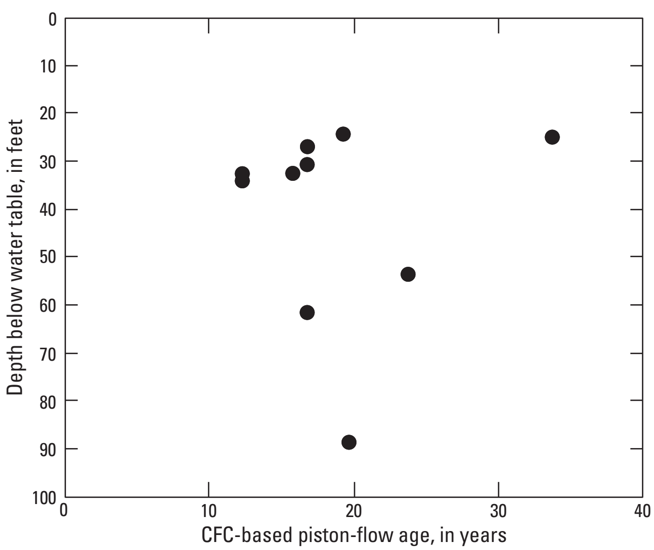

Figure B147. CFC-based age gradient for dated sites from the LUSRC2 and REFRE2 networks, SCTX Study Unit.

The age gradients show a great deal of scatter as would be expected for samples taken from wells finished in karst with large open intervals. The $^3H/^3He$-based ages appear to be biased toward young ages, which may be the result of helium loss in karst environments.

The reconstructed ^3H plots for CFC-, SF_6-, and $^3H/^3He$-based ages are shown in figures B150, B151, and B152. The reconstructions show evidence of mixing with old groundwater.

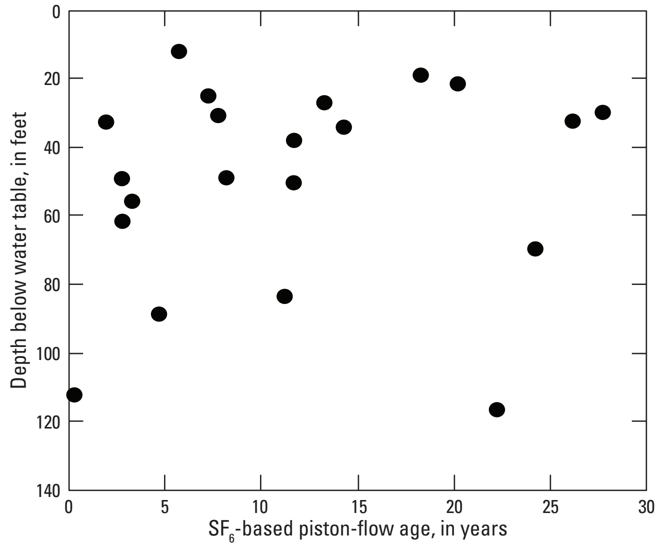

Figure B148. SF_6-based age gradient for dated sites from the LUSRC2 and REFRE2 networks, SCTX Study Unit.

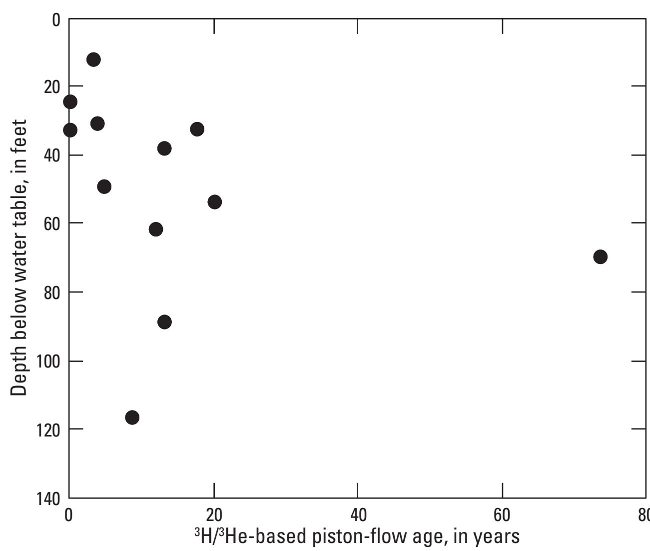

Figure B149. $^3H/^3He$-based age gradient for dated sites from the LUSRC2 and REFRE2 networks, SCTX Study Unit.

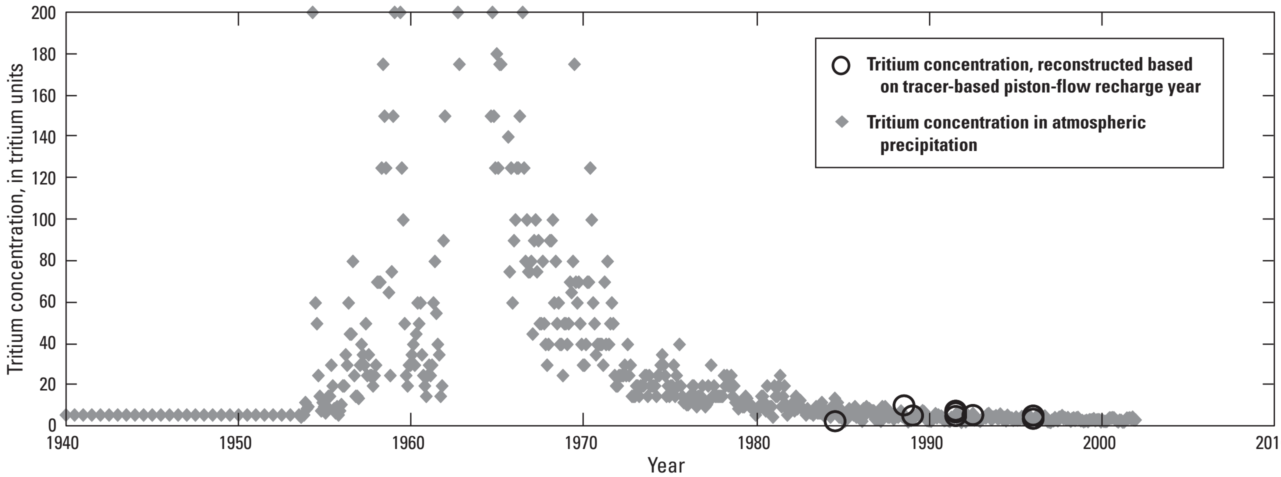

Figure B150. Reconstructed tritium concentrations (using CFC-based ages) and tritium in atmospheric precipitation, LUSRC2 and REFRE2 networks, SCTX Study Unit.

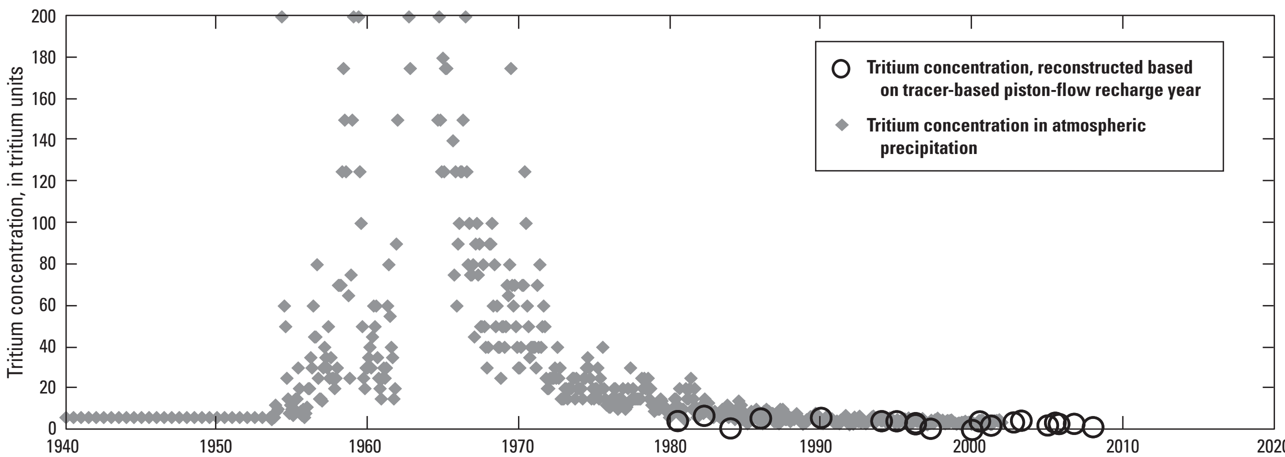

Figure B151. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, LUSRC2 and REFRE2 networks, SCTX Study Unit.

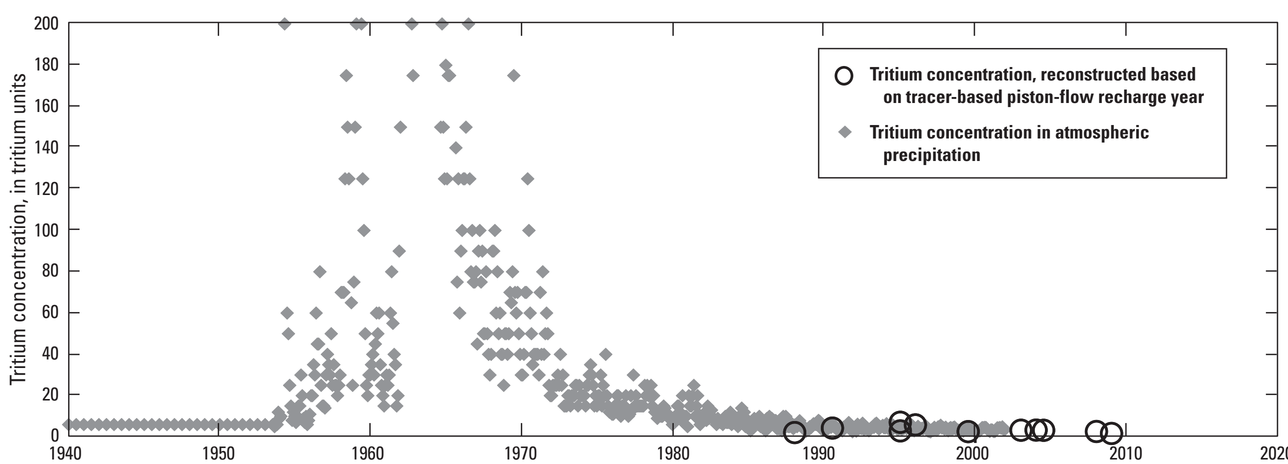

Figure B152. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, LUSRC2 and REFRE2 networks, SCTX Study Unit.

The SF_6- versus CFC-based age comparison, the $^3H/^3He$-versus CFC-based age comparison, and the $^3H/^3He$- versus SF_6-based age comparison for this network are shown in figures B153, B154, and B155. The age comparisons show similar trends to the figures shown above, with a great deal of scatter resulting from mixing in karst environments.

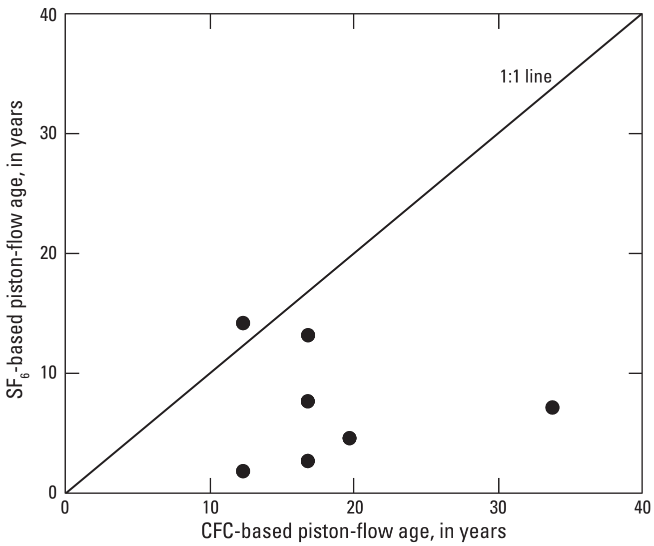

Figure B153. SF_6- versus CFC-based age comparison, LUSRC2 and REFRE2 networks, SCTX Study Unit.

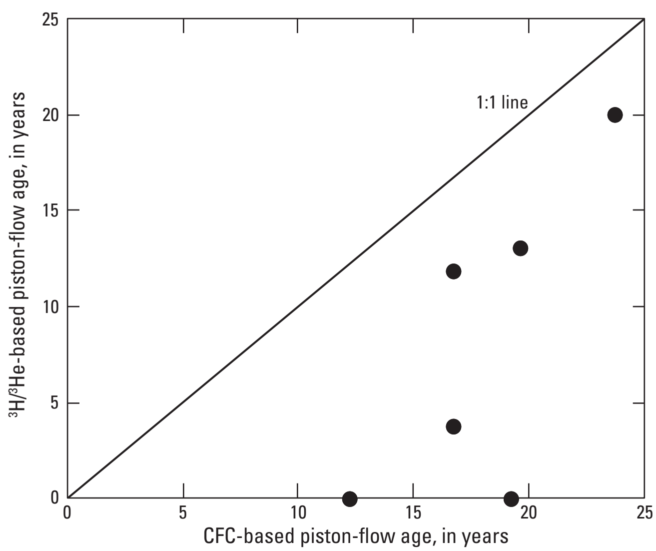

Figure B154. $^3H/^3He$- versus CFC-based age comparison, LUSRC2 and REFRE2 networks, SCTX Study Unit.

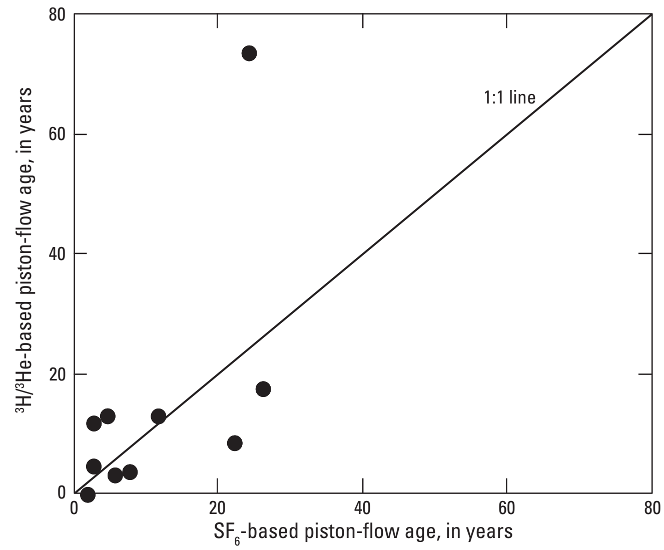

Figure B155. $^3H/^3He$- versus SF_6-based age comparison, LUSRC2 and REFRE2 networks, SCTX Study Unit.

SCTX SUS4

Samples from 30 sites in the SCTX Study Unit were collected in 2008 for CFCs, SF_6, and $^3H/^3He$ (networks and, in parentheses, number of sites):

- SUS4 (CFCs, 29; SF_6, 28; $^3H/^3He$, 17)

The aquifer is composed of sands of the Texas coastal uplands aquifer system.

Major dissolved-gas data were available for 30 sites. Of these 30 sites, 4 were oxic and 26 were suboxic. Using the oxic sites to constrain the excess air for the suboxic sites resulted in unreasonable recharge temperatures. The median recharge temperature of the dissolved-gas data was 19.3, which was similar to the MAAT+1°C, so used MAAT+1°C.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table, that recharge temperature was equal to the mean annual air temperature +1°C, and that excess air concentrations were 2 cc STP/kg.

$^3H/^3He$ ages were calculated for eight sites (only one of the eight sites required a correction for terrigenic helium).

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B43.

- Advantages associated with these samples:
    - Multiple tracers (CFCs, SF_6, $^3H/^3He$, as well as major dissolved gases).

- Disadvantages associated with these samples:
  - Mixture of domestic, irrigation, stock, and public supply wells, so variable pumping rates.
  - Relatively large open intervals ranging from 4 to 650 feet so mixing likely.
  - Median penetration of center of open interval into water table was 212.9 feet (not sampling close to the water table, potentially mixing).
  - Suboxic conditions.
- Depth to water (can affect tracer transport to water table):
  - Median: 208.61 feet
  - Mean: 218.36 feet
  - Min: 7.36 feet
  - Max: 619.06 feet
- Brief analysis:
  - The SF_6-based age gradient for these sites is shown in figure B156. The age gradient shows a great deal of scatter as would be expected for samples taken from such a wide variety of types of wells with large open intervals. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth. In addition, the suboxic conditions could be stripping the SF_6 from the water resulting in ages that are biased old.

The reconstructed ^3H plots for SF_6- and $^3H/^3He$-based ages are shown in figures B157 and B158. The reconstructions show evidence of mixing and/or SF_6 loss due to suboxic conditions.

The $^3H/^3He$- versus SF_6-based age comparison for this network is shown in figure B159. The age comparison is poor and likely results from mixing and possible gas stripping of SF_6 due to suboxic conditions.

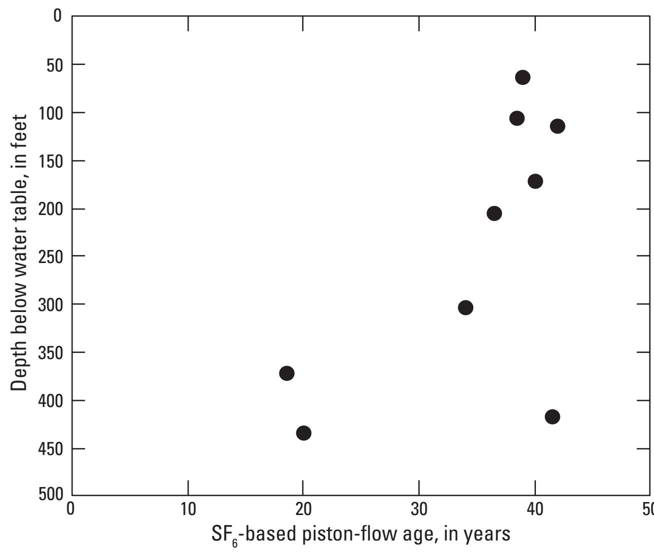

Figure B156. SF_6-based age gradient for dated sites from the SUS4 network, SCTX Study Unit.

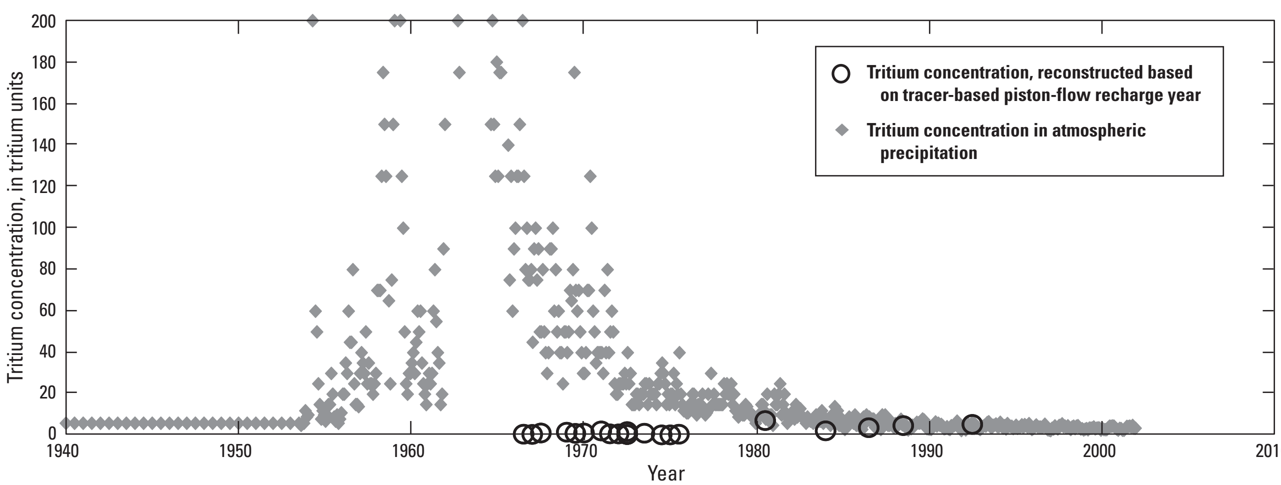

Figure B157. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, SUS4 network, SCTX Study Unit.

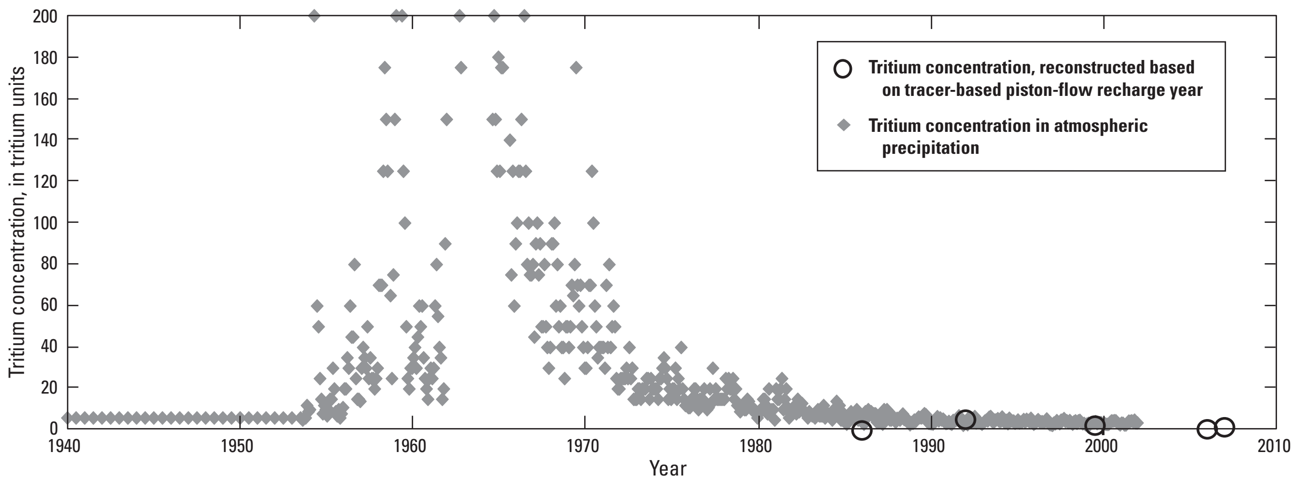

Figure B158. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, SUS4 network, SCTX Study Unit.

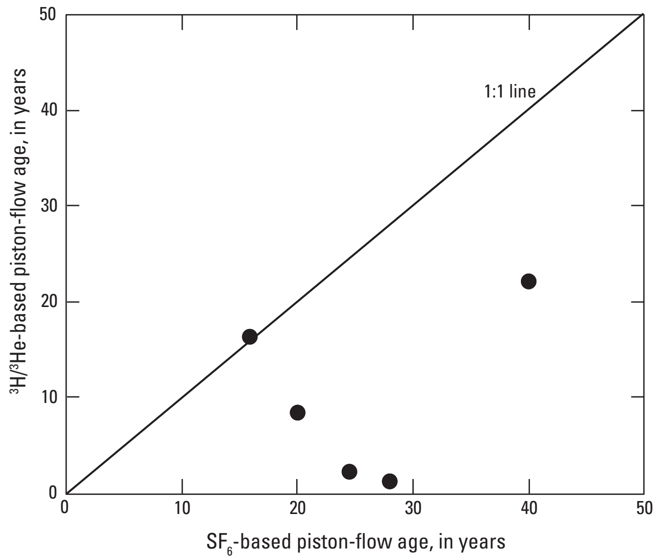

Figure B159. $^3H/^3He$- versus SF_6-based age comparison, SUS4 network, SCTX Study Unit.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites.

$^3H/^3He$ ages were calculated for two sites (both sites required a correction for terrigenic helium), while one site was not datable because the tritium was too low.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B44.

. Advantages associated with these samples:
  . Multiple tracers (SF_6 and $^3H/^3He$, as well as major dissolved gases).
. Disadvantages associated with these samples:
  . Public supply wells, so variable pumping rates more likely.
  . Relatively large open intervals ranging from 169 to 931 feet so mixing likely.
  . Median penetration of center of open interval into water table was 371.2 feet (not sampling close to the water table, potentially mixing).
. Depth to water (can affect tracer transport to water table):
  . Median: 130.05 feet
  . Mean: 164.50 feet
  . Min: 46.00 feet
  . Max: 360.00 feet

SOCA SUS1 and SUS2

Samples from 7 sites in the SOCA Study Unit were collected in 2008 for SF_6 and $^3H/^3He$ (networks and, in parentheses, number of sites):

. SUS1 (SF_6, 4)
. SUS2 (SF_6, 3; $^3H/^3He$, 3)

The aquifer is composed of sand, gravel, silt, and clay.

Major dissolved-gas data were available for 10 sites. Of these 10 sites, 8 were oxic and 2 were suboxic.

. Brief analysis:

. The SF_6-based age gradient for these sites is shown in figure B160. The age gradient shows a great deal of scatter as would be expected for samples taken from wells with large open intervals. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

The reconstructed ^3H plot for SF_6-based ages is shown in figure B161. The reconstruction shows evidence of mixing as would be expected for such a wide variety of pumping rates and large open intervals.

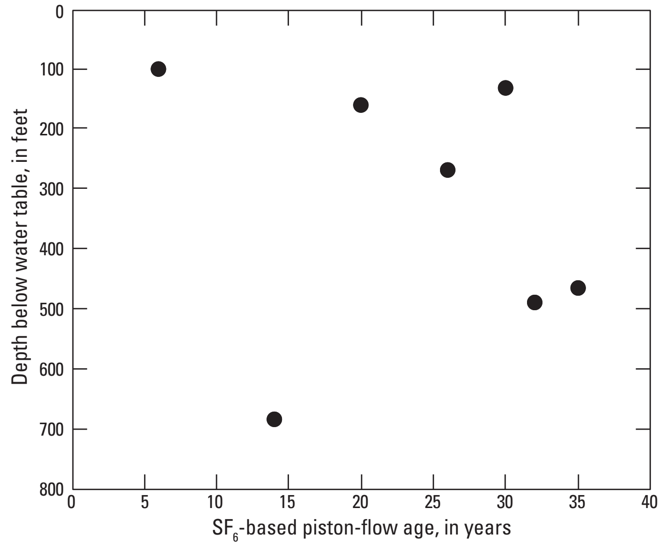

Figure B160. SF_6-based age gradient for dated sites from the SUS1 and SUS2 networks, SOCA Study Unit.

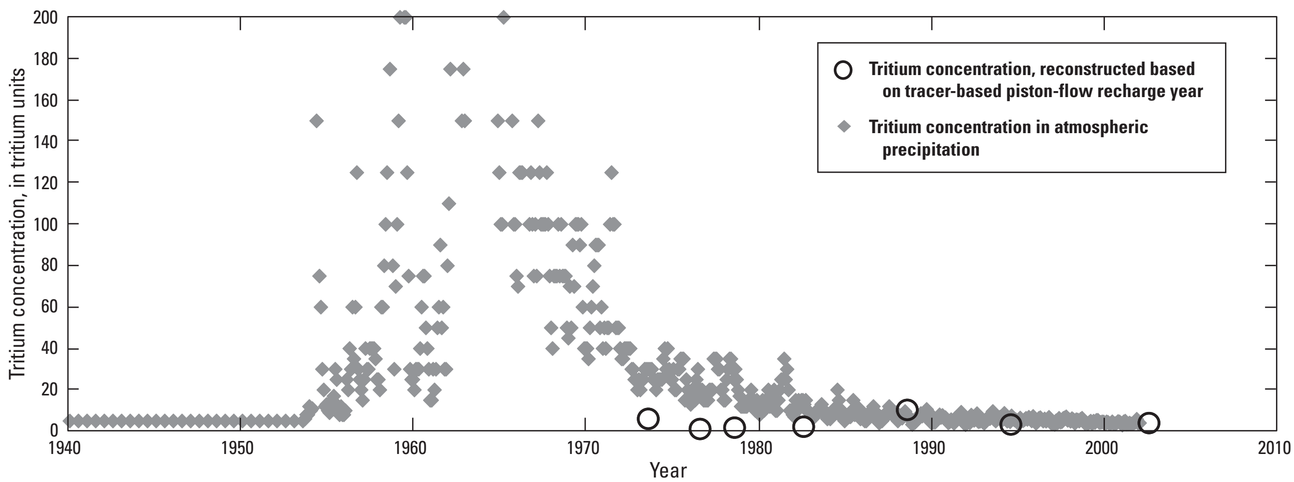

Figure B161. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, SUS1 and SUS2 networks, SOCA Study Unit.

SOFL LUSOR1 and LUSOT1

Samples from 13 sites in the SOFL Study Unit were collected in 2009 for CFCs, SF_6, and $^3H/^3He$ (networks and, in parentheses, number of sites):

. LUSOR1 (CFCs, 11; SF_6, 8; $^3H/^3He$, 11)

. LUSOT1 (SF_6, 2)

The aquifer is composed of sand.

Major dissolved-gas data were available for nine LUSOR1 sites. Of these nine sites, all were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table, that recharge temperature was equal to the mean annual air temperature +1°C, and that excess air concentrations were 2 cc STP/kg.

$^3H/^3He$ ages could not be calculated for any sites as a result of fractionation.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B45.

. Advantages associated with these samples:

. Multiple tracers (CFC, SF_6, and $^3H/^3He$, as well as major dissolved gases).

. Monitoring wells, therefore low pumping stress.

. Relatively short open intervals ranging from 2.95 to 10 feet so mixing likely minimized.

- Median penetration of center of open interval into water table was 5.34 feet (sampling close to the water table, potentially minimizes mixing).
- Disadvantages associated with these samples:
  - Suboxic conditions.
- Depth to water (can affect tracer transport to water table):
  - Median: 3.69 feet
  - Mean: 4.59 feet
  - Min: 1.25 feet
  - Max: 9.05 feet
- Brief analysis:
  - The SF_6-based age gradient for these sites is shown in figure B162. The age gradient shows a great deal of scatter as would be expected for samples taken from wells in suboxic conditions. The SF_6 concentrations have likely been affected by stripping due to high methane concentrations. In addition, differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

The reconstructed ^3H plot for SF_6-based ages is shown in figure B163. The reconstruction shows evidence of unmixed, piston-flow transport, however, it is also likely that the SF_6 ages should be younger and would shift to the right on the ^3H input function.

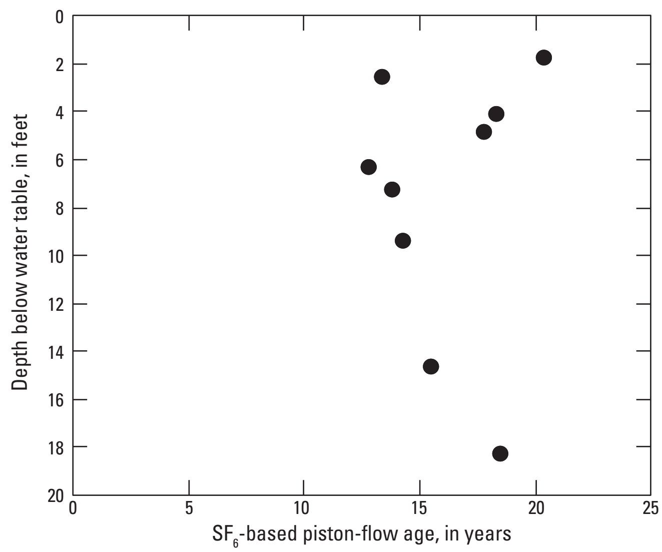

Figure B162. SF_6-based age gradient for dated sites from the LUSOR1 and LUSOT1 networks, SOFL Study Unit.

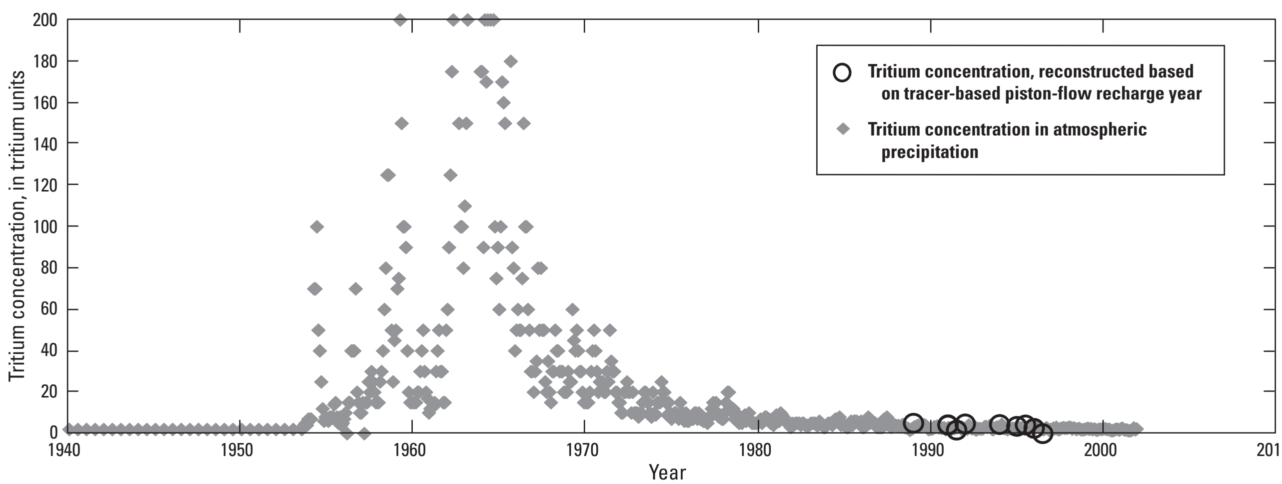

Figure B163. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, LUSOR1 and LUSOT1 networks, SOFL Study Unit.

SOFL LUSRC1a

Samples from 4 sites in the SOFL Study Unit were collected in 2009 for SF_6 and $^3H/^3He$, and 21 sites in the SOFL Study Unit were collected in 2010 for SF_6 (networks and, in parentheses, number of sites):

- LUSRC1a (SF_6, 4 in 2009 and 21 in 2010; $^3H/^3He$, 3 in 2009)

The aquifer is composed of limestone of the Biscayne Limestone aquifer.

Major dissolved-gas data were available for 21 sites. Of these 21 sites, all were suboxic, and some had very high methane concentrations.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table, that recharge temperature was equal to the mean annual air temperature +1°C, ad that excess air concentrations were 2 cc STP/kg.

$^3H/^3He$ ages could not be calculated for any sites as a result of fractionation.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B46.

- Advantages associated with these samples:
  - Multiple tracers (SF_6 and $^3H/^3He$, as well as major dissolved gases).
  - Monitoring wells, therefore low pumping stress.
  - Relatively short open intervals ranging from 2-10 feet so mixing likely minimized.
  - Median penetration of center of open interval into water table was 9.25 feet (sampling close to the water table, potentially minimizes mixing).
- Disadvantages associated with these samples:
  - Suboxic conditions.
- Depth to water (can affect tracer transport to water table):
  - Median: 3.82 feet
  - Mean: 4.46 feet
  - Min: 1.86 feet
  - Max: 13.60 feet
- Brief analysis:
  - The SF_6-based age gradient for these sites is shown in figure B164. The age gradient shows a great deal of scatter as would be expected for samples taken from wells in suboxic conditions. The SF_6 concentrations have likely been affected by stripping due to high methane concentrations. In addition, differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

The reconstructed ^3H plot for SF_6-based ages is shown in figure B165. The reconstruction shows evidence of unmixed, piston-flow transport, however, it is also likely that the SF_6 ages should be younger and would shift to the right on the ^3H input function.

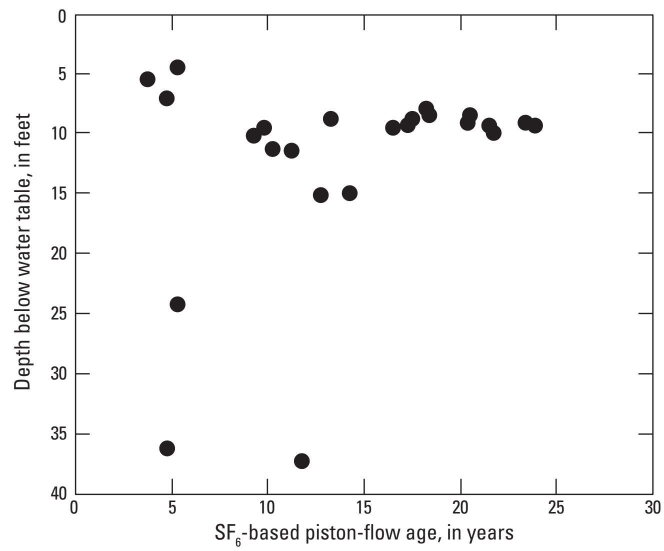

Figure B164. SF_6-based age gradient for dated sites from the LUSRC1a network, SOFL Study Unit.

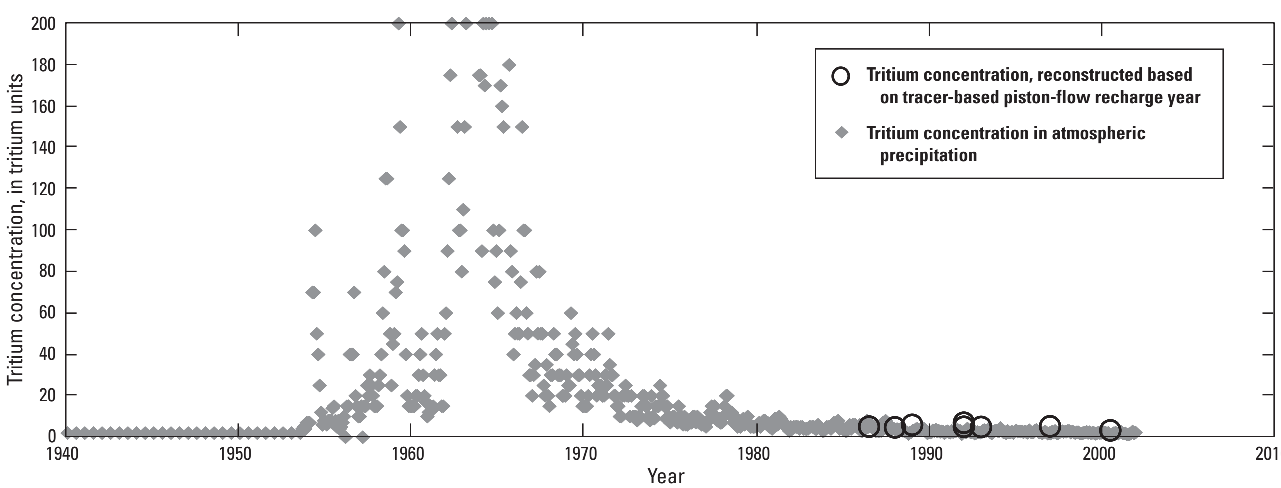

Figure B165. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, LUSRC1a network, SOFL Study Unit.

SOFL SUS1

Samples from five sites in the SOFL Study Unit were collected in 2009 for SF_6 and ^3H/3He (networks and, in parentheses, number of sites):

- SUS1 (5)

The aquifer is composed of limestone of the Biscayne Limestone aquifer.

Major dissolved-gas data were available for five sites. Of these five sites, all five were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table, that recharge temperature was equal to the mean annual air temperature +1°C, and that excess air concentrations were 2 cc STP/kg.

$^3H/^3He$ ages could not be calculated for any sites as a result of fractionation.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B47.

- Advantages associated with these samples:
  - Multiple tracers (SF_6 and $^3H/^3He$, as well as major dissolved gases).
- Disadvantages associated with these samples:
  - Mixture of monitoring and public supply wells, so variable pumping rates.
  - Relatively large open intervals ranging from 7 to 50 feet (with 2 unknown) so mixing likely.
  - Median penetration of center of open interval into water table was 68.37 feet (not sampling close to the water table, potentially mixing).
  - Suboxic conditions.
  - Fractionation of $^3H/^3He$ samples.
- Depth to water (can affect tracer transport to water table):
  - Median: 5.30 feet
  - Mean: 9.64 feet
  - Min: 3.00 feet
  - Max: 19.13 feet
- Brief analysis:
  - The reconstructed ^3H plot for SF_6-based ages is shown in figure B166. The reconstruction shows evidence of unmixed, piston-flow transport, however, it is also likely that the SF_6 ages should be younger and would shift to the right on the ^3H input function.

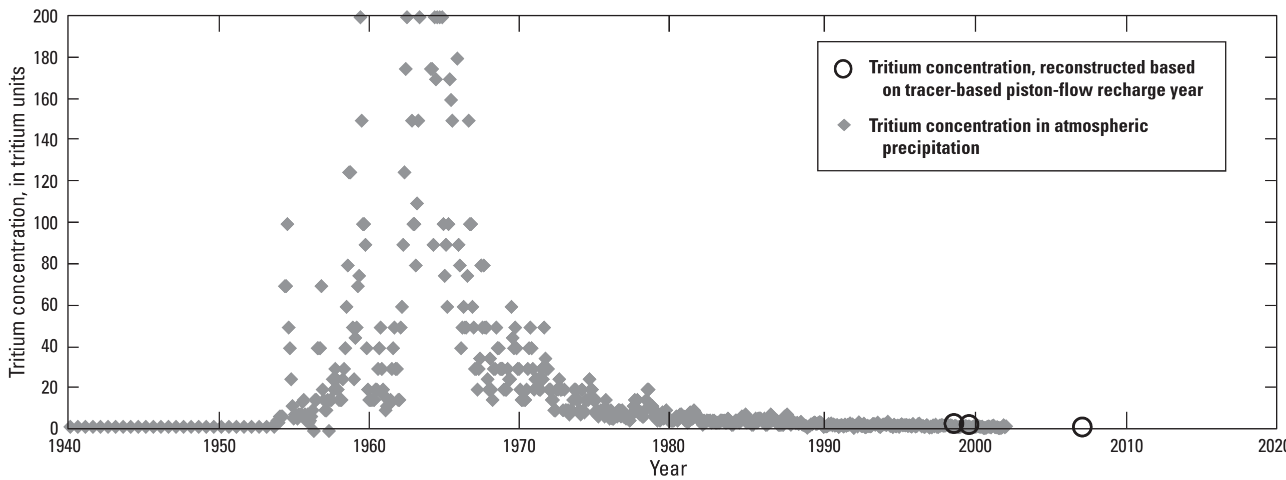

Figure B166. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, SUS1 network, SOFL Study Unit.

SPLT LUSCR1

Samples from four sites in the SPLT Study Unit were collected in 2008 for CFCs and $^3H/^3He$ (networks and, in parentheses, number of sites):

- LUSCR1 (4)

The aquifer is composed of alluvial gravel, sand, and silt.

Major dissolved-gas data were available for all four sites. Of these four sites, all four were oxic, however, because recharge temperatures and excess air were so variable, they were not used in the CFC and $^3H/^3He$ spreadsheets.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table, that recharge temperature was equal to the mean annual air temperature +1°C, and that excess air concentrations were 2 cc STP/kg.

$^3H/^3He$ ages were calculated for all four sites and did not require a correction for terrigenic He.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B48.

- Advantages associated with these samples:
  - Multiple tracers (CFCs and $^3H/^3He$, as well as major dissolved gases).
  - Monitoring wells, therefore low pumping stress.
  - Relatively short open intervals ranging from 7 to 10.78 feet so mixing likely minimized.
  - Median penetration of center of open interval into water table was 5.05 feet (sampling close to the water table, potentially minimizing mixing).
- Disadvantages associated with these samples:
  - None.
- Depth to water (can affect tracer transport to water table):
  - Median: 7.21 feet
  - Mean: 13.02 feet
  - Min: 3.79 feet
  - Max: 33.86 feet
- Brief analysis:
  - The CFC- and $^3H/^3He$-based age gradients for these sites are shown in figures B167 and B168. The age gradients show a great deal of scatter as would be expected for samples taken from such a narrow range in depth and in a cropland area affected by irrigation. The $^3H/^3He$-based ages are also significantly younger than the CFC-based ages indicating likely helium loss during irrigation. In addition, differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

The reconstructed ^3H plots for CFC- and $^3H/^3He$-based ages are shown in figures B169 and B170. The reconstructions show evidence of unmixed, piston-flow transport, however, as with the age gradient plots above, there is a significant discrepancy between CFC- and $^3H/^3He$-based ages, likely resulting from irrigation practices.

The $^3H/^3He$- versus CFC-based age comparison for this network is shown in figure B171. The age comparison is limited by the low number of samples, but also shows poor agreement likely resulting from helium loss during irrigation.

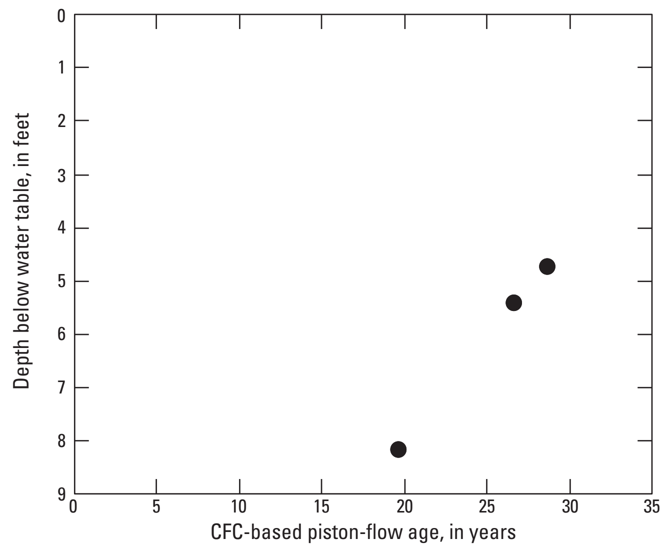

Figure B167. CFC-based age gradient for dated sites from the LUSCR1 network, SPLT Study Unit.

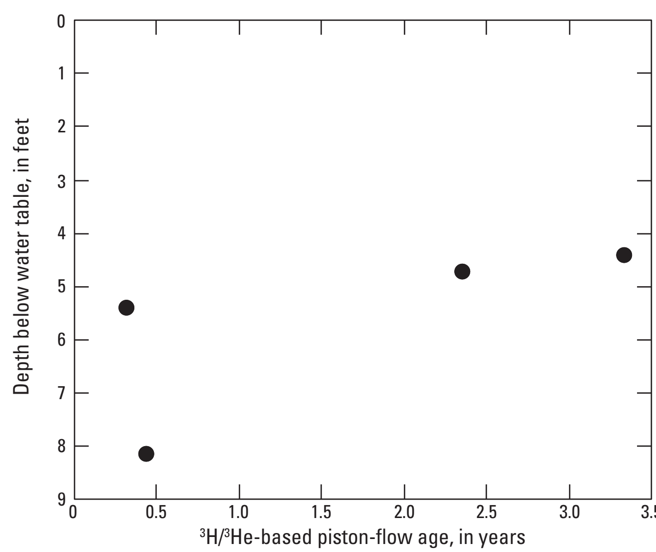

Figure B168. $^3H/^3He$-based age gradient for dated sites from the LUSCR1 network, SPLT Study Unit.

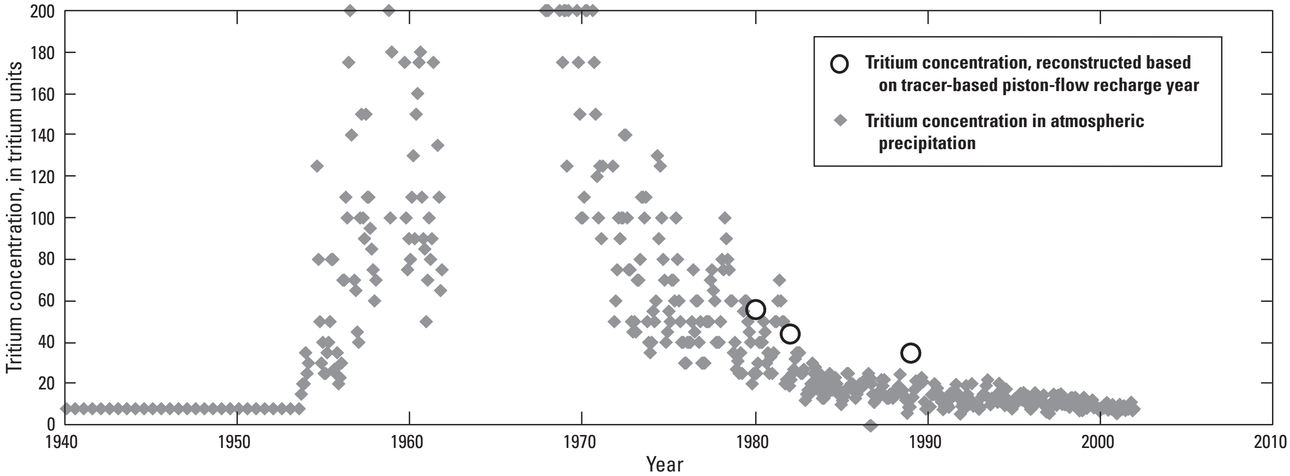

Figure B169. Reconstructed tritium concentrations (using CFC-based ages) and tritium in atmospheric precipitation, LUSCR1 network, SPLT Study Unit.

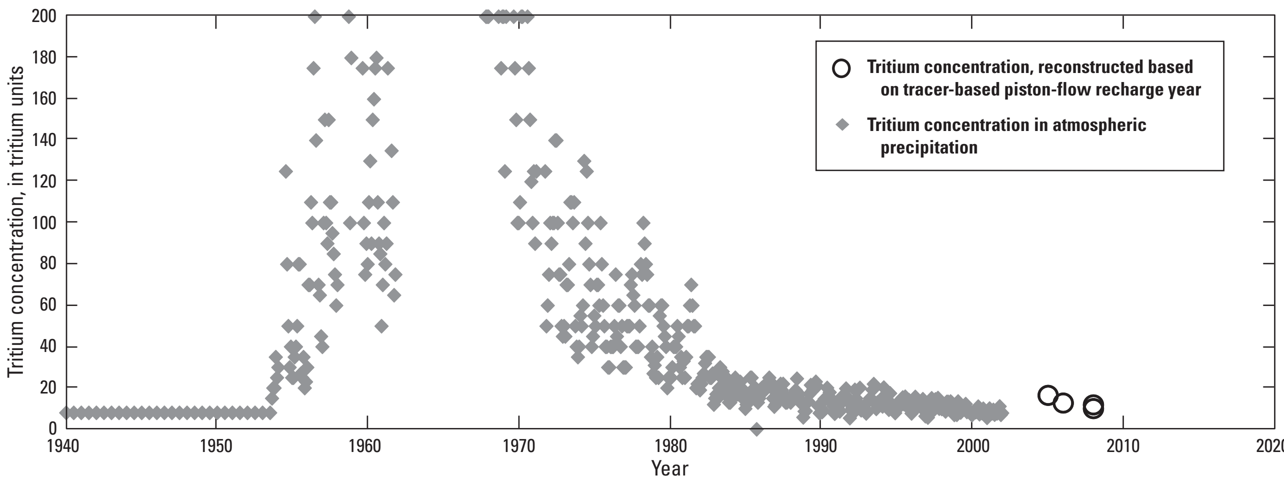

Figure B170. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, LUSCR1 network, SPLT Study Unit.

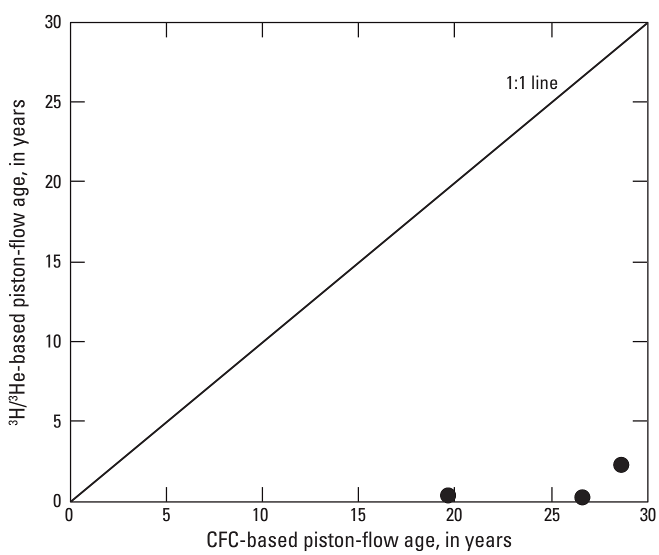

Figure B171. $^3H/^3He$- versus CFC-based age comparison, LUSCR1 network, SPLT Study Unit.

SPLT LUSRC2

Samples from five sites (two of which were sampled twice) in the SPLT Study Unit were collected in 2007 for CFCs and $^3H/^3He$ (networks and, in parentheses, number of sites):

- LUSRC2 (5)

The aquifer is composed of sandstone of the Dawson Arkose for three of the sites, and alluvium for two of the sites.

Major dissolved-gas data were available for all five sites. Of these five sites, two were oxic and three were suboxic. Recharge temperatures ranged from 5 to 18°C and were even lower if denitrification was assumed.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table, that recharge temperature was equal to the mean annual air temperature +1°C, and that excess air concentrations were 2 cc STP/kg.

$^3H/^3He$ ages were calculated for four sites (only one of the four sites required a correction for terrigenic helium), while one site was not datable because of fractionation.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B49.

- Advantages associated with these samples:
  - Multiple tracers (CFCs and $^3H/^3He$, as well as major dissolved gases).
  - Monitoring wells, therefore low pumping stress.
  - Relatively short open intervals <10 feet so mixing likely minimized.
  - Median penetration of center of open interval into water table was 11.66 feet (sampling close to the water table, potentially minimizes mixing).
- Disadvantages associated with these samples:
  - None.
- Depth to water (can affect tracer transport to water table):
  - Median: 33.83 feet
  - Mean: 28.43 feet
  - Min: 10.95 feet
  - Max: 41.46 feet
- Brief analysis:
  - The CFC- and $^3H/^3He$-based age gradients for these sites are shown in figures B172 and B173. The age gradients show little structure, likely as a result of the narrow range in depths for these wells. The $^3H/^3He$-based ages also are significantly younger than the CFC-based ages indicating likely helium loss.

The reconstructed ^3H plots for CFC- and $^3H/^3He$-based ages are shown in figures B174 and B175. The reconstructions show evidence of unmixed, piston-flow transport, however, as with the age gradient plots above, there is a significant discrepancy between CFC- and $^3H/^3He$-based ages, likely resulting from irrigation practices near the residential and commercial areas.

The $^3H/^3He$- versus CFC-based age comparison for this network is shown in figure B176. The age comparison is poor, likely as a result of irrigation practices near the residential and commercial areas.

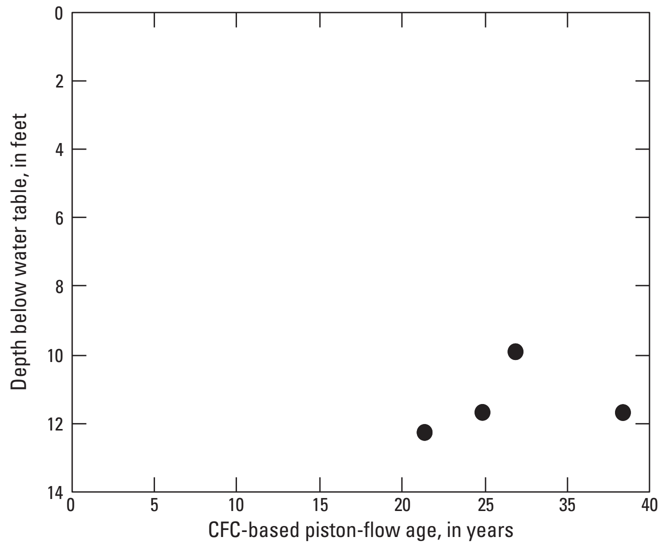

Figure B172. CFC-based age gradient for dated sites from the LUSCR2 network, SPLT Study Unit.

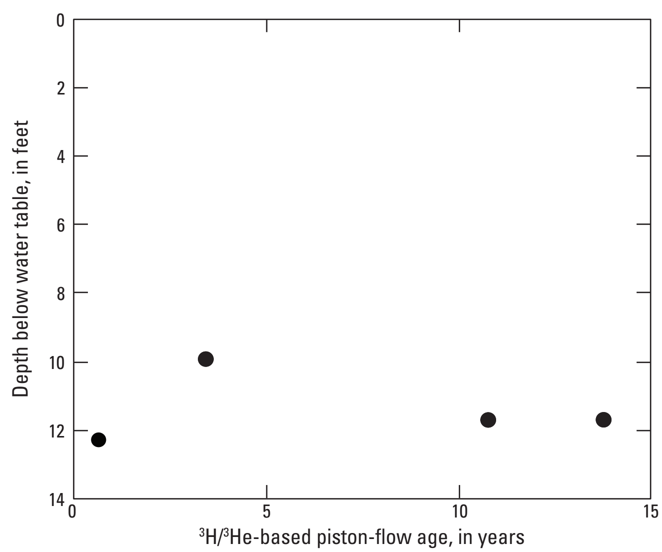

Figure B173. $^3H/^3He$-based age gradient for dated sites from the LUSCR2 network, SPLT Study Unit.

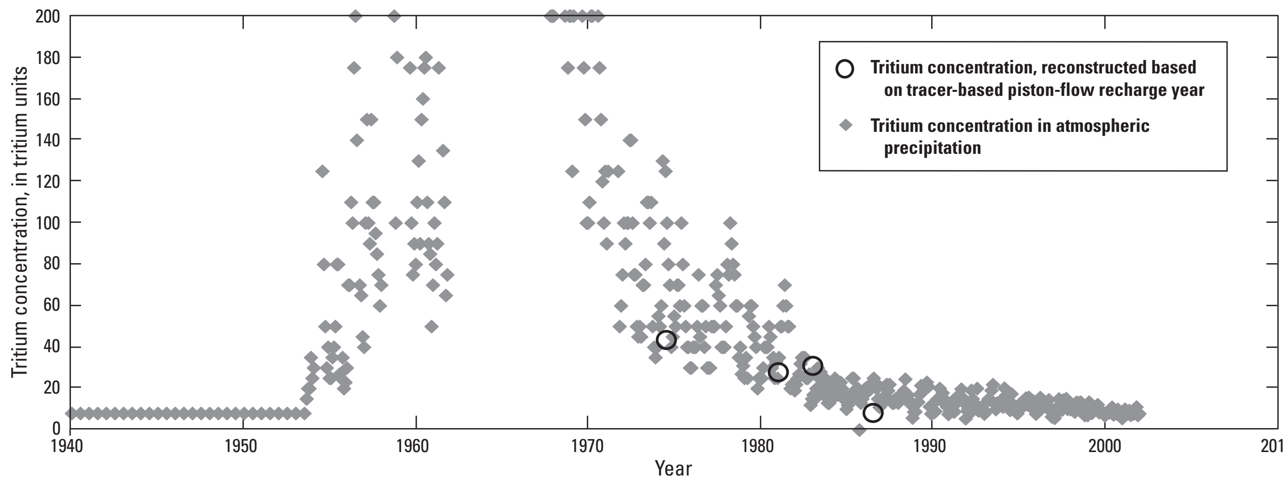

Figure B174. Reconstructed tritium concentrations (using CFC-based ages) and tritium in atmospheric precipitation, LUSRC2 network, SPLT Study Unit.

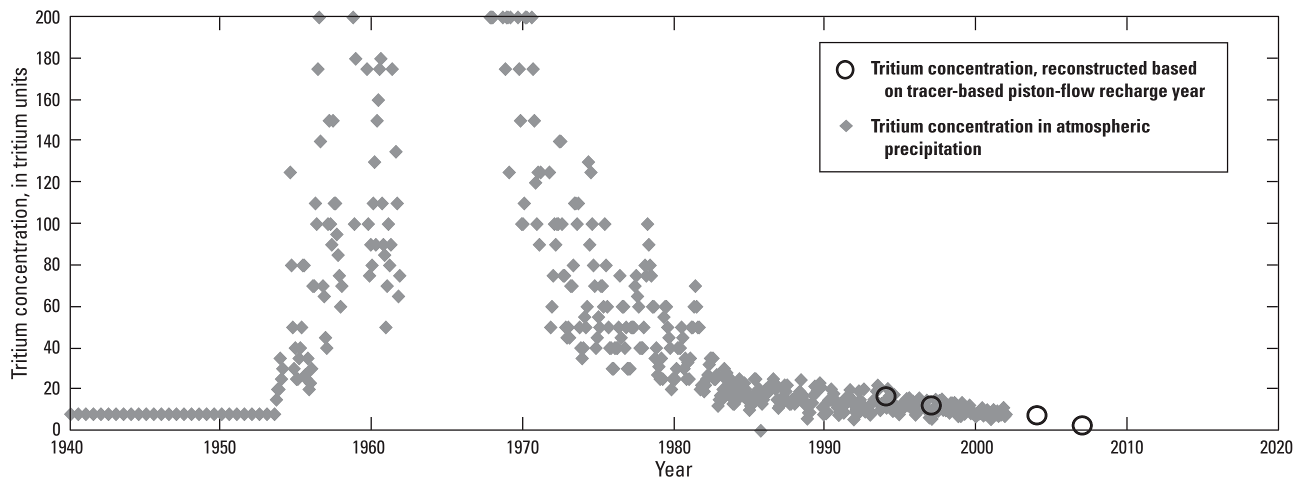

Figure B175. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, LUSRC2 network, SPLT Study Unit.

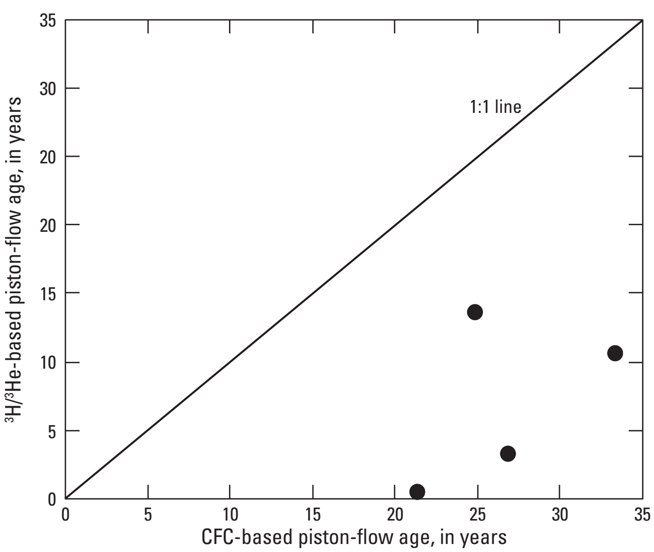

Figure B176. $^3H/^3He$- versus CFC-based age comparison, LUSRC2 network, SPLT Study Unit.

TRIN LUSRC1 and REFOT1

Samples from six sites in the TRIN Study Unit were collected in 2007 for CFCs and SF_6 (networks and, in parentheses, number of sites):

. LUSRC1 (3)

. REFOT1 (3)

The aquifer is composed of sand and clay of the Chicot Aquifer.

Major dissolved-gas data were available for all six sites. Of these six sites, four were oxic and two were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B50.

- Advantages associated with these samples:
  - Multiple tracers (CFCs and SF_6, as well as major dissolved gases).
  - Monitoring wells, therefore low pumping stress.
  - Relatively short open intervals of 10 feet so mixing likely minimized.
  - Median penetration of center of open interval into water table was 10.7 feet (sampling close to the water table, potentially minimizes mixing).
- Disadvantages associated with these samples:
  - Suboxic conditions.
  - No tritium.
- Depth to water (can affect tracer transport to water table):
  - Median: 14.31 feet
  - Mean: 12.63 feet
  - Min: 0.89 feet
  - Max: 25.91 feet
- Brief analysis:
  - The CFC- and SF_6-based age gradients for these sites are shown in figures B177 and B178. The age gradients show a great deal of scatter and the CFC-based ages are older than the SF_6-based ages. The older CFC-based ages are likely the result of suboxic conditions in the aquifer. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

The SF_6- versus CFC-based age comparison for this network is shown in figure B179. The age comparison is poor, likely as the result of CFC degradation in the suboxic conditions in the aquifer.

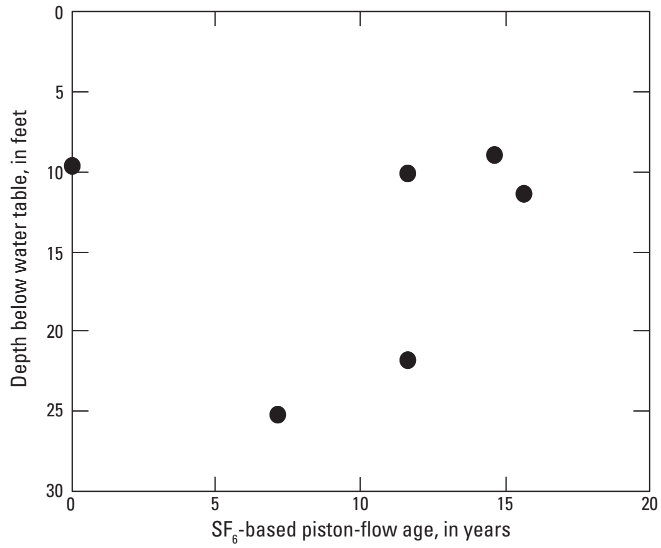

Figure B178. SF_6-based age gradient for dated sites from the LUSRC1 and REFOT1 networks, TRIN Study Unit.

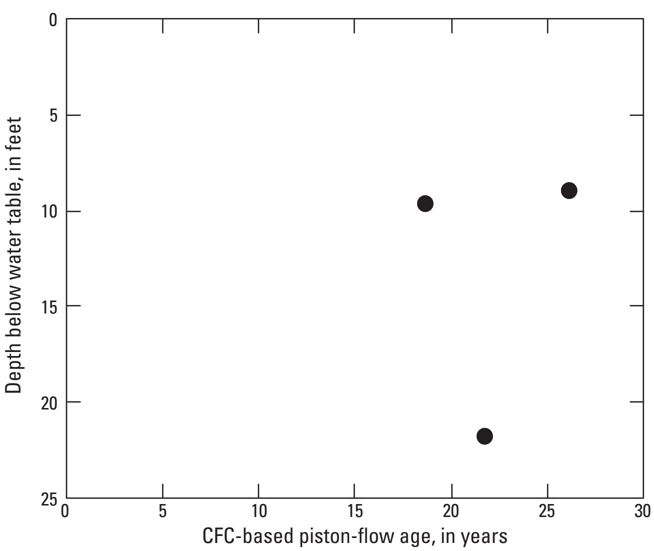

Figure B177. CFC-based age gradient for dated sites from the LUSRC1 and REFOT1 networks, TRIN Study Unit.

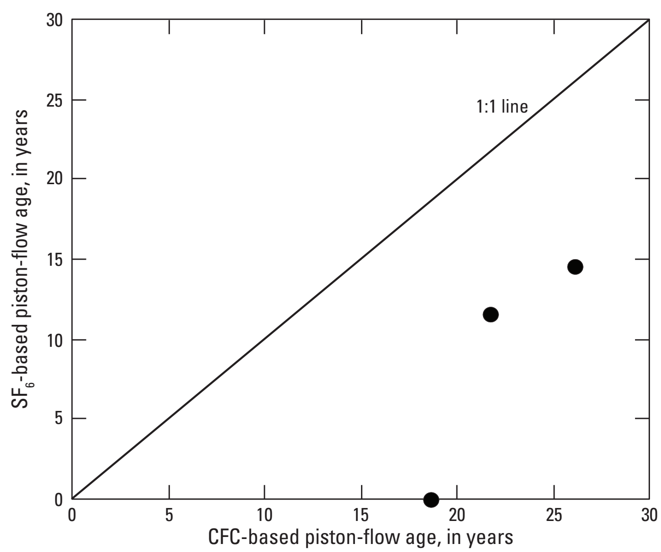

Figure B179. SF_6- versus CFC-based age comparison, LUSRC1 and REFOT1 networks, TRIN Study Unit.

TRIN SUS3

Samples from five sites in the TRIN Study Unit were collected in 2007 for $^3H/^3He$ (networks and, in parentheses, number of sites):

- SUS3 (5)

The aquifer is composed of sand and clay of the Chicot and Evangeline aquifers.

Major dissolved-gas data were not available.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table, that recharge temperature was equal to the mean annual air temperature +1°C, and that excess air concentrations were 2 cc STP/kg.

$^3H/^3He$ ages could not be calculated for any sites. Four of the sites had tritium concentrations that were too low, and the sample from one site was lost due to high pressure (in addition to having a tritium concentration that was too low).

The raw tracer data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B51.

- Advantages associated with these samples:
  - None.
- Disadvantages associated with these samples:
  - No multiple tracers or major dissolved gases.
  - Mixture of domestic and public supply wells, so variable pumping rates.
  - Relatively large open intervals ranging from 10 to 120 feet so mixing likely.
  - Median penetration of center of open interval into water table was 130.62 feet (not sampling close to the water table, potentially mixing).
- Depth to water (can affect tracer transport to water table):
  - Median: 102.90 feet
  - Mean: 93.24 feet
  - Min: 30.38 feet
  - Max: 161.26 feet
- Brief analysis:
  - The only thing that can be concluded from the $^3H/^3He$ data is that with tritium concentrations so low, the age of the water is pre-bomb, or greater than 54 years old.

UMIS FPSUR1

Samples from 16 sites in the UMIS Study Unit were collected in 2008 for CFCs (networks and, in parentheses, number of sites):

- FPSUR1 (16)

The aquifer is composed of glacial sand, silt, clay, and gravel.

Major dissolved-gas data were available for all 16 sites.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table, that recharge temperature was equal to the mean annual air temperature +1°C, and that excess air concentrations were 2 cc STP/kg.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B52.

- Advantages associated with these samples:
  - CFCs, as well as major dissolved gases.
  - Monitoring wells, therefore low pumping stress.
  - Relatively short open intervals ranging from 0.5 to 5 feet so mixing likely minimized.
  - Median penetration of center of open interval into water table was 7.10 feet (sampling close to the water table, potentially minimizes mixing).
- Disadvantages associated with these samples:
  - Suboxic conditions.
- Depth to water (can affect tracer transport to water table):
  - Median: 9.38 feet
  - Mean: 10.56 feet
  - Min: 1.00 feet
  - Max: 29.86 feet
- Brief analysis:
  - Age-dating in this network was not possible as a result of the suboxic conditions and the fact that the only tracer samples that were taken were for CFCs, which were affected by degradation.

UMIS LUSCR1

Samples from 26 sites in the UMIS Study Unit were collected in 2006 for SF_6 and $^3H/^3He$ (networks and, in parentheses, number of sites):

- LUSCR1 (SF_6, 26; $^3H/^3He$, 1)

The aquifer is composed of glacial sand, silt, clay, and gravel.

Major dissolved-gas data were available for 29 sites. Of these 29 sites, 22 were oxic and 7 were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites.

$^3H/^3He$ age was calculated for one site and did not require a correction for terrigenic He.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B53.

. Advantages associated with these samples:

. Multiple tracers (SF_6 and $^3H/^3He$, as well as major dissolved gases).

. Mixture of domestic and monitoring wells, therefore low pumping stress.

. Relatively short open intervals ranging from 2.66 to 20 (with most <5) feet so mixing likely minimized.

. Median penetration of center of open interval into water table was 2.44 feet (sampling close to the water table, potentially minimizes mixing).

. Disadvantages associated with these samples:

. None.

. Depth to water (can affect tracer transport to water table):

. Median: 16.07 feet

. Mean: 19.96 feet

. Min: 4.57 feet

. Max: 44.28 feet

. Brief analysis:

. The SF_6-based age gradient for these sites is shown in figure B180. The age gradient shows a great deal of scatter, which because of the excellent SF_6-based ^3H reconstruction, would indicate that the scatter may simply result from the location of wells in a flow system, with wells in discharge areas having shallow depths and older ages.

The reconstructed ^3H plot for SF_6-based ages is shown in figure B181. The reconstruction shows evidence of unmixed, piston-flow transport.

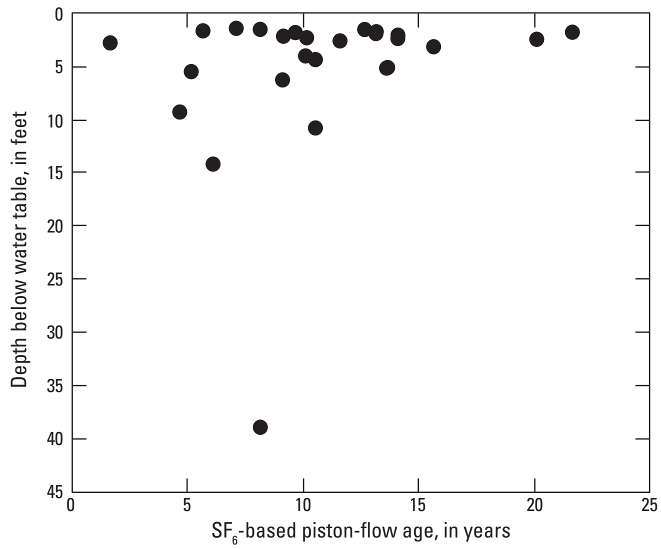

Figure B180. SF_6-based age gradient for dated sites from the LUSCR1 network, UMIS Study Unit.

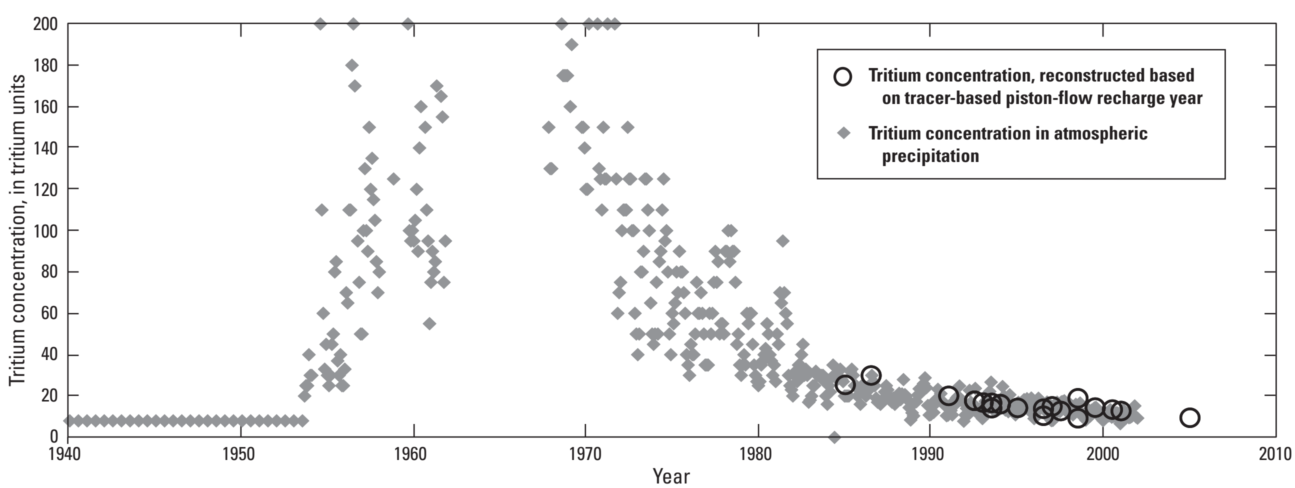

Figure B181. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, LUSCR1 network, UMIS Study Unit.

UMIS LUSRC1, REFFO1, and REFFO2

Samples from 27 sites in the UMIS Study Unit were collected in 2006 and 2008 for SF_6 and $^3H/^3He$ (networks and, in parentheses, number of sites):

- LUSRC1 (CFC, 2; SF_6, 21; $^3H/^3He$, 14)
- REFFO1 (SF_6, 1)
- REFFO2 (SF_6, 1)

The aquifer is composed of glacial sand, silt, clay, and gravel.

Major dissolved-gas data were available for 30 sites. Of these 30 sites, 11 were oxic and 19 were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites.

$^3H/^3He$ ages were calculated for eight sites (two of the eight sites required a correction for terrigenic helium), while six sites were not datable because of fractionation.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B54.

- Advantages associated with these samples:
  - Multiple tracers (SF_6 and $^3H/^3He$, as well as major dissolved gases).
  - Monitoring wells, therefore low pumping stress.
  - Relatively short open intervals ranging from 2 to 5 feet so mixing likely minimized.
  - Median penetration of center of open interval into water table was 3.73 feet (sampling close to the water table, potentially minimizes mixing).
- Disadvantages associated with these samples:
  - Suboxic conditions.
- Depth to water (can affect tracer transport to water table):
  - Median: 10.04 feet
  - Mean: 11.29 feet
  - Min: 2.25 feet
  - Max: 24.03 feet
- Brief analysis:
  - The SF_6- and $^3H/^3He$-based age gradients for these sites are shown in figures B182 and B183. The age gradients show a great deal of scatter and may result from SF_6 loss (and therefore older ages) from stripping due to high methane concentrations. In addition, differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

The reconstructed ^3H plots for SF_6- and $^3H/^3He$-based ages are shown in figures B184 and B185. The reconstructions show evidence of unmixed, piston-flow transport, however, the SF_6 ages are biased old likely as a result of stripping due to high methane concentrations.

The $^3H/^3He$- versus SF_6-based age comparison for this network is shown in figure B186. The age comparison is poor as a result of the SF_6 ages being biased old due to stripping from high methane concentrations.

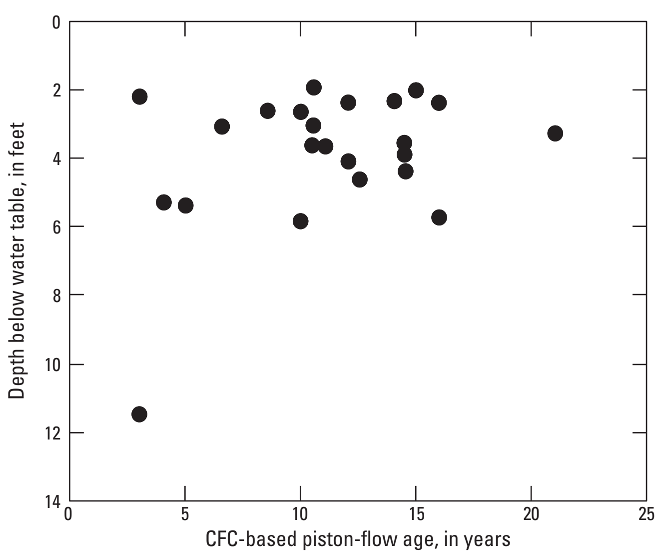

Figure B182. SF_6-based age gradient for dated sites from the LUSRC1, REFFO1, and REFFO2 networks, UMIS Study Unit.

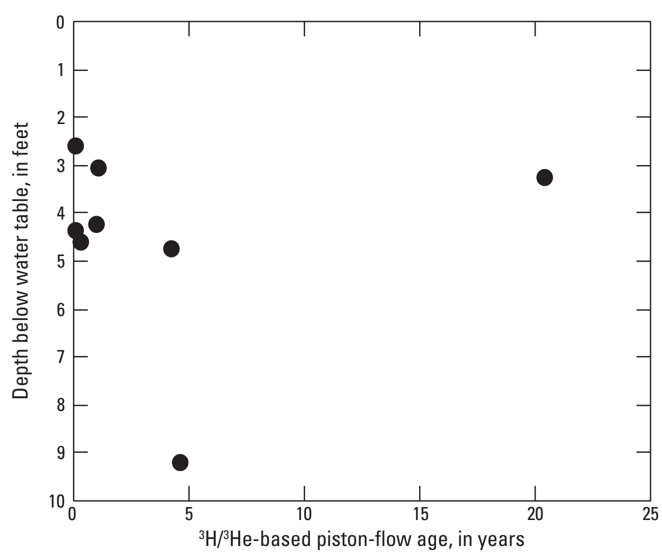

Figure B183. $^3H/^3He$-based age gradient for dated sites from the LUSRC1 and REFFO1 networks, UMIS Study Unit.

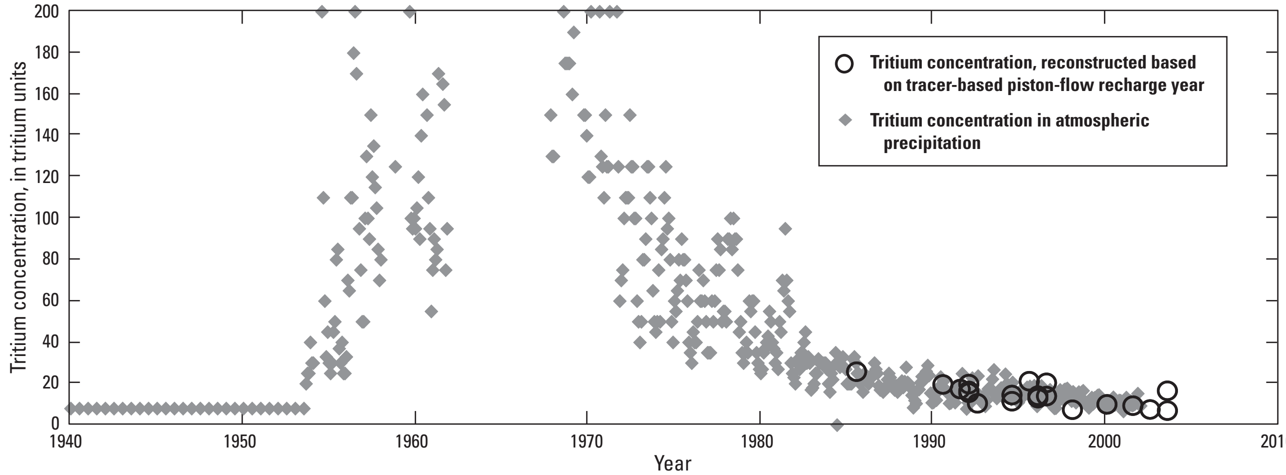

Figure B184. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, LUSRC1, REFFO1, and REFFO2 networks, UMIS Study Unit.

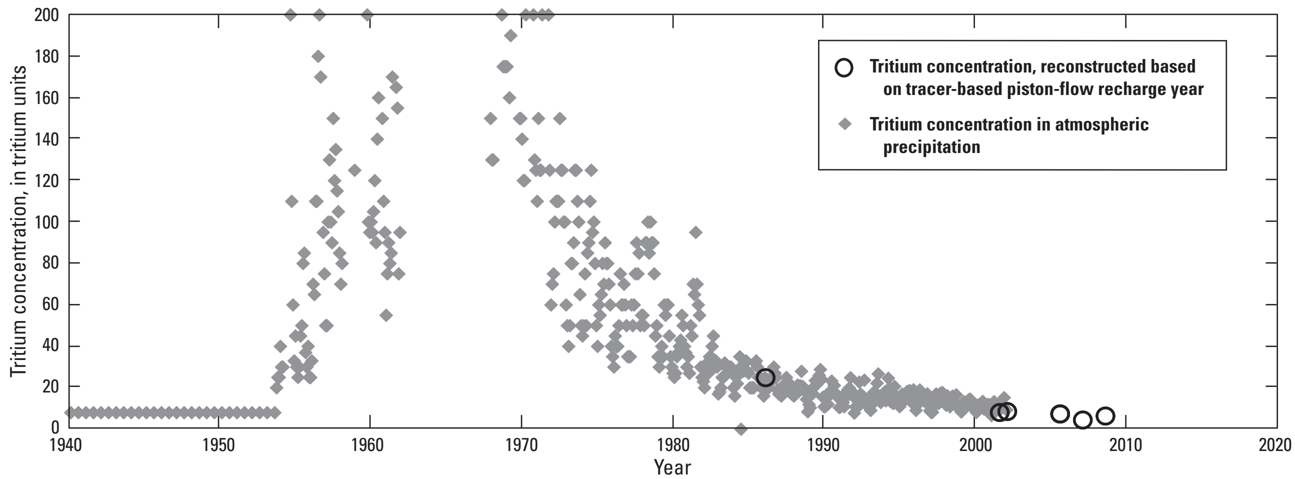

Figure B185. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, LUSRC1 and REFFO1 networks, UMIS Study Unit.

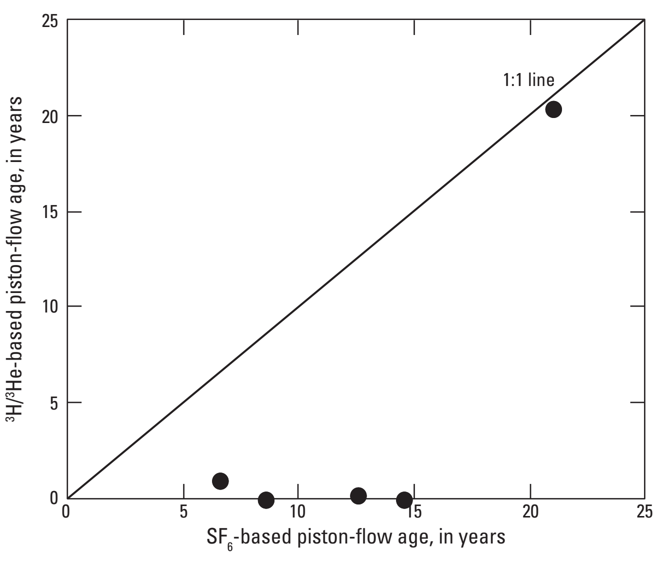

Figure B186. $^3H/^3He$- versus SF_6-based age comparison, LUSRC1 and REFFO1 networks, UMIS Study Unit.

UMIS SUS3

Samples from 20 sites in the UMIS Study Unit were collected in 2007 for SF_6 (networks and, in parentheses, number of sites):

. SUS3 (20)

The sites are finished in aquifers composed of sandstone, limestone, and dolomite.

Major dissolved-gas data were available for 30 sites. Of these 30 sites, 14 were oxic and 16 were suboxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data, with recharge temperature and excess air at suboxic sites being constrained using median excess air at oxic sites.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B55.

- Advantages associated with these samples:
  - SF_6, as well as major dissolved gases.
  - Domestic wells (with some unknown), therefore low pumping stress.
- Disadvantages associated with these samples:
  - Relatively large open intervals ranging from 1 to 71.55 feet so mixing likely.
  - Median penetration of center of open interval into water table was 69.00 feet (not sampling close to the water table, potentially mixing).
- Depth to water (can affect tracer transport to water table):
  - Median: 65.51 feet
  - Mean: 76.52 feet
  - Min: 11.65 feet
  - Max: 219.13 feet
- Brief analysis:
  - The SF_6-based age gradient for these sites is shown in figure B187. The age gradient shows no particular structure. Differences in screen length, recharge source/strength, aquifer heterogeneity, pumping stresses, and the position of the well within the flow system may cause some wells to deviate from the general pattern of increasing age with depth.

The reconstructed ^3H plot for SF_6-based ages is shown in figure B188. The reconstruction shows evidence of unmixed, piston-flow transport for some samples, and mixing for other samples, as would be expected for samples taken from wells with large open intervals. Also, several samples plot to the right of the ^3H reconstruction as might be expected for samples taken from sites with relatively deep unsaturated zones.

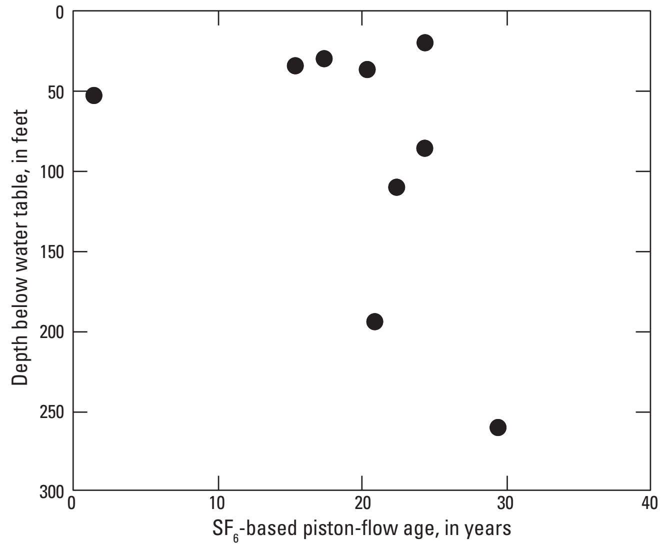

Figure B187. SF_6-based age gradient for dated sites from the SUS3 network, UMIS Study Unit.

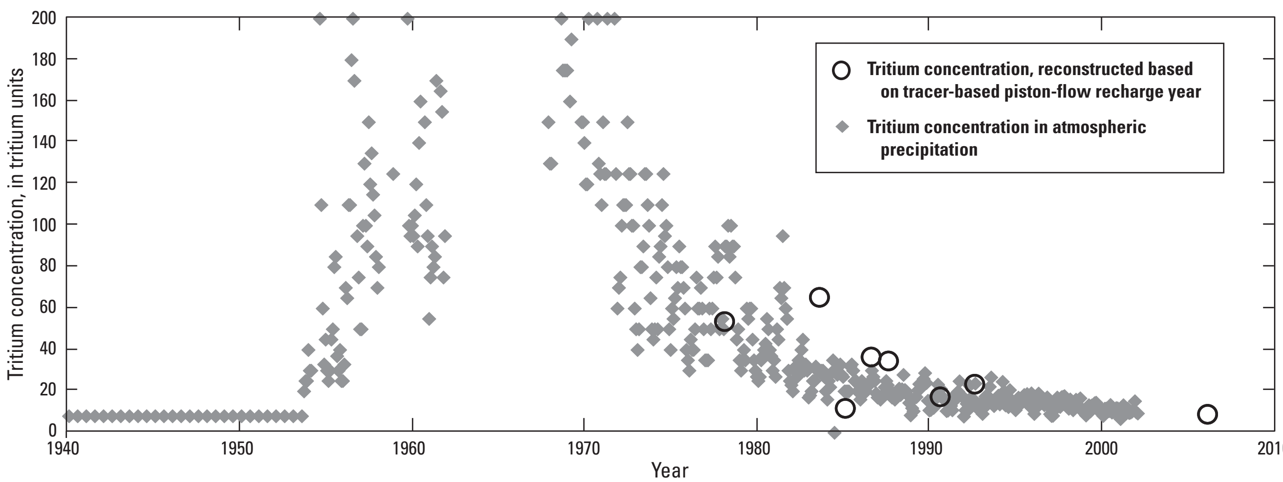

Figure B188. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, SUS3 network, UMIS Study Unit.

USNK LUSCR2 and LUSCR3

Samples from 14 sites in the USNK Study Unit were collected in 2008 for CFCs, SF_6, and $^3H/^3He$ (networks and, in parentheses, number of sites):

- LUSCR2 (CFCs, 7; SF_6, 7; $^3H/^3He$, 6)
- LUSCR3 (CFCs. 7; and SF_6, 6; $^3H/^3He$, 7)

The aquifer is composed of Snake River Group basalts.

Major dissolved-gas data were available for all 14 sites. Of these 14 sites, all 14 were oxic.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table. Estimates of recharge temperature and excess air were based on major dissolved-gas data.

$^3H/^3He$ ages were calculated for 12 sites (9 of the 12 sites required a correction for terrigenic helium), while the sample from 1 site was lost due to high pressure. No tritium errors were reported so a value of 0.3 TU was used in the $^3H/^3He$ worksheet.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B56.

- Advantages associated with these samples:
  - Multiple tracers (CFCs, SF_6, and $^3H/^3He$, as well as major dissolved gases).
  - Domestic wells, therefore low pumping stress.
  - Median penetration of center of open interval into water table was 28.25 feet (sampling relatively close to the water table, potentially minimizing mixing).
- Disadvantages associated with these samples:
  - Relatively large open intervals ranging from 5.6 to 107.51 feet so mixing likely.
- Depth to water (can affect tracer transport to water table):
  - Median: 227.87 feet
  - Mean: 241.02 feet
  - Min: 113.58 feet
  - Max: 453.67 feet
- Brief analysis:
  - The CFC-, SF_6-, and $^3H/^3He$-based age gradients for these sites are shown in figures B189, B190, and B191. The age gradients show a great deal of scatter as would be expected for samples taken from domestic wells with large open intervals dispersed among a large geographic area. The CFC- and SF_6-based ages are similar and are confined to a small range in ages, while the $^3H/^3He$-based ages show a wider spread in values. Surprisingly, there was no effect of mantle helium in these wells, which are finished in basalt, and the $^3H/^3He$-based ages appear to be more reliable than the CFC- and SF_6-based ages as seen in the reconstructed ^3H plots for CFC-, SF_6-, and $^3H/^3He$-based ages, which are shown in figures B192, B193, and B194, and the age comparisons as shown in figures B195, B196, and B197. In addition, the reconstructed ^3H plots show that some wells are a mixture of old and young groundwater.

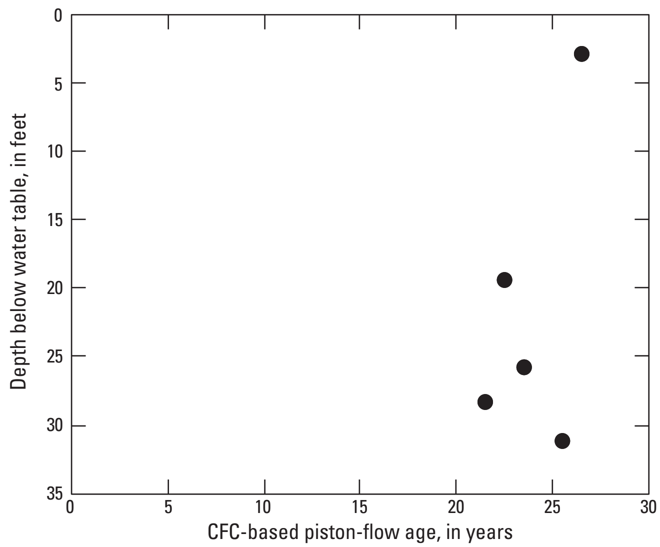

Figure B189. CFC-based age gradient for dated sites from the LUSCR2 and LUSCR3 networks, USNK Study Unit.

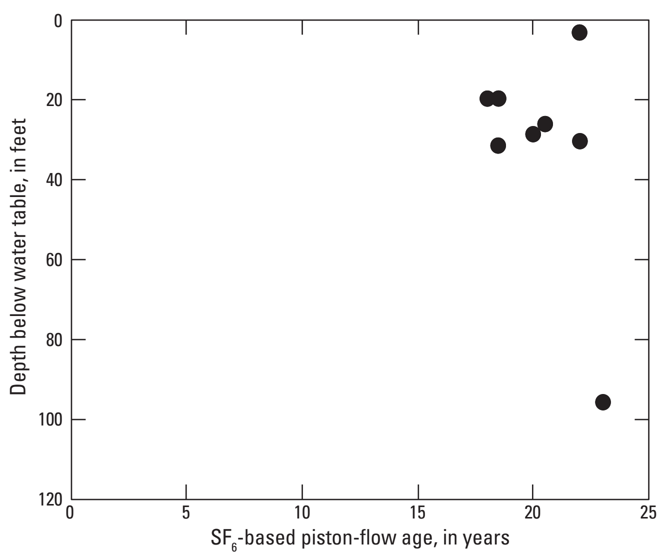

Figure B190. SF_6-based age gradient for dated sites from the LUSCR2 and LUSCR3 networks, USNK Study Unit.

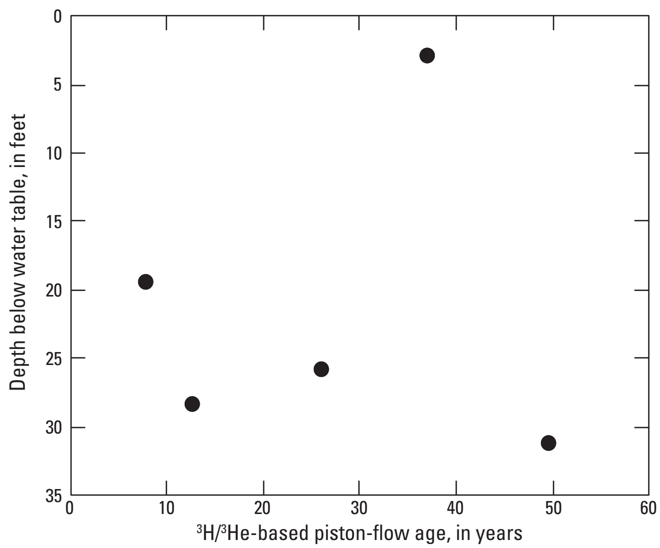

Figure B191. $^3H/^3He$-based age gradient for dated sites from the LUSCR2 and LUSCR3 networks, USNK Study Unit.

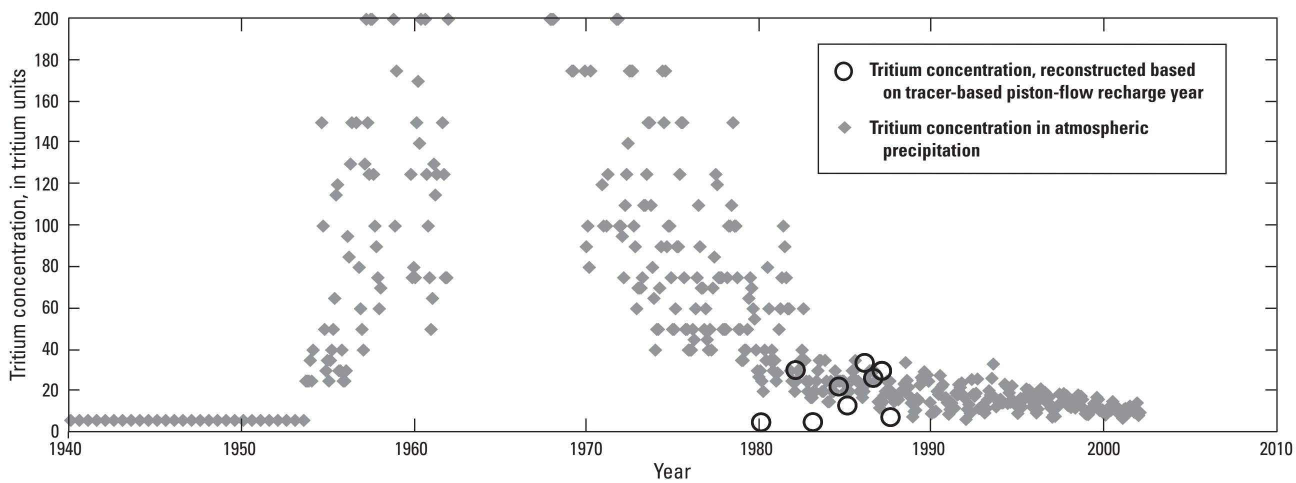

Figure B192. Reconstructed tritium concentrations (using CFC-based ages) and tritium in atmospheric precipitation, LUSCR2 and LUSCR3 networks, USNK Study Unit.

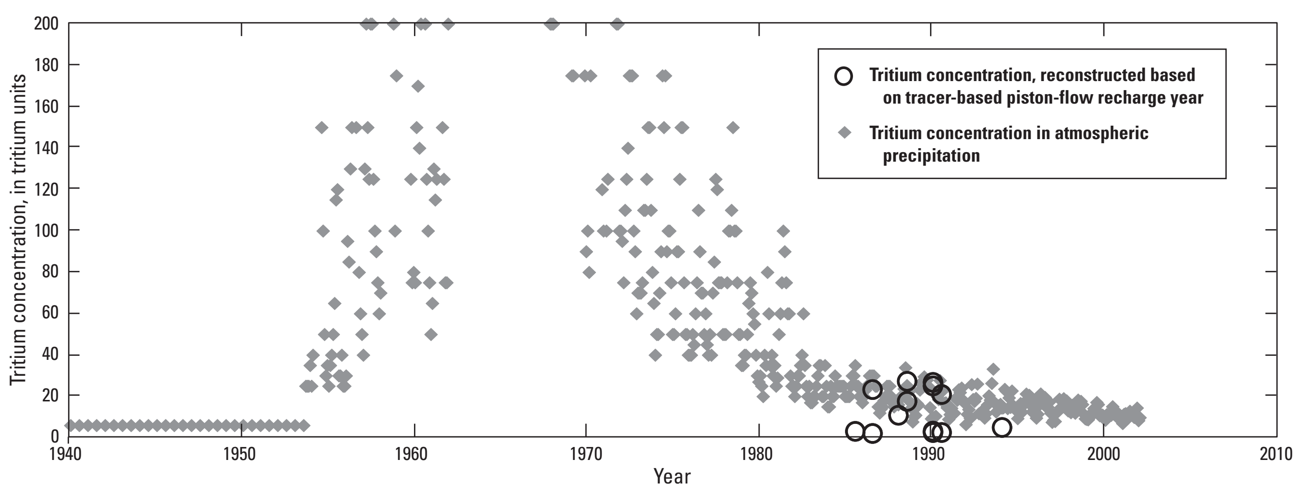

Figure B193. Reconstructed tritium concentrations (using SF_6-based ages) and tritium in atmospheric precipitation, LUSCR2 and LUSCR3 networks, USNK Study Unit.

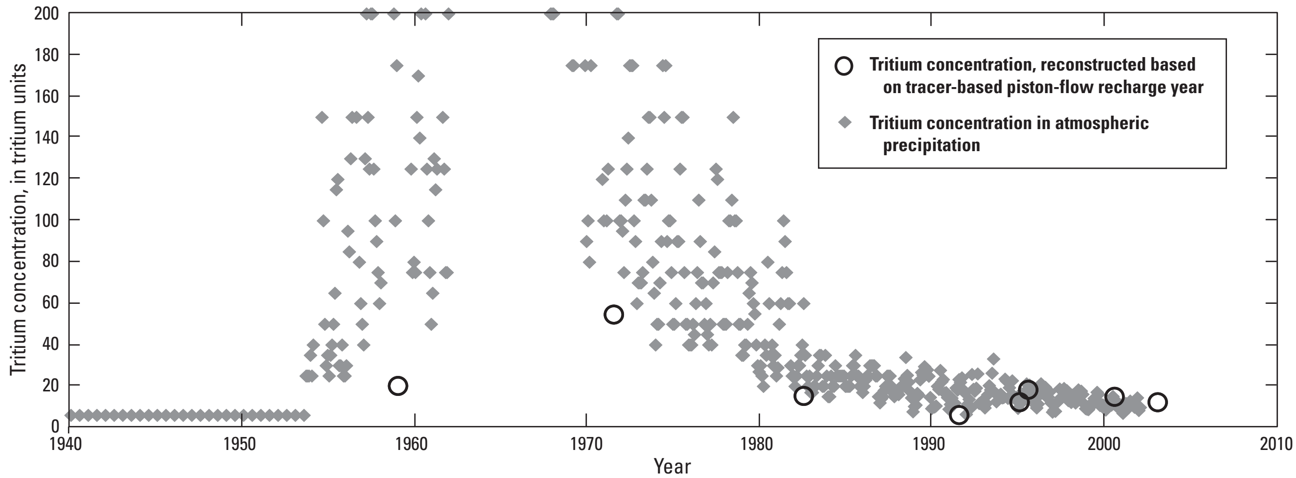

Figure B194. Reconstructed tritium concentrations (using $^3H/^3He$-based ages) and tritium in atmospheric precipitation, LUSCR2 and LUSCR3 networks, USNK Study Unit.

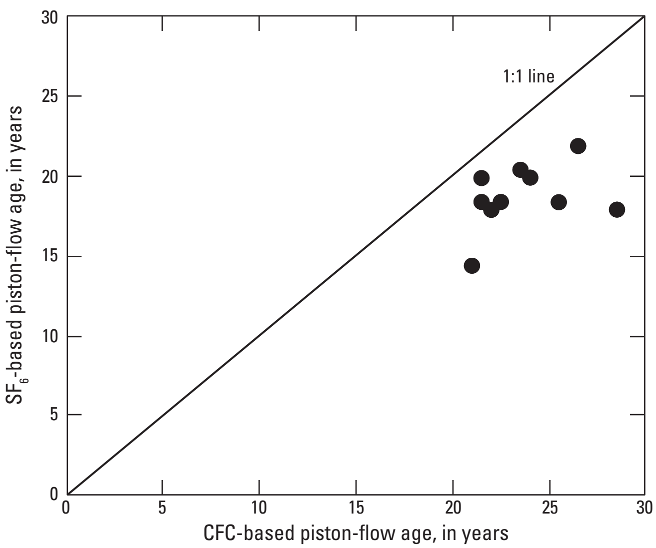

Figure B195. SF_6- versus CFC-based age comparison, LUSCR2 and LUSCR3 networks, USNK Study Unit.

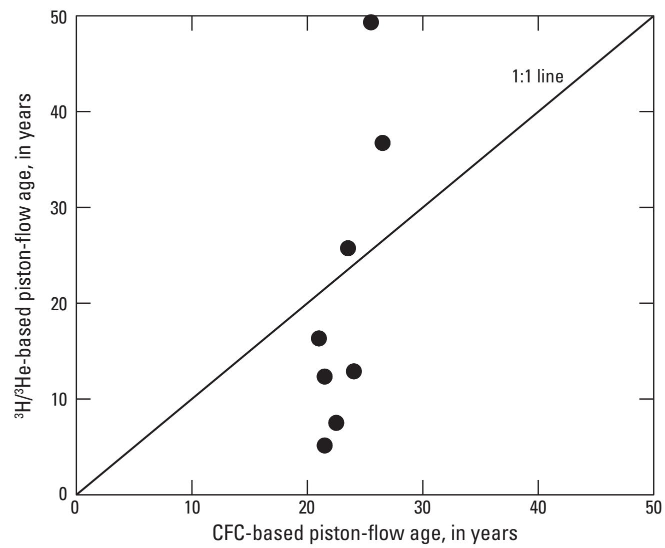

Figure B196. $^3H/^3He$- versus CFC-based age comparison, LUSCR2 and LUSCR3 networks, USNK Study Unit.

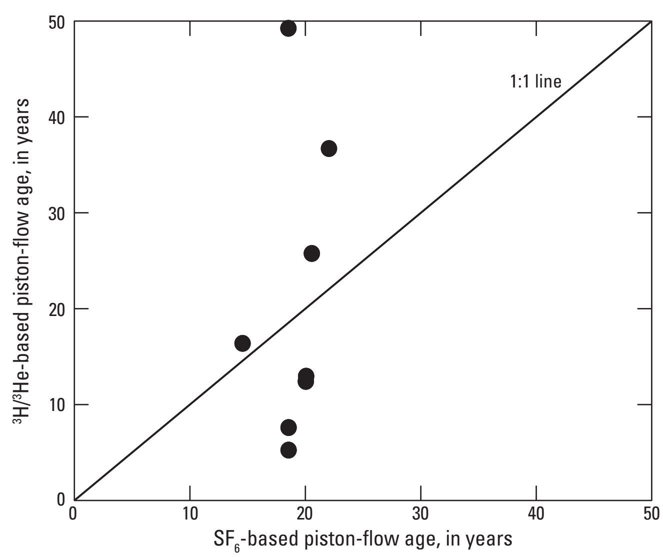

Figure B197. $^3H/^3He$- versus SF_6-based age comparison, LUSCR2 and LUSCR3 networks, USNK Study Unit.

WMIC REFFO1

Samples from seven sites in the WMIC Study Unit were collected in 2007 for CFCs (networks and, in parentheses, number of sites):

- REFFO1 (CFCs, 2)

The aquifer is composed of sand, gravel, and clay.

Major dissolved-gas data were available for seven sites. Of these seven sites, six were oxic and one was suboxic, but recharge temperatures unreasonably high.

Age interpretations from tracer concentrations were made assuming that recharge elevation was equal to the elevation of the water table, that recharge temperature was equal to the mean annual air temperature +1°C, and that excess air concentrations were 2 cc STP/kg.

The raw tracer data, major dissolved-gas data, the ancillary chemical and well construction data that were used in the interpretations, and the piston-flow ages are presented in table B57.

- Advantages associated with these samples:
  - CFCs, as well as major dissolved gases.
  - Monitoring wells, therefore low pumping stress.
  - Relatively short open intervals of 5 feet so mixing likely minimized.
  - Median penetration of center of open interval into water table was 14.78 feet (sampling close to the water table, potentially minimizing mixing).
- Depth to water (can affect tracer transport to water table):
  - Median: 18.78 feet
  - Mean: 25.75 feet
  - Min: 12.51 feet
  - Max: 50.72 feet
- Brief analysis:
  - Only two sites were sampled for CFCs in this network, and there were no tritium data, therefore no plots were created. The deeper sample is older than the shallower sample, but with only two points, it is difficult to determine the age structure of the aquifer.