Sodium Tetrathiocarbonate Summary Document: Registration Review

December 2007

Sodium Tetrathiocarbonate Summary Document
Registration Review: Initial Docket
December 2007

Case Number: 7009

Approved by: ____________________
Steven Bradbury, Ph.D.
Director
Special Review and Reregistration Division

Date: 12/12/07

TABLE OF CONTENTS

I. PRELIMINARY WORK PLAN

Introduction:
The Food Quality Protection Act of 1996 mandated a new program: registration review. All pesticides distributed or sold in the United States generally must be registered by EPA, based on scientific data showing that they will not cause unreasonable risks to human health, workers, or the environment when used as directed on product labeling. The new registration review program is intended to make sure that, as the ability to assess risk evolves and as policies and practices change, all registered pesticides continue to meet the statutory standard of no unreasonable adverse effects. Changes in science, public policy, and pesticide use practices will occur over time. Through the new registration review program, the Agency periodically reevaluates pesticides to make sure that as change occurs, products in the marketplace can be used safely. Information on this program is provided at: http://www.epa.gov/oppsrrd1/registration_review/.

The Agency has begun to implement the new registration review program and will review each registered pesticide every 15 years to determine whether it continues to meet the FIFRA standard for registration. The public phase of registration review begins when the initial docket is opened for each case. The docket is the Agency's opportunity to state clearly what it knows about the pesticide and what additional risk analyses and data or information it believes are needed to make a registration review decision. After reviewing and responding to comments and data received in the docket during this initial comment period, the Agency will develop and commit to a Final Work Plan and schedule for the registration review of sodium tetrathiocarbonate.

Sodium tetrathiocarbonate (Na_2Cs_4) is a soil fumigant which acts as a fungicide, insecticide, and nematicide. Sodium tetrathiocarbonate degrades to carbon disulfide (CS_2), hydrogen sulfide (H_2S), sodium hydrazide, and elemental sulfur upon contact with water. CS_2 (PC code 016401) is the major biologically active degradate. Tolerances are established for CS_2 from the application of sodium tetrathiocarbonate. CS_2 from the application of sodium tetrathiocarbonate is the residue of concern for risk assessment.

Sodium tetrathiocarbonate is registered for pre-plant and post-plant soil applications on almonds, grapes, lemons, oranges, peaches, prunes, and plums. It provides control of soil nematodes (e.g., ring, root-knot), diseases (e.g., phytophthora, armillaria) and insects (e.g., grape phylloxera). It cannot be used in greenhouses and other enclosed areas. There are no registered residential uses. Sodium tetrathiocarbonate is currently labeled for use only in Arizona, California, Oregon, and Washington.

Anticipated Risk Assessment and Data Needs:
The Agency will conduct a comprehensive ecological risk assessment, including an endangered species assessment, for the registered uses of sodium tetrathiocarbonate. Human health occupational and residential bystander risk assessments will also be

needed for the registered uses of sodium tetrathiocarbonate. The Agency also anticipates conducting a drinking water risk assessment for groundwater.

Ecological Risk:

- The environmental fate database for sodium tetrathiocarbonate is largely complete. Fate data requirements have been satisfied with data from sodium, calcium, or potassium tetrathiocarbonate. Physical and chemical properties are available from open literature sources.

- There are gaps and uncertainties in the ecological effects database for sodium tetrathiocarbonate. The following data on freshwater fish and invertebrates, terrestrial plants, and honeybees will be required to complete the ecological assessment and will be issued in a data call-in (DCI) during the registration review process:
  - Early life stage freshwater-fish (850.1400)
  - Freshwater invertebrate lifecycle toxicity (850.1300)
  - Tier I vegetative vigor (850.4150)
  - Tier I seedling emergence (850.4100)
  - Acute oral or contact honeybees (850.3020)

- The planned ecological risk assessment will allow the Agency to determine if sodium tetrathiocarbonate's use has "no effect" on federally listed threatened or endangered species (listed species) or their designated critical habitat. If the screening level assessment indicates that sodium tetrathiocarbonate "may affect" a listed species or its designated critical habitat, the assessment will be refined. The refined assessment will allow the Agency to determine whether use of sodium tetrathiocarbonate is "likely to adversely affect" the species or critical habitat or "not likely to adversely affect" the species or critical habitat. When an assessment concludes that a pesticide's use "may affect" a listed species or its designated critical habitat, the Agency will consult with the U.S. Fish and Wildlife Service and/or National Marine Fisheries Service (Services), as appropriate.

Human Health Risk:

- Human health risk assessments for agricultural workers and handlers and residential bystanders potentially exposed to CS_2 as a result of agricultural uses of sodium tetrathiocarbonate will need to be updated to reflect current policy and practice for soil fumigants.

- The Agency anticipates needing the following study to complete the bystander assessment for CS_2 as a result of agricultural uses of sodium tetrathiocarbonate:
  - Special study to determine the flux rate of the compound off-site

- The Agency will also review and consider the available literature on toxicity and exposure, air monitoring databases developed by the California Air Resources Board (CARB), and other information available on CS_2 prior to issuing the Final Work Plan.

- Dietary assessments were not conducted in the past because in food CS_2 residues from application of sodium tetrathiocarbonate were considered "de minimus" meaning that residues were not detected at levels above natural background.

- Although dietary risk from food is not a concern, tolerances for CS_2 from application of sodium tetrathiocarbonate will need to be re-evaluated since the existing tolerances were established based on exaggerated application rates.

- The Agency anticipates conducting a drinking water assessment for groundwater.

- If a drinking water assessment indicates potential exposures to CS_2 as a result of agricultural uses of sodium tetrathiocarbonate, an aggregate risk assessment combining potential residential bystander exposures with dietary and drinking water exposures will be needed.

Timeline:
EPA has created the following estimated timeline for the completion of the sodium tetrathiocarbonate registration review.

Sodium Tetrathiocarbonate – Projected Registration Review Timeline	
Activities	**Estimated Year/Month**
Phase 1: Opening the docket	
Open Public Comment Period	2007 – Dec.
Close Public Comment Period	2008 – Mar.
Phase 2: Case Development	
Develop Final Work Plan (FWP)	2008 – Apr.-Jun.
Issue DCI	2009 – Jan.-Mar
Data Submission	2011 – Jan.-Mar.
Preliminary Risk Assessment and Public Comment	2012 – Jul.-Sep.
Close Public Comment Period	2012 – Oct.-Dec.
Phase 3: Registration Review Decision	
Proposed Registration Review Decision	2013 – Jan.-Mar.
Public Comment Period	2013 – Apr.-Jun.
Final Registration Review Decision and Begin Post-Decision Follow-up	2013 – Jul.-Sep.
Total (years)	6

Guidance for Commenters:
The public is invited to comment on EPA's preliminary registration review work plan and rationale. The Agency will carefully consider all comments as well as any additional

information or data provided prior to issuing a Final Work Plan for the sodium tetrathiocarbonate case.

- Through the registration review process, the Agency intends to solicit information on trade irritants and, to the extent feasible, take steps toward facilitating irritant resolution. Growers and other stakeholders are asked to comment on any trade irritant issues resulting from lack of Maximum Residue Limits (MRLs) or disparities between U.S. tolerances and MRLs in key export markets, providing as much specificity as possible regarding the nature of the concern. See page 43 of Section IV, Human Health Effects Scoping Document, for a listing of U.S. tolerances.

- Sodium tetrathiocarbonate is not identified as a cause of impairment for any waterbodies listed as impaired under section 303(d) of the Clean Water Act, based on information provided at http://oaspub.epa.gov/tmdl/waters_list.impairments?p_impid=3. The Agency invites submission of water quality data for this pesticide. To the extent possible, data should conform to the quality standards in Appendix A of the "OPP Standard Operating Procedure: Inclusion of Impaired Water Body and Other Water Quality Data in OPP's Registration Review Risk Assessment and Management Process" (see: http://www.epa.gov/oppfead1/cb/ppdc/2006/november06/session1-sop.pdf), to ensure they can be used quantitatively or qualitatively in pesticide risk assessments.

- EPA seeks to achieve environmental justice, the fair treatment and meaningful involvement of all people, regardless of race, color, national origin, or income, in the development, implementation, and enforcement of environmental laws, regulations, and policies. To help address potential environmental justice issues, the Agency seeks information on any groups or segments of the population who, as a result of their location, cultural practices, or other factors, may have atypical, unusually high exposure to sodium tetrathiocarbonate, compared to the general population. Please comment if you are aware of any such sub-populations.

Stakeholders are also specifically asked to provide information and data that will assist the Agency in refining the ecological risk assessment, including any species-specific effects determinations.

The Agency is interested in the following information regarding the use of sodium tetrathiocarbonate:

1. confirmation on the following label information
    a. sites of application
    b. formulations
    c. application methods and equipment
    d. maximum application rates

   e. frequency of application, application intervals, and maximum number of applications per season
   f. geographic limitations on use
2. use or potential use distribution (e.g., acreage and geographical distribution of relevant crops)
3. use history
4. median and 90th percentile reported use rates (lbs ai/acre) from usage data – national, state, and county
5. application timing (date of first application and application intervals) by crop – national, state, and county
6. sub-county crop location data
7. usage/use information for non-agricultural uses (e.g., forestry, residential)
8. directly acquired county-level usage data (not derived from state level data)
   a. maximum reported use rate (lbs ai/acre) from usage data – county
   b. percent crop treated – county
   c. median and 90th percentile number of applications – county
   d. total pounds per year – county
   e. the year the pesticide was last used in the county/sub-county area
   f. the years in which the pesticide was applied in the county/sub-county area
9. typical interval (days)
10. state or local use restrictions
11. ecological incidents (non-target plant damage and avian, fish, reptilian, amphibian and mammalian mortalities) not already reported to the Agency
12. monitoring data

Next Steps:

After the comment period closes, the Agency will prepare a Final Work Plan for this pesticide.

II. FACT SHEET

Background Information:

- Sodium tetrathiocarbonate [Carbono(dithioperoxo)dithioic acid, disodium salt] registration review case number: 7009.
- Sodium tetrathiocarbonate: PC Code: 128904; CAS#: 7345-69-9.
- The major biologically active degradate, carbon disulfide (CS_2), is also considered in the sodium tetrathiocarbonate registration review case.
- Carbon disulfide (CS_2): PC Code: 016401; CAS# 75-15-0.
- Technical registrant: Arysta LifesSciences North America Corp.
- Not subject to reregistration; thus, no Reregistration Eligibility Decision (RED) is available.
- Tolerances were reassessed under FQPA to include a new use May 16, 1997 (62 FR 26946) (FRL – 5716-8).
- Currently, there are two active Section 3 registrations: 66330-63 (ETK-1101) and 66330-69 (ENZONE).
- Labeled for use only in Arizona, California, Oregon, and Washington.
- Currently, there are no active Section 24c registrations.
- Special Review and Reregistration Division Chemical Review Manager (CRM): Katherine St. Clair (stclair.katherine@epa.gov).
- Registration Division Product Contacts: Tawanda Spears (spears.tawanda@epa.gov) and/or Cynthia Giles-Parker (giles-parker.cynthia@epa.gov).

Use & Usage Information:

For additional details on label rates and allowed uses, please refer to the BEAD Appendix A document in the Sodium tetrathiocarbonate docket.

- Sodium tetrathiocarbonate is fumigant pesticide which acts as a fungicide, nematicide, and insecticide.
- It is registered for pre-plant and post-plant soil applications on almonds, grapes, lemons, oranges, peaches, prunes, and plums.
- It is used to control soil nematodes (e.g., ring, root-knot), diseases (e.g., phytophthora, armillaria) and insects (e.g., grape phylloxera).
- The pesticidal mode of action of sodium tetrathiocarbonate and carbon disulfide is unknown.
- Sodium tetrathiocarbonate is formulated as an aqueous solution that breaks down in the soil to CS_2 gas, the major biologically active degradate.
- Sodium tetrathiocarbonate may be applied through ground injection equipment or may be metered into irrigation water used for low-volume irrigation (chemigation) or flood and furrow irrigation.
- Sodium tetrathiocarbonate cannot be used in greenhouses and other enclosed areas.

- There are no residential uses.
- Approximately 700,000 pounds of sodium tetrathiocarbonate are used annually (lbs a.i./yr.).
- Nearly 90% (600,000 lbs a.i./yr.) of sodium tetrathiocarbonate usage is on grapes; almonds is the crop with the next highest usage at approximately 6% (40,000 lbs a.i./yr.).

Recent Actions:

- A request to expand use directions, add restrictions, and add Florida to EPA reg# 66330-63 was denied in February 2003 due to data and label deficiencies.

Ecological Risk Assessment Status:

Please refer to Section III of this document, Ecological Risk Assessment Problem Formulation, for a detailed discussion of the anticipated ecological risk assessment needs. The following is a summary of these anticipated needs:

- The most recent ecological risk assessment for sodium tetrathiocarbonate was conducted in 1995 for proposed new uses on almonds, peaches, and prunes. The 1995 ecological risk assessment concluded that labeled use of sodium tetrathiocarbonate was not expected to pose acute or chronic risk to non-target avian, mammalian, fish, aquatic invertebrate, or plant species. However, some of the risks were assessed qualitatively (i.e., aquatic exposures were not quantitatively estimated), and the potential risks to some receptors (terrestrial plants and terrestrial invertebrates) were not assessed.

- An additional uncertainty is the potential for exposure to aquatic organisms through release of treated tailwater. Labels state that "tailwater must not be allowed to leave the treated field," but no details, such as trapping methods or holding times, are included. The possibility remains, then, that different interpretations of this requirement by users could lead to surface water exposure.

- The environmental fate database for sodium tetrathiocarbonate is largely complete. Fate data requirements have been satisfied with data from sodium, calcium, or potassium tetrathiocarbonate. Physical and chemical properties are available from open literature sources.

- There are gaps and uncertainties in the ecological effects database for sodium tetrathiocarbonate. Data on freshwater fish and invertebrates, terrestrial plants, and honeybees will be required to complete the ecological assessment and will be issued in a data call-in (DCI) during the registration review process.

- The Agency plans to conduct a comprehensive ecological risk assessment, including an endangered species assessment, for the registered uses of sodium tetrathiocarbonate.

Human Health Risk Assessment Status:
Please refer to Section IV of this document, Human Health Effects Scoping Document, for a detailed discussion of the anticipated risk assessment needs for human health. The following is a summary of these anticipated needs:

Dietary (Food and Water):
- Dietary assessments were not conducted in the past because in food CS_2 residues from application of sodium tetrathiocarbonate were considered "de minimus" meaning that residues were not detected at levels above natural background.
- Although dietary risk from food is not a concern, tolerances for CS_2 from application of sodium tetrathiocarbonate will need to be re-evaluated since the existing tolerances were established based on exaggerated application rates.
- The Agency anticipates conducting a drinking water assessment for groundwater.

Residential:
- There are no residential uses for sodium tetrathiocarbonate. However, there is potential for residential bystander exposure to CS_2 as a result of agricultural uses of sodium tetrathiocarbonate.
- Human health risk assessments for residential bystanders potentially exposed to CS_2 as a result of agricultural uses of sodium tetrathiocarbonate will need to be updated to reflect current policy and practice for soil fumigants.

Occupational:
- Human health risk assessments for agricultural workers and handlers potentially exposed to CS_2 as a result of agricultural uses of sodium tetrathiocarbonate will need to be updated to reflect current policy and practice for soil fumigants.

Aggregate:
- If a drinking water assessment indicates potential exposures to CS_2 as a result of agricultural uses of sodium tetrathiocarbonate, an aggregate risk assessment combining potential residential bystander exposures with dietary and drinking water exposures will be needed.

Overall:
- The Agency anticipates needing a "flux" study in order to complete a risk assessment of occupational and residential bystander exposure to CS_2 as a result of agricultural uses of sodium tetrathiocarbonate and for use in setting appropriate buffer zones to mitigate off-site exposure.

- The Agency will review and consider the available literature on toxicity and exposure, air monitoring databases developed by the California Air Resources Board (CARB), and other information available on CS_2 prior to issuing the Final Work Plan.

Incident Reports:

- Three data bases were searched for incidents reports on sodium tetrathiocarbonate: Poison Control Center (PCC) Data, NIOSH SENSOR, and the Incidents Data System. No incidents for sodium tetrathiocarbonate were reported in the PCC during the period 1993 through 2005 or the Incident Data System from 1999 to the present. NIOSH SENSOR reported 2 cases of sodium tetrathiocarbonate poisonings. Both incidents occurred in California with one in 1999 and one in 2001. A more detailed summary is provided in the scoping document for registration review located in the docket.

Tolerances:

U.S. tolerances are listed under 40 CFR 180.467. Tolerances are established for the nematicide, insecticide, and fungicide CS_2 from the application of sodium tetrathiocarbonate. No MRLs for sodium tetrathiocarbonate have been established or proposed by Codex for any agricultural commodities. There are no Canadian or Mexican tolerances for carbon disulfide.

Data Call-In Status:

A DCI has not been issued for sodium tetrathiocarbonate.

Labels:

A list of registration numbers is included below and the labels can then be obtained from the Pesticide Product Label System (PPLS) website:
http://oaspub.epa.gov/pestlabl/ppls.home.
These labels were transferred from Entek Corp. to Arysta LifeScience North America Corp. and the labels are available under their previous EPA registration numbers, 68891-9 for 66330-63 and 68891-2 for 66330-69.

Registration Number	Product Name	Company	% Active Ingredient
66330-63	ETK-1101	Arysta LifeScience North America Corporation	53
66330-69	ENZONE	Arysta LifeScience North America Corporation	31.8

III. ECOLOGICAL RISK ASSESSMENT PROBLEM FORMULATION

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C., 20460

OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

PC Code: 128904, 016401
DP Barcode: D343837

MEMORANDUM

Subject: Sodium Tetrathiocarbonate Registration Review: Ecological Risk Assessment Problem Formulation

To: Katherine St. Clair, Chemical Review Manager
Special Review and Registration Division (7508P)

From: Keara Moore, Chemist
Colleen Flaherty, Biologist
Environmental Risk Branch 3
Environmental Fate and Effects Division (7507P)

Thru: Tom Bailey, Branch Chief
Environmental Risk Branch 3
Environmental Fate and Effects Division (7507P)

Date: 22 October 2007

Attached is the Environmental Fate and Effects Division's (EFED) problem formulation document in support of the sodium tetrathiocarbonate (PC code 128904) registration review docket opening. The major degradate and pesticide active agent, carbon disulfide (PC code 016401), is also considered in this problem formulation. This memorandum outlines (1) the methods that will likely be used in the ecological risk assessment, (2) anticipated ecological risk conclusions, (3) uncertainties and data gaps, and (4) additional data needs.

It should be noted that for several of the outstanding issues identified in this analysis, conclusions and data needs could be amended depending on decisions made within the Office of Pesticide Programs. One area of concern is the potential for drinking water exposure through groundwater. Because human health advisory levels for carbon disulfide have not been set, risk cannot be precluded. The value of additional data for estimating groundwater exposure could depend on the levels of concern. Previous labels have required well setbacks to minimize risk from this uncertainty, but it appears that current labels do not include these requirements.

An additional uncertainty is the potential for exposure to aquatic organisms through release of treated tailwater. Labels state that "tailwater must not be allowed to leave the treated field," but no details, such as trapping methods or holding times, are included. The possibility remains, then, that different interpretations of this requirement by users could lead to surface water exposure.

1. PRELIMINARY PROBLEM FORMULATION

The purpose of problem formulation is to provide the foundation for the ecological risk assessment to be conducted for sodium tetrathiocarbonate. It sets the objectives for the risk assessment, evaluates the nature of the problem, and provides a plan for analyzing the data and characterizing the risk (US EPA, 1998).

1.1 Nature of Regulatory Action

The registration for sodium tetrathiocarbonate is being reviewed under the Registration Review program mandated by the Federal Insecticide, Fungicide, and Rodenticide Act in order to determine whether it continues to meet the statutory standard for registration.

The current analysis is based on the original new chemical assessment, the most recent new use and drinking water assessments, and an early fate review which includes the most complete discussion of available field studies:

- Review of lysimeter and groundwater monitoring studies (7/27/1988, P. Holden)
- Section 3 New Chemical Risk Assessment of proposed uses on grapes, citrus, orchards, and potatoes (Eco: 9/20/88, J. Ackerman; Fate: 5/16/89, E. Regelman)
- Section 3 New Use Risk Assessment of proposed uses on almonds, peaches, and prunes (Eco: 5/4/1995, DP Barcode D213559; Fate: 7/9/1996, DP Barcodes D220367, D223296)
- Drinking Water Assessment for proposed new use on citrus in Florida (3/19/02, A. Clem)

Additional ecological toxicity studies (MRIDs 46423901, -02, -03, -04) have been submitted and will be formally reviewed during the risk assessment process.

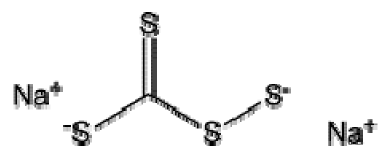
1.2 Stressor Source and Distribution

1.2.1 Nature of the Chemical Stressor

Sodium tetrathiocarbonate (Na_2CS_4) is a fumigant which acts as a fungicide and nematicide. Sodium tetrathiocarbonate has two soluble concentrate formulations, EnZone® (3.4 lb a.i./gal, 31.8% a.i., Reg No. 68891-2) and ETK-1101® (6.8 lb a.i./gal, 53% a.i., Reg. No. 68891-9). Upon mixing with water, Na_2CS_4 converts readily to carbon disulfide (CS_2), the compound that is actually responsible for pesticidal activity.

The pesticidal mode of action of carbon disulfide is unknown. Chemical identification information and physical and chemical properties of these compounds are presented in Table 1.

Table 1. Nature of the Chemical Stressor

Common name	**Sodium tetrathiocarbonate** (*parent chemical*)	**Carbon disulfide** (*major degradate*)
Chemical name	Carbono(dithioperoxo)dithioic acid, disodium salt	Carbon disulfide
Pesticide type	fungicide, nematicide	fungicide, nematicide
CAS number	7345-69-9	75-15-0
PC Code	128904	016401
Empirical formula	Na_2CS_4	CS_2
Chemical Structure		S = C = S
Molecular Mass (g/mol)	186.2	76.1
Vapor pressure (mm Hg)	4E-10 [a,b]	359 [a]
Henry's Law Constant (atm-m^3/mol)	--	0.014 [a]
Solubility in water (g/L)	1E6 [a,b]	1180 [a]
Log K_{ow}	-4.68 [a,b]	1.94 [a]

[a] From the SRC Physical Properties database (http://www.syrres.com/esc/physdemo.htm, accessed 9/07).
[b] Estimated rather than experimental value.

1.2.2 Overview of Pesticide Usage

1.2.2.1 Labeled Uses and Application Rates

Sodium tetrathiocarbonate is a fumigant used on grapes, some citrus crops (oranges, grapefruit, lemons) and some orchard crops (almonds, peaches, prunes, and plums). It is currently only labeled for use in Arizona, California, Oregon, and Washington.

In crops established for one year or more and in preplant sites, sodium tetrathiocarbonate is used to control nematodes in all labeled crops and to control phytophthera root rot in all crops except grapes. It is also used to control oak root fungus in all crops, although for grapes and citrus crops, it can only be used in preplant sites. In grapes, sodium tetrathiocarbonate is also used to control phylloxera. Sodium tetrathiocarbonate cannot be used in greenhouses and other enclosed areas.

Sodium tetrathiocarbonate is applied through ground injection or through chemigation, where the active ingredient is metered into water used for low-volume irrigation or flood and furrow irrigation. Low-volume irrigation systems allowed by the label include drip, drip-tape, strip tubing, foggers, jets, misters, and mini-sprinklers, with limits specified for pressure and flow rates of the equipment. Ground injection is to a depth of six to nine inches and is only used for established crops. Applications to established orchard crops, citrus crops, and grapes can generally be made through the entire growing season. Preplant applications can be made one to four weeks before planting.

The label directs application by specific procedures designed for rapid penetration and uniform coverage: 1) prior to application, the soil is to be brought to near, but less than, field moisture capacity; 2) chemigation is continuously metered for up to 12 hours to attain the necessary application rate; 3) finally, the soil is "sealed" by slowly flushing lines and emitters for up to 4 hours with sufficient clean water to attain field moisture capacity. Chemigation water concentrations are required to be maintained at minimum levels of 250 to 2400 ppm, depending on the use. The labels direct that "tailwater must not be allowed to leave the treated field" but no holding times or other specific instructions are included.

The maximum annual application rate for sodium tetrathiocarbonate is 340 lb a.i./A (139 lb CS_2/A). For ground injection, it is applied in one to three applications with maximum single application rates of up to 170 lb a.i./A (69 lb CS_2/A) and minimum application intervals of 30 days. For most low-volume or flood and furrow applications, sodium tetrathiocarbonate is applied in one to six applications with maximum single application rates of 102 to 204 lbs a.i./A (42 to 84 lb CS_2/A), depending on the use. For preplant use in citrus and orchard crops, though, it can be applied as a single application at 340 lbs a.i./A. For flood and furrow irrigation, the minimum application interval is 30 days, while for low-volume irrigation, the application interval can be up to 21 days with no minimum specified.

1.2.2.2 Use Characterization

The Screening Level Usage Analysis (SLUA) report prepared by the Biological and Economics Analysis Division (5/29/07) indicates a national use of sodium tetrathiocarbonate of approximately 674,000 lbs a.i./yr. Nearly 90% of this use (600,000 lbs) is on grapes, with almonds being the next highest use at 6% (40,000 lbs). Other uses of sodium tetrathiocarbonate include peaches, prunes and plums, lemons, oranges, nectarines, pecans, and cherries. These estimates are based on data from USDA-NASS, private market research from 2000 to 2006, the 2000 National Pesticide Use Database, and California Department of Pesticide Regulation (CDPR) data.

Annual data specific to California are available from the Pesticide Use Reports compiled by CDPR. In 2005, approximately 330,000 lbs of sodium tetrathiocarbonate were applied to 8,000 acres in California. The primary use that year was on grapes (table, raisin, and wine), which accounted for 227,000 lbs. Also in 2005, about 90,000 lbs of sodium tetrathiocarbonate were used on almonds; this is a dramatic increase in usage on this crop since less than 5,000 lbs were used annually on almonds between 2000 and 2004. Total sodium tetrathiocarbonate use in California has been dropping since 2000, when approximately 600,000 lbs were used (Source: http://calpip.cdpr.ca.gov/cfdocs/calpip/prod/main.cfm, accessed 9/07).

1.2.3 Environmental Fate and Transport Summary

The environmental fate database for sodium tetrathiocarbonate (Na_2CS_4) is largely complete. Fate studies show that Na_2CS_4 degrades rapidly in water (half-lives on the order of several hours to one day) through hydrolysis and photolysis. Carbon disulfide (CS_2) is the active agent released through hydrolysis in water. CS_2 has a high vapor pressure and a high Henry's Law constant, physical properties favorable for volatilization. CS_2 diffuses rapidly through soil air, initially moving downward through the soil profile, followed by diffusion upwards and volatilization to the atmosphere. In aerobic soil environments, CS_2 is oxidized to sulfates through biological degradation (half-lives ranging from 3-27 days). Field studies show that contamination of CS_2 in ground water may occur under normal uses of sodium tetrathiocarbonate. The observed contamination was short-lived, but these studies did not represent worst case conditions. Air monitoring shows half-lives of hours to several days for dissipation of CS_2 in air from ground level to five feet about the surface.

1.2.3.1 Environmental Fate Assessment

Some of the available fate studies tested the calcium or potassium salts of tetrathiocarbonate rather than the sodium salt. Data from sodium, calcium, and potassium tetrathiocarbonate are considered to be equivalent for the purposes of this discussion. Aqueous solutions of the salts are essentially totally ionized and the character of the solution is dominated by the common anion, CS_4^{2-}, so the nature of the cation has little direct effect on the properties of the product (11/20/86, E. Regelman).

When Na_2CS_4 is mixed with water, it hydrolyzes rapidly to the volatile degradate CS_2 at rates dependant on concentration and pH. Below pH 7, hydrolysis is essentially immediate, with rates limited only by the rate of mass transfer of CS_2 out of solution. At a higher pH, hydrolysis is slower, with half-lives from 3 hours to 1 day (MRID 40375114). Aquatic photolysis of Na_2CS_4 can also contribute to the formation of CS_2, with thiosulfate ($S_2O_3^-$) as another major degradate. The photolysis half-life at pH 9 was 3.8 hours; at lower pHs, hydrolysis is too rapid for measurement of photolysis rates (MRIDs 43817201, 40437401).

Other products of these reactions include sodium hydroxide (NaOH), sulfur (S), and hydrogen sulfide (H_2S). The environmental chemistry of these sulfur species is complex and highly dependent on local conditions. In aerobic conditions, sulfate (SO_4^{2-}) and carbon dioxide (CO_2) tend to be the ultimate products and in anaerobic conditions, degradates can remain as generated or be reduced to lower oxidation states. All of these species can be present naturally and are also generated from common agricultural fertilizers. CS_2 is the only substance produced in disproportionate environmental concentrations that also may be of toxicological concern (3/19/02, A. Clem).

The major degradate CS_2, the active pesticide agent, is a gas with a high vapor pressure (359 mm Hg) and a high Henry's Law constant (0.014 atm-m^3/mol), so rapid volatilization is likely[1]. CS_2 is subject to aerobic soil metabolism with half-lives of 3 to 25 days, leading to sulfate and carbon dioxide as end products (MRID 00152990). Aerobic soil metabolism studies were conducted in closed systems and so do not include dissipation by volatilization. CS_2 is not metabolized in anaerobic soil environments (MRID 40375115). Because of the rapid volatilization of CS_2, its adsorption to soil cannot be measured and is not expected to affect its environmental fate (MRID 00152991). No laboratory studies of the air or soil photolysis of CS_2 are available, although based on its known chemistry, carbon disulfide is expected to undergo photochemical reactions to yield carbonyl sulfide (COS), sulfur dioxide (SO_2) and carbon monoxide (CO) (5/16/89, E. Regelman).

1.2.3.2 Environmental Transport Assessment

The labeled application methods are designed to distribute Na_2CS_4 below the soil surface, either through ground injection to a depth of 6 to 9 inches or by application in irrigation water to soils near field capacity, followed by "sealing" with additional irrigation water. The irrigation methods used for application of Na_2CS_4 are not expected to result in spray drift. Ground injection and chemigation through drip, drip-tape or strip tubing systems or through flood and furrow irrigation do not have an opportunity for drift. Other low-volume irrigation systems including foggers, jets, misters, and mini-sprinklers are permitted but labels include equipment specifications for pressure and flow rates designed to prevent drift. Drift is therefore not considered here as a likely route for aquatic or terrestrial exposure.

The labeled application methods also have relatively low runoff potential. Na_2CS_4 labels specify that following application, fields should not be irrigated to the point of runoff (Reg Nos. 68891-2 and 68891-9), although runoff could still be possible in a situation where rainfall occurs right after application. The pathway leading to the greatest potential concentrations of carbon disulfide in surface water would be release of tailwater from flood and furrow application methods. Labels require that treated tailwater be trapped and not allowed to leave the field, but no specifications for implementation of this requirement, such as holding times or trapping methods, are included. Different interpretations of this requirement by users could therefore lead to surface water exposure.

The high vapor pressure and Henry's Law constant of CS_2 suggest that it will volatilize rapidly from surface water, but available aquatic studies show contradictory results and rates cannot be quantified based on the available information. Measurements taken in concurrence with hydrolysis studies found that, at concentrations from 65 to 1300 ppm

---

[1] Lyman, W.J., W.F. Reehl, and D.H. Rosenblatt, 1990. Handbook of Chemical Property Estimation Methods: Environmental Behavior of Organic Compounds. ACS, Washington D.C.

CS_2, mass transfer of CS_2 out of water took place with a mean half-life of 90 minutes (MRID 40375114). A bluegill sunfish acute toxicity study, however, showed rates of dissipation that were substantially lower (MRID 40375113). This static 96-hour test, conducted in five gallon tanks with nominal concentrations from 4.1 to 41 ppm as CS_2, showed that after 2 hours, 80% to 95% of the initial concentration remained. After 96 hours, tests at lower concentrations ($\leq$ 7.4 ppm CS_2) showed complete dissipation, but at higher doses (13 to 41 ppm), up to 46% of the initial concentration remained. Concentrations in these studies are on the same scale as those in irrigation water at the time of application but they are much higher than the concentrations likely to reach surface water through runoff. At lower concentrations, it is probable that more rapid volatilization will occur.

Field dissipation studies suggest that the CS_2 formed by breakdown of CS_4^{2-} initially moves downward through the soil profile, followed by diffusion upwards and volatilization to the atmosphere (7/9/1996, DP Barcodes D220367, D223296). Initial downward diffusion is rapid, with one study detecting CS_2 at 20 ft below the surface after 8 hours. All studies found maximum soil air concentrations, up to 37,500 ppmv, at one foot below the surface on the first day after application. Half-lives measured for dissipation of CS_2 in soil air were one to six days. The relative contributions of metabolism and diffusion to CS_2 dissipation have not been quantified and may vary depending on environmental conditions.

Under normal uses of sodium tetrathiocarbonate, CS_2 may reach groundwater. Prospective groundwater (PGW) studies in Florida found CS_2 concentrations of up to 215 ppb with observed dissipation half-lives on the order of several days to one week (7/27/1988, P. Holden). The one PGW conducted in California did not detect carbon disulfide in groundwater after sodium tetrathiocarbonate application, although terrestrial field dissipation studies in California found carbon disulfide reaching the water table in soil air. Volatilization, rather than movement off-site, was determined to be the primary mechanism for dissipation. Maximum potential concentrations have not been predicted because these studies indicate that CS_2 occurrence in groundwater is highly dependent on recharge conditions, and none of these studies had significant recharge during the times when CS_2 levels in soil air were at a maximum.

Volatilization is the primary pathway for transport of CS_2. A ground level air monitoring study using several application methods at half of the current labeled application rate found maximum air concentrations ranging from 2 ppm (furrow) to 24 ppm (mini-sprinkler) (MRID 42569101). At one hour after application, these levels had dropped to 1.1 to 5.7 ppm. Higher application rates may result in higher concentrations, but the observed dissipation suggests that any exposure will not be long-lived. A second air monitoring study measuring CS_2 levels at one foot and five feet above the ground surface found mean dissipation half-lives of 1.8 days (MRID 42304401). Maximum concentrations at one foot off the ground were 4.50 ppmv on the field and 0.252 ppmv 100 ft off site. The amounts of CS_2 and its degradates that may be released to the atmosphere as a result of the pesticidal use of sodium tetrathiocarbonate are not expected to be high enough to have any impact on global sulfur cycles (5/4/89, S. Termes; 7/7/89, G. Hume).

1.3 Receptors

1.3.1 Aquatic and Terrestrial Effects

For sodium tetrathiocarbonate and carbon disulfide, the major degradate and active pesticide agent, ecological measures of effect are based on a suite of registrant-submitted toxicity studies as well as other lines of evidence, including studies from the open literature. A scan of the on-line ECOTOX database (http://www.epa.gov/ecotox) shows that there are several studies available for carbon disulfide, which will be considered during the risk assessment process. Below is a brief summary of currently available ecotoxicity information for sodium tetrathiocarbonate and carbon disulfide. Where toxicity data gaps exist, the associated uncertainties and the "value added" for new data are briefly discussed (see Section 1.6.2 for more details).

Aquatic Effects

Several of the available freshwater toxicity studies were conducted with calcium tetrathiocarbonate ($CaCS_4$) as the test substance, rather than sodium tetrathiocarbonate (Na_2CS_4). Due to the rapid hydrolysis of the parent compound, though, test organisms were actually exposed to carbon disulfide (CS_2), and it is CS_2 concentrations which were analytically verified. The nature of the cation, then, is not expected to affect the properties of the product. Two bluegill sunfish acute toxicity studies confirmed that the aquatic toxicity of sodium tetrathiocarbonate and calcium tetrathiocarbonate are equivalent in aquatic toxicity, and the data can be bridged (Acc. # 072331, MRID 40375113). Available data for the most sensitive species indicate that CS_2 is highly toxic to freshwater fish based on acute toxicity information for the rainbow trout (96-hr LC_{50} = 0.87 mg CS_2/L or 6.7 mg $CaCS_4$/L; Acc. # 072331). An acute toxicity test with the freshwater invertebrate, *Daphnia magna*, also indicates that CS_2 is highly toxic (48-hr EC_{50} = 0.87 mg CS_2/L or 6.6 mg $CaCS_4$/L; Acc. # 072331).

There are no chronic toxicity data available to assess the potential effects of CS_2 on freshwater animal growth and/or reproduction. A fish early life stage toxicity test (§72-4(a)) with rainbow trout, the most acutely sensitive species of those tested, and a freshwater invertebrate lifecycle toxicity test (§72-4(b)) with *Daphnia magna* would reduce the uncertainty in the risk assessment. These data gaps have been identified as important uncertainties in risk assessments for other fumigant pesticides.

Acute toxicity data for estuarine and marine organisms are required to support the registration of an end use product intended for direct application to the estuarine or marine environment or if the product is expected to enter this environment in significant concentrations because of its expected use or mobility pattern. Use on citrus represents a potential for estuarine exposure. However, since Enzone® labeling prohibits use "in areas adjacent to or draining to marine or estuarine waters," estuarine/marine toxicity testing is not required at this time.

No aquatic plant toxicity information was available for previous assessments, but an additional 72-hour study with *Selenastrum capricornutum* with the ENZONE formulation as the test substance has recently been submitted (MRID 46423901). A preliminary review of these data suggests that biomass is the most sensitive endpoint with a NOAEC and EC_{50} of 9.98 and 17 mg ENZONE/L, respectively. Based on the time-weighted-averages of measured concentrations, this is equivalent to a NOAEC and EC_{50} of 80.1 and 150 µg CS_2/L.[2] The open literature ecotoxicity database indicates that additional carbon disulfide toxicity data exist for non-vascular aquatic plants, and this information will be considered during the risk assessment process.

Terrestrial Effects

Given the nature of sodium tetrathiocarbonate and its expected behavior in the environment, there is a potential risk to terrestrial animals via drinking contaminated water at the application site. A mallard duck drinking water toxicity study revealed no mortality among ducklings that drank water contaminated with 2400 ppm sodium tetrathiocarbonate[3], the maximum concentration of expected to be the environment (MRID 422308501). The study also shows that the birds found the Enzone® treated water to be less palatable. These findings are consistent with a drinking water toxicity study with rats; no mortality occurred in male or female rats following exposure to drinking water with 2000 ppm sodium tetrathiocarbonate (MRID 43185201). This study also shows that the rats found the Enzone® treated water to be less palatable.

Another potential exposure route for terrestrial animals is via inhalation of the degradate, carbon disulfide (CS_2). A bobwhite quail inhalation toxicity study revealed no mortality, clinical signs of toxicity, or effects on food consumption or body-weight following 4 hours of inhalation exposure to 1060 ppm CS_2 (MRID 42531001). For mammals, based on the 1995 ecological risk assessment for new uses on almonds, peaches, and prunes, the rat acute inhalation LC_{50} is 1513 ppm CS_2 (males) and 1014 ppm CS_2 (females) (guideline grade) and 736 ppm CS_2 (minimum grade) for both male and female rats. Potential reproductive and/or developmental toxicity effects in terrestrial animals via inhalation of CS_2 will be explored, and relevant study reviews from the Health Effects Division (HED) will be considered during the risk assessment process.

Given the method of application of sodium tetrathiocarbonate and its predicted behavior in the environment, dietary exposures are unlikely for terrestrial animals. Nevertheless, acute oral and dietary toxicity data are available for birds and mammals. A bobwhite quail acute oral toxicity test (with calcium tetrathiocarbonate) suggests that sodium tetrathiocarbonate (a.i.) is moderately toxic to birds on an acute oral basis (LD_{50} = 1180 mg product/kg or 363 mg a.i./kg; Acc. # 260638). Based on information from the HED, the rat acute oral LD_{50} is > 587 mg a.i./kg, which classifies sodium tetrathiocarbonate as no more than slightly toxic to mammals on an acute basis. (However, it is unclear if this endpoint has been adjusted for the purity of the test substance; this will be explored

[2] Conclusions may change pending formal review of the study.

[3] Drinking water toxicity is considered in terms of nominal concentrations of parent Na_2CS_4, rather than measured concentrations of CS_2. This differs from aquatic toxicity studies in which CS_2 was the species analytically verified. Due to rapid hydrolysis, actual exposure is likely to a mix of Na_2CS_4 and CS_2.

during the risk assessment process). An acute dietary toxicity test is available for the bobwhite quail and the mallard duck; both tests suggest that sodium tetrathiocarbonate (a.i.) is no more than slightly toxic to birds on an acute dietary basis (LC_{50} > 5620 ppm product or >1731 ppm a.i.; Acc. # 260638).

Terrestrial invertebrate toxicity information has recently been submitted for earthworms and two beneficial insects, the predatory mite and the parasitic wasp.[4] A 14-day earthworm (*Eisenia foetida*) acute toxicity test with the formulation ENZONE suggests that the NOAEC and LC_{50} are 607 and 1300 mg a.i./kg dw soil, respectively (MRID 46423902). A 7-day acute toxicity test with the predatory mite (*Typhlodromus pyri* Scheuten) revealed almost complete mortality (92%) at the lowest level tested, 3.125 L ENZONE/ha (MRID 46423903). A 48-hour acute toxicity test with the parasitic wasp (*Aphidius rhopalosiphi*) suggests the NOAEC and LC_{50} are <0.1 and 0.41 L ENZONE/ha, respectively (MRID 46423904). There are no acute oral or contact toxicity data available for honey bees (§141-1). These data would be useful for characterizing the potential risk of carbon disulfide to non-target beneficial insects.

There are no terrestrial plant toxicity data available with which to assess the potential risk of sodium tetrathiocarbonate. Due to the application methods and fate properties of this pesticide, exposure to terrestrial plants through drift and runoff is unlikely. However, there is a possibility of vapor phase exposure to terrestrial plants, and adverse ecological incidents in which non-target terrestrial plants have been impacted by off-gassing have been reported for other fumigants. In addition, the label suggests that phytotoxic effects are possible (e.g., ENZONE Reg. No. 68891-2 says that the "crop must be established in the field for at least one year prior to treatment or injury may occur"). Tier I seedling emergence and vegetative vigor studies (§122-1) using the maximum application rate of formulated product would reduce the amount of uncertainty in this risk assessment. Tier II phytotoxicity tests would be required if a 25% or greater detrimental effect is found in one or more plant species in the Tier I tests.

1.3.2 Ecosystems Potentially at Risk

The ecosystems at risk are often extensive in scope, and as a result, it may not be possible to identify specific ecosystems during the development of a baseline risk assessment. However, in general terms, terrestrial ecosystems potentially at risk could include the treated field and areas immediately adjacent to the treated field that may be impacted by drift, runoff, or volatilization of the applied pesticide. This could include the field itself as well as other cultivated fields, fencerows and hedgerows, meadows, fallow fields or grasslands, woodlands, riparian habitats and other uncultivated areas. For Tier 1 assessment purposes, risk will be assessed to terrestrial animals that are assumed to feed on and otherwise occupy the treated area. Exposure to animals off the treated site is also possible, but exposure and risk estimates are not likely to be higher than on the treated site.

[4] Conclusions may change pending formal review of these studies.

Aquatic ecosystems potentially at risk include water bodies adjacent to, or down stream from, the treated field and might include impounded bodies such as ponds, lakes and reservoirs, or flowing waterways such as streams or rivers. For uses in coastal areas, aquatic habitat also includes marine ecosystems, including estuaries. For Tier 1 assessment purposes, risk will be assessed to aquatic animals assumed to occur in small, static ponds receiving runoff and drift from treated areas. These ponds are used as surrogates for a number of small vulnerable water bodies that occur near the headwaters of watersheds including swamps, bogs, prairie potholes, vernal pools, playa lakes, and first-order streams.

1.4 Assessment Endpoints

A summary of the assessment endpoints and measures of ecological effect selected to characterize potential ecological risks associated with exposure to sodium tetrathiocarbonate is provided in **Table 2.**

Table 2. Summary of Ecological Risk Assessment Endpoints for Sodium Tetrathiocarbonate and Carbon Disulfide

Assessment Endpoint	Effects Measurement Endpoint
1. Survival, reproduction and growth of **birds** (Birds are surrogates for reptiles and terrestrial-phase amphibians)	Acute oral LD_{50} (bobwhite quail) Acute dietary LC_{50} (bobwhite quail, mallard duck) Acute inhalation LC_{50} (bobwhite quail) Acute drinking water exposure NOAEC (mallard duck) * No chronic bird toxicity data available
2. Survival, reproduction and growth of **mammals**	Acute oral LD_{50} (rat) Acute inhalation LC_{50} (rat) Acute drinking water exposure NOAEC (rat) * No chronic rat toxicity data available
3. Survival, reproduction, and growth of **freshwater fish and invertebrates** (Fish are surrogates for aquatic-phase amphibians)	Acute fish LC_{50} (rainbow trout, bluegill sunfish) Acute invertebrate EC_{50} (*Daphnia magna*) * No chronic fish or invertebrate toxicity data available
4. Survival, reproduction, and growth of **saltwater fish and invertebrates**	* No acute or chronic toxicity data available.
5. Survival of **beneficial insect**s	Parasitic wasp NOAEC and LC50 * No honey bee toxicity data available
6. Perpetuation of individuals and populations of non-target **terrestrial plant** species (crops and non-crop plant species)	* No seedling emergence or vegetative vigor data available
7. Maintenance and growth of individuals and populations of **aquatic plants** from standing crop	*Selenastrum capricornutum* NOAEC and EC50

LC_{50} = Lethal concentration to 50% of the test population.
LD_{50} = Lethal dose to 50% of the test population.
NOAEC = No observed adverse effect level.

1.5 Conceptual Model

For a pesticide to pose an ecological risk, it must reach ecological receptors in biologically significant concentrations. An exposure pathway is the means by which a pesticide moves in the environment from a source to an ecological receptor. For an ecological pathway to be complete, it must have a source, a release mechanism, an environmental transport medium, a point of exposure for ecological receptors, and a feasible route of exposure.

A conceptual model provides a written description and visual representation of the predicted relationships between the applied pesticide, potential routes of exposure, and the predicted effects for the assessment endpoint. A conceptual model consists of two major components: risk hypotheses and a conceptual diagram (US EPA, 1998).

For sodium tetrathiocarbonate, the conceptual model has been developed in terms of carbon disulfide. In water, sodium tetrathiocarbonate is rapidly converted to carbon disulfide, which is likely to be the stressor in any aquatic exposure route. All aquatic toxicity has been measured in terms of carbon disulfide. Carbon disulfide is volatile and off-gasses from treated fields and so will also be the stressor in any exposure through air.

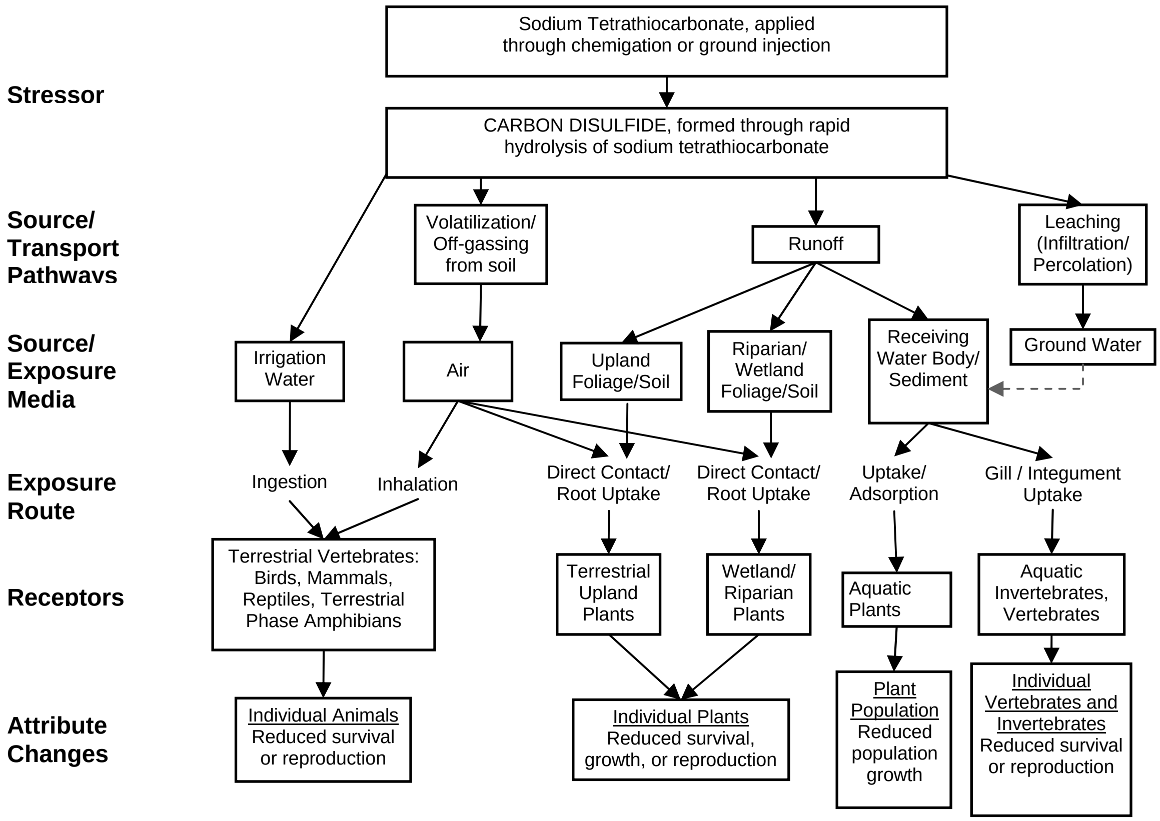
1.5.1 Risk Hypotheses

For carbon disulfide, the following ecological risk hypothesis is being employed for this baseline risk assessment:

> *Carbon disulfide, when produced by degradation of sodium tetrathiocarbonate used in accordance with the label, results in potential adverse effects upon the survival, growth, and reproduction of non-target terrestrial and aquatic organisms.*

1.5.2 Conceptual Diagram

The conceptual diagram depicts the potential ecological risk associated with carbon disulfide by identifying possible exposure routes and receptors and providing a visual representation of their relationships.



*Dotted lines indicate that although this exposure route was considered, it was not thought to contribute significantly to the fate and transport of carbon disulfide.

Figure 1. Conceptual model of the environmental transport and effects of carbon disulfide.

Carbon disulfide is released from sodium tetrathiocarbonate applied through ground injection or in irrigation water. Spray drift does not occur with these application methods and so is not considered in this conceptual model. The major exposure routes of carbon disulfide for terrestrial animals are likely via ingestion of irrigation (drinking) water on the treated field or via inhalation resulting from off-gassing from the soil. Volatile carbon disulfide released by off-gassing may also impact nearby terrestrial plants. Due to its physical properties, off-gassing carbon disulfide is not expected to settle on adjacent soils, water bodies, or food items so these exposure routes are not considered. Carbon disulfide can move off-site through runoff to adjacent upland or riparian/wetland areas, where it may affect plants through direct contact or root uptake. Carbon disulfide in runoff also may reach adjacent water bodies where it could affect aquatic plants through uptake or adsorption and aquatic animals via uptake through the respiratory surface (gills) or the integument. Leaching to groundwater may occur but carbon disulfide is expected to be too transient to reach surface water through this route.

1.6 Analysis Plan

In Registration Review, pesticide ecological risk assessments will follow the Agency's Guidelines for Ecological Risk Assessment, will be in compliance with the paper titled "Overview of the Ecological Risk Assessment Process in the Office of Pesticide

Programs, U.S. Environmental Protection Agency" ("Overview Document"; January 2004), and will be done in accordance with Section 7 of the Endangered Species Act.

1.6.1 Conclusions from Previous Risk Assessments

The original new chemical registration for sodium tetrathiocarbonate was completed in 1988 (Eco: 9/20/88, J. Ackerman; Fate: 5/16/89, E. Regelman). Since then, additional data for sodium tetrathiocarbonate and its major degradate, carbon disulfide, have been received and considered during the risk assessment process for several new uses.

The most recent ecological risk assessment for sodium tetrathiocarbonate conducted by the EFED is the 1995 assessment for the proposed new uses on almonds, peaches, and prunes (Eco: 5/4/1995, DP Barcode D213559; Fate: 8/21/1995, DP Barcodes D213560, D199125, D196916). The application scheme (maximum rates, use areas, general use instructions) considered in that assessment is the same as that on the current labels. The 1995 ecological risk assessment concluded that labeled use of sodium tetrathiocarbonate was not expected to pose acute or chronic risk to non-target avian, mammalian, fish, aquatic invertebrate or plant species. However, some of the risks were assessed qualitatively (*i.e.,* aquatic exposures were not quantitatively estimated), and the potential risks to some receptors (terrestrial plants, terrestrial invertebrates) were not assessed.

The only available drinking water assessment found estimated drinking water concentrations (EDWCs) in groundwater of 1 to 100 ppb and in surface water of 120 ppb (acute), 1 ppb (chronic, non-cancer) and 0.35 ppb (chronic, cancer), based on modeling using PRZM/VADOFT and PRZM/EXAMS (3/19/02, A. Clem). These were estimated based on use in Florida at application rates that are half of maximum labeled rates.

1.6.2 Preliminary Identification of Data Gaps and Analysis Plan

1.6.2.1 Environmental Fate

The fate database for sodium tetrathiocarbonate is largely complete. All fate data requirements are satisfied or partially satisfied and physical and chemical properties are available from open literature sources. Past assessments have identified some uncertainties about the fate and transport of carbon disulfide that are not addressed by required studies; additional information would help to further characterize the fate of CS_2 but would not be expected to change risk conclusions:

- Due to the complexity of environmental sulfur chemistry, the relative concentrations of individual degradation products of CS_2 have not been determined, particularly for "H_2S," which really represents a mix of $H_2S/HS^-/H^{2-}$.

- Studies of CS_2 photolysis behavior in soil and air have not been submitted, so rates and degradation products are uncertain. Studies of photodegradation in air may be useful in understanding the fate of CS_2 in the atmosphere, important because air is the ultimate sink for CS_2.

- The relative contributions of degradation and diffusion to dissipation of CS_2 from soil have not been determined.

1.6.2.2 Aquatic Exposure

In previously completed screening level risk assessments for sodium tetrathiocarbonate, there has been some uncertainty in risk conclusions for aquatic organisms and for drinking water. These uncertainties and potential paths forward are described below:

- All available ecological aquatic toxicity data are reported as Na_2CS_4 rather than CS_2, which is likely to be the actual stressor. CS_2 is formed rapidly in water through hydrolysis of Na_2CS_4, though, and test solutions were aged at least two hours. It is likely that these studies are effectively testing CS_2 exposure, and in fact it was CS_2 that was analytically verified. No additional data are therefore required.

- In the most recent (1995) ecological risk assessment, all levels of concern (LOCs) for aquatic organisms were exceeded based on the assumption of direct exposure to treated irrigation water, the maximum possible exposure. This assumption is appropriately conservative to estimate the risk if treated tailwater were to reach surface water bodies. Labels direct that "tailwater must not be allowed to leave the treated field," but no details such as trapping methods or holding times are included, so there is still some possibility for exposure through this route.

  For other routes of aquatic exposure, it is likely that substantial dilution and volatilization will occur before irrigation water reaches aquatic environments and so this assumption may be overprotective. For this case, past assessments have qualitatively concluded that use of sodium tetrathiocarbonate is unlikely to pose significant risk to aquatic organisms, but there has been no quantitative assessment of risk.

  Based on available data, the most sensitive aquatic animal endpoint is the *Daphnia magna* EC_{50} of 0.86 mg CS_2/L. An aquatic EEC $\geq$ 43 µg CS_2/L would be required to exceed the endangered species LOC. Based on the aquatic plant NOAEC of 80.1 µg CS_2/L, an aquatic EEC $\geq$ 80.1 µg CS_2/L would yield a risk quotient that would exceed the acute endangered species LOC for plants. Surface water exposure is expected to be low, but at these LOCs, the possibility of risk cannot be precluded at this time. For the current risk assessment, aquatic exposures will be quantitatively estimated using models to determine potential risk to aquatic organisms. No additional data are required to complete this modeling.

- Previous assessments have concluded that application of sodium tetrathiocarbonate may result in groundwater levels of carbon disulfide that exceed background levels, based on prospective groundwater (PGW) studies and modeling. These sources do not represent worst-case scenarios because of the recharge conditions of the PGW studies and the application rate used in modeling. However, both sources are based on environmental conditions in Florida, which has higher vulnerability to leaching than would be expected in Arizona, California, Oregon, and Washington, the areas where use of sodium tetrathiocarbonate is currently supported.

For this assessment, we will characterize the potential for groundwater exposure from current uses based on the Florida PGW studies and modeling, as well as several PGW and terrestrial field dissipation studies conducted in California and Arizona. Additional PGW studies or monitoring data could reduce the uncertainty in this characterization by investigating potential groundwater exposure in worst-case recharge conditions in the areas labeled for use. These studies would be rated as being of low value. In the absence of additional data, any conclusions of potential exposure for the current uses may lead to a recommendation of label language requiring a 100 ft setback from drinking water wells, as has been recommended in past assessments.

1.6.2.3 Ecological Effects

Table 3 presents an evaluation of the uncertainty resulting from each ecotoxicity data gap. There is inherent uncertainty associated with not receiving data to fulfill data gaps. However, the submission of some studies to address specific data gaps is unlikely to affect conclusions in the risk assessment, whereas some data gaps are more critical. This determination is made on a case-by-case basis.

Table 3. Summary of ecotoxicity data gaps for sodium tetrathiocarbonate		
Assessment endpoint with data gap	**Value of Additional Data***	**Rationale**
Early life-stage freshwater fish toxicity study (72-4a)	High	Persistence of carbon disulfide in surface water bodies may be unlikely; however, given the high annual application rate of sodium tetrathiocarbonate and the potential for multiple applications per year, chronic risk to freshwater fish cannot be precluded at this time. This data gap has been identified as an important uncertainty in risk assessments for other fumigants. The value of this chronic study would be in quantifying and potentially refining the risks to fish (surrogate for aquatic-phase amphibians). Defining an action area for endangered species and exploring risk mitigation strategies cannot be evaluated without these data.
Freshwater invertebrate lifecycle toxicity study (72-4b)	High	See above. Chronic risk of to freshwater invertebrates cannot be precluded at this time. The value of this chronic study would be in quantifying and potentially refining the risks to aquatic invertebrates. Defining an action area for endangered species and exploring risk mitigation cannot be evaluated without these data.
Acute toxicity to estuarine/marine fish and invertebrates (72-3)	Low	Enzone® labeling prohibits use "in areas adjacent to or draining to marine or estuarine waters."
Survivorship, reproduction, and growth (chronic toxicity) of estuarine/marine fish and invertebrates (72-4)	Low	Enzone® labeling prohibits use "in areas adjacent to or draining to marine or estuarine waters."
Perpetuation of non-target terrestrial plants, crops and non-crop species (122-1, vegetative vigor and seedling emergence)*	High	Risk to terrestrial plants has not been considered in previous assessments, and no terrestrial plant toxicity data are currently available for sodium tetrathiocarbonate. Potential exposure routes for terrestrial plants include runoff and via off-gassing and volatilization. Adverse ecological incidents have been reported for other fumigants in which non-target terrestrial plants have been impacted by off-gassing. At one foot above ground level, the mean dissipation half-life for CS_2 is 1.8 days, long enough for potential exposure. The value of these seedling emergence and vegetative vigor studies would be in quantifying and potentially refining risks to non-target terrestrial plants. Defining an action area for endangered species and exploring risk mitigation strategies cannot be evaluated without these data.

Table 3. Summary of ecotoxicity data gaps for sodium tetrathiocarbonate		
Maintenance and growth of aquatic plants from standing crop or biomass (122-2, aquatic plant growth)	High	Risk to vascular aquatic plants (e.g., duckweed) has not been considered in previous assessments, and no vascular aquatic plant toxicity data are currently available for sodium tetrathiocarbonate. The value of a vascular aquatic plant toxicity study would be in quantifying and potentially refining risks to non-target terrestrial plants. Defining an action area for endangered species and exploring risk mitigation strategies cannot be evaluated without these data.
Acute oral or contact toxicity to honeybees (141-1)	High	Non-target terrestrial invertebrates have the potential to be exposed to sodium tetrathiocarbonate by direct contact and via off-gassing. There are no honey bee toxicity data available for sodium tetrathiocarbonate. The value of these honey bee studies would be in quantifying and potentially refining risks to non-target terrestrial invertebrates. Defining an action area for endangered species and exploring risk mitigation strategies cannot be evaluated without these data.
Reproduction and growth of birds (71-4)	Moderate	Given the method of application of sodium tetrathiocarbonate and its predicted behavior in the environment, dietary exposures are unlikely. Thus, a dietary exposure chronic avian reproduction study would be of limited use in this risk assessment. Since inhalation is a more likely exposure route for carbon disulfide, a non-guideline chronic avian toxicity test (with inhalation exposure) would address this uncertainty.

* Tier II phytotoxicity tests would be required if a 25% or greater detrimental effect is found in one or more plant species in the Tier I tests.

1.6.3 Measures of Effect and Exposure

1.6.3.1 Exposure

Exposure estimates will be determined for carbon disulfide, the rapidly formed degradate that is the actual active ingredient, rather than for parent sodium tetrathiocarbonate.

For ecological aquatic exposures, previous assessments have based EECs on the minimum concentration of sodium tetrathiocarbonate in irrigation water required by the label, a very conservative approach. For drinking water exposure in surface water, EDWCs have been estimated for application rates lower than the current labeled maximum. Additionally, these estimates have used out of date models which don't account for irrigation. New modeling will therefore be required to quantitatively estimate aquatic exposures to assess ecological and human health risk.

Tier I aquatic exposure models are not sufficient to estimate exposure from fumigants because they do not account for volatilization. New estimates of surface water exposure in aquatic environments and in drinking water will be determined using the linked Tier II aquatic exposure models, PRZM (v. 3.12.2; May 12, 2005) and EXAMS (v. 2.98.04; April 25, 2005), run with the PE5 (v. 5.0; Nov. 15, 2006). Modeling will assume the maximum application rate, a single application of 340 lb a.i./A (139 lb CS_2/A).

Potential groundwater exposure will be characterized based on previous model results and based on available prospective groundwater studies and terrestrial field dissipation studies.

Drift is not a potential route of exposure from these application methods, so the highest exposure to terrestrial species would be from drinking treated irrigation water or from exposure to off-gassing carbon disulfide, either through inhalation or direct contact. Ecological exposure in drinking water is based on the irrigation concentrations recommended by the labels and additional estimates are not needed. For exposure to off-gassing CS_2, there are acceptable data from field studies which measure concentrations of CS_2 in air from one inch to five feet above ground level. Further refinement of these values will not be needed.

1.6.3.2 Effects

Ecotoxicity data are available for several assessment endpoints. **Table 4** summarizes the specific toxicity values that will be used to assess acute and chronic risk of carbon disulfide to receptors.

Table 4. Summary of Measure of Effects for Sodium Tetrathiocarbonate (a.i.) and Carbon Disulfide (CS_2)

Assessment Endpoint	Effects Measurement Endpoint
1. Survival, reproduction and growth of **birds** (Birds are surrogates for reptiles and terrestrial-phase amphibians)	Bobwhite quail acute oral 14-day LD_{50} = 1180 mg/kg = 363 mg a.i./kg Bobwhite quail dietary 8-day LC_{50} >5620 ppm or >1731 ppm a.i. Bobwhite quail acute inhalation 4-hr NOAEC = 1060 ppm CS_2 Mallard duck acute drinking water exposure 8-hr NOAEC = 2400 ppm a.i. * No chronic bird toxicity data available
2. Survival, reproduction and growth of **mammals**	Rat acute oral LD_{50} >587 mg a.i./kg Rat acute inhalation LC_{50} = 736 ppm CS_2 Rat acute drinking water exposure 24-hour NOAEC = 2000 ppm a.i. * No chronic rat toxicity data available
3. Survival, reproduction, and growth of **freshwater fish and invertebrates** (Fish are surrogates for aquatic-phase amphibians)	Rainbow trout acute 96-hr LC_{50} = 6.7 mg a.i./L = 0.87 mg CS_2/L *Daphnia magna* 48-hr EC_{50} = 6.6 mg a.i./L = 0.86 mg CS_2/L * No chronic fish or invertebrate toxicity data available
4. Survival, reproduction, and growth of **saltwater fish and invertebrates**	* No acute or chronic toxicity data available.
5. Survival of **beneficial insects**	Parasitic wasp 48-hr NOAEC <0.1 L ENZONE/ha and LC_{50} = 0.41 L ENZONE/ha * No honey bee toxicity data available
6. Perpetuation of individuals and populations of non-target **terrestrial plant** species (crops and non-crop plant species)	* No seedling emergence or vegetative vigor data available
6. Maintenance and growth of individuals and populations of **aquatic plants** from standing crop	*Selenastrum capricornutum* biomass 72-hour NOAEC = 80.1 µg CS_2/L and EC50 = 520 µg CS_2/L

1.6.3 Other Information Needs

There is specific information that will assist the Agency in refining the ecological risk assessment, including any species-specific effects determinations. The Agency is very much interested in obtaining the following information:

1. confirmation on the following label information
    a. sites of application
    b. formulations
    c. application methods and equipment
    d. maximum application rates
    e. annual frequency of application, date of initial application per year, application intervals, and maximum number of applications per year
    f. geographic limitations on use
2. use or potential use distribution (*e.g.*, acreage and geographical distribution of relevant uses)
3. use history
4. median and 90th percentile reported use rates (lbs. a.i./acre) from usage data – national, state, and county
5. application timing (date of first application and application intervals) by use – national, state, and county
6. sub-county crop location data
7. usage/use information for non-agricultural uses (*e.g.*, golf courses, athletic fields, ornamentals)
8. directly acquired county-level usage data (not derived from state level data)
    a. maximum reported use rate (lbs. a.i./acre) from usage data – county
    b. percent crop treated – county
    c. median and 90th percentile number of applications – county
    d. total pounds per year – county
    e. the year the pesticide was last used in the county/sub-county area
    f. the years in which the pesticide was applied in the county/sub-county area
9. typical application interval (days)
10. state or local use restrictions
11. ecological incidents (non-target plant damage and avian, fish, reptilian, amphibian and mammalian mortalities) not already reported to the Agency
12. monitoring data

The analysis plan will be revisited and may be revised depending upon the data available in the open literature and the information submitted by the public in response to the opening of the Registration Review docket.

IV. HUMAN HEALTH EFFECTS SCOPING DOCUMENT

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
PREVENTION, PESTICIDES
AND TOXIC SUBSTANCES

Date: December 7, 2007

Subject: Sodim Tetrathiocarbonate. PC Code: 128904. **HED Scoping Document for Registration Review. DP Barcode: D**343843.

To: **Katherine St. Clair, CRM**
Special Review and Reregistration Division

From: Catherine Eiden, Chief
Health Effects Division
Reregistration Branch 3 (7508P)

Thru: Danette Drew, Senior Scientist
Health Effects Division
Reregistration Action Branch 3(7508P)

Executive Summary: Sodium tetrathiocarbonate degrades to carbon disulfide (CS_2), hydrogen sulfide (H_2S) sodium hydroxide, and elemental sulfur upon contact with soil and water. CS_2 is the active ingredient. It is a soil fumigant and a neurotoxicant.

Sodium tetrathiocarbonate is registered for use on grapes, citrus, almonds, peaches, prunes, and plums. Tolerances are established for residues of CS_2 under 40 CFR §180.467. CS_2 is the residue of concern for risk assessment.

Sodium tetrathiocarbonate's registered agricultural uses provide the potential for exposures of the general public to residues of CS_2 in foods, drinking water, and via bystander drift. In food, residues of CS_2 are considered "de minimus" as those residues are indistinguishable from naturally-occurring background levels in foods (plants). Consequently, a dietary risk assessment for CS_2 was not conducted. A drinking water assessment has not been conducted for sodium tetrathiocarbonate and its main degradate (CS_2). Current labels require protective clothing and gear (PPE) for workers mixer, loading, and applying sodium tetrathiocarbonate. A 4-day Restricted Entry Interval (REI) has been established on current labels for harvesters. Current labels specify buffer zones to limit potential bystander exposure through drift from agricultural fields in California, only. Buffer zones are not specified on the labels for other states with active registrations.

HED concludes that existing assessments for agricultural workers and residential bystanders potentially exposed to CS_2 as a result of agricultural uses must be updated to reflect current policy and practice for soil fumigants. If an assessment indicates the

reflect current policy and practice for soil fumigants. If an assessment indicates the potential for significant exposures to CS_2 above naturally-occurring background levels in drinking water as a result of registered uses, a drinking water risk assessment will be needed. In addition, tolerances for carbon disulfide need to be reassessed and potentially lowered. Prior to requiring any new data, a thorough review of relevant and available papers, reports, and databases covering worker and bystander exposures, and mammalian toxicity should be conducted.

Introduction: Registration activity on sodium tetrathiocarbonate occurred mainly between 1985 and 1995. Although tolerances for CS_2 have been reassessed under the Food Quality Protection Act (FQPA), neither a Registration Standard nor a Reregistration Eligibility Decision (RED) has been developed for it. HED's databases contain individual decision memoranda regarding the history and disposition of data requirements and registration actions. Although these memoranda capture the registration process and decisions as practiced at the time, no risk assessments in accordance with FQPA have been conducted for sodium tetrathiocarbonate or CS_2 .

Sodium tetrathiocarbonate is a soil fumigant used for the management of nematodes and phytophthora root rot, oak root fungus, and phylloxera. There are two end-use products registered for use: Enzone and Entek. It is registered for use on grapes, citrus, almonds, peaches, prunes, and plums in Arizona (AZ), California (CA), Oregon (OR), and Washington (WA), only. CDPR reports that during the five years from 2001 to 2005, between 200,000 and 400,000 pounds of sodium tetrathiocarbonate were used annually in CA. There is also a registration for non-bearing fruit and nut trees, considered a non-food use and exempt from tolerances. There are no registered residential uses.

Sodium tetrathiocarbonate is applied through dilution in irrigation water by means of low-volume irrigation (chemigation), flood and furrow irrigation, and ground injection equipment. The majority of sodium terathiocarbonate used in CA is applied to grapes (vineyards) via irrigation. A 14-day post harvest interval (PHI) has been established on all labels. Once in water, it rapidly dissolves and then hydrolyzes in moist soil to form H_2S, CS_2, sodium hydroxide, and elemental sulfur. Soil particles rapidly bind and immobilize the sulfur ion and H_2S components, leaving only CS_2 to migrate and act as the biocide (nematicide). CS_2's vapor pressure (294 mmHg @ 20C) suggests that it will exist as vapor in the air. The degradation half-life is approximately 3 to 25 days.

Literature searches on sodium tetrathicarbonate revealed no new information. However, literature searches on CS_2 revealed extensive sources of information on this soil fumigant. HED has identified multiple articles and papers published in the open literature within the last five years relevant to worker exposure to CS_2 and mammalian toxicity of CS_2. HED has also contacted the California Department of Pesticide Registration (CDPR) and will ensure that information and data are exchanged on sodium tetrathiocarbonate and CS_2. CDPR is actively working on their assessments for sodium tetrathiocabonate and CS_2.

Hazard: CS_2 is a neurotoxicant. Headache and nausea are commonly associated with exposures to CS_2 as well as a range of more severe effects. These effects include obvious clinical signs of neurotoxicity, such as, convulsions and death, as well as changes in tissues and organs, such as lesions on and swelling of nerves, and brain weight effects, respectively. Additional effects observed in developmental and reproduction studies include: abortions/resorptions and body weight changes.

The most recent documents (memoranda) indicate that the available toxicity data on sodium tetrathiocarbonate include: acute toxicity studies, oral rat and rabbit developmental studies, and several mutagenicity studies. These studies are considered to be of either acceptable or "minimum" quality. The developmental studies indicate endpoints based on neurotoxicity (including death) in the adults, and increased resorptions and post-implantation losses in fetuses. The effects occur in adults at lower doses than in fetuses. The mutagenicity studies were negative. A data waiver for a 21-day dermal study was granted because of the severe corrosive nature of CS_2.

Available toxicity studies on CS_2 include: three inhalation studies (one in mice and two in rats) and developmental studies in rats and rabbits using CS_2. Inhalation effects included epithelial necrosis of the nasal tract and death at the highest doses.

Requirements for all subchronic and long-term studies, including acute, subchronic, and developmental neurotoxicity studies, have been waived because dietary exposures to CS_2 were determined to be "de minimus" relevant to background (naturally-occurring) concentrations of CS_2. Endpoints for risk assessment have not been selected previously.

Dietary Exposure: Field trial data were submitted in the late 1980s and early 1990s to support an Experimental Use Permit (EUP) on citrus and grapes. An extension allowed for the inclusion of many trials in 5 states (AZ, CA, OR, WA, and FL). A nature of the residue study in plants outlining the metabolism of sodium tetrathiocarbonate in plants was submitted, reviewed, and a determination made that the study was adequate. The nature of the residue is understood and the primary degradate and residue of concern for regulation and risk assessment is CS_2. Animal metabolism studies are not required because plant metabolism studies indicate that significant, reversibly bound CS_2 is only detected in root crops, but not in other crops. As there are no registrations of sodium tetrathiocarbonate on root crops, HED does not expect any transfer of residues through livestock commodities. Consequently, animal feeding studies are not warranted either. Issues related to the analytical method used to detect CS_2 in plants were resolved; an adequate analytical method exists to analyze CS_2 in plants. No processing studies were required given the volatile nature of the residue of concern (CS_2); residues are not expected to withstand conditions normally encountered during processing. Storage stability data are adequate.

By 1996, HED determined that residue data were adequate to grant permanent tolerances of 0.1 ppm for peaches, plums (fresh plums), prunes, citrus, almonds, and grapes. All of the residue data on peaches, plums, and almonds were from field trials in CA. Field trial data were also submitted for lemons, tomatoes, and apricots. Residue data from the available field trials showed that levels of CS_2 were generally either non-detectable or in the low parts per billion (ppb), i.e., 1 to 3 ppb. Maximum residues were detected in one sample in tomatoes, in which residues were 6 ppb, one sample of peaches, in which residues were 18 .4 ppb, and one sample of almond nutmeats, in which residues were 6.8 ppb. HED concluded that residues of CS_2 were likely to be less than 10 ppb on the commodities treated, and a tolerance of 0.05 ppm would be appropriate, but retained the 0.1 ppm tolerance since available residue data from field trials conducted at maximum and exaggerated rates were limited. These tolerances should be reassessed and a determination made if they can be lowered.

HED chemists used information on the background levels of CS_2 in soils, decaying organic matter, plants, and air in making their determination that CS_2 is always present in the environment, is ubiquitous, and occurs at low levels in the environment. HED concluded that CS_2 was probably present in the diet of humans at low levels (< 10 ppb). Higher levels have been detected in Shitake mushrooms and in the headspace above beer, but on average are not expected to exceed 10 ppb. HED concluded that because "*residues of CS_2 in crops do not exceed natural background levels and will be indistinguishable from those background levels, the standard approach to dietary [sic] risk assessment is not warranted*".

Previously, OPP concluded that residues of CS_2 generated from the use of sodium tetrathiocarbonate as a result of registered uses were not likely to impact potable water provided labels contain restrictions prohibiting application within 100 feet of a potable well. OPP will revisit the potential for exposures to CS_2 in drinking water under registration review.

Occupational and Residential Exposures: HED previously determined that worker exposures to individuals handling, mixing, and applying products containing sodium tetrathiocarbonate will be "de minimus" provided appropriate PPE as per the labels are used. The labels state that handlers must wear respirators (NIOSH TC-23C or TC-14G). Post-application worker exposures were also determined to be "de minimus" previously provided the 4-day REI on the labels was followed. Monitoring data from a field volatility/dissipation study representing worst-case conditions for use of the products indicated that residues of CS_2 are below detectable levels at 96 hours. The detection limit for that study was 0.019 ng/m^3. Occupational exposure and risk assessments reflecting current policy and practice for soil fumigants are necessary to confirm worker safety.

There are no residential uses of sodium tetrathiocarbonate. However, application techniques such as flood and furrow irrigation provide the potential for bystander exposure. Current labels state "posting" requirements to address issues of drift that may affect bystanders. CA labels provide buffer zones to protect bystanders. However, a risk assessment for residential bystanders potentially exposed to CS_2 as a result of sodium tetrathiocarbonate applications in nearby fields reflecting current policy and practice for soil fumigants has not been conducted. A risk assessment for potential bystander exposures to CS_2 is necessary under registration review and new data may be required to support this risk assessment.

Incident Reports: Three data bases were searched for incidents reports on sodium tetrathiocarbonate: Poison Control Center (PCC) Data, NIOSH SENSOR, and the Incidents Data System. No exposures to sodium tetrathiocarbonate were reported in the PCC during the period 1993 through 2005 or the Incident Data System from 1999 to the present. NIOSH SENSOR reported 2 cases of sodium tetrathiocarbonate poisonings. One case took place in CA in 1999. A 31 year-old man was a mechanic exposed to ENZONE; he reported headache, diarrhea, and malaise. The second incident also occurred in CA, but in 2001, when a 50-year old farm worker inhaled the pesticide and reported nausea, palpitations, upper respiratory pain and irritation, and muscle weakness. Both are likely attributed to CS_2 poisoning.

An additional poisoning incident associated with sodium tetrathiocarbonate was reported under Section 6(a)2 of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Two workers at Unocal's West Sacramento Plant in California were exposed to sodium tetrathiocarbonate in 1994 and reported headaches lasting two days. The company reported the effects to be due to CS_2, a known degradation product of Enzone.

Exposures to sodium tetrathiocarbonate are not reported frequently in the available databases capturing poisoning incidents with pesticides.

Aggregate Risk: There are no dietary exposures anticipated to sodium tetrathiocarbonate. Dietary exposures to CS_2 have been determined to be "de minimus". As a result, no quantitative dietary risk assessments have been conducted for sodium tetrathiocarbonate, or CS_2 in food. A drinking water exposure assessment has not been conducted. There are no registered residential uses; however, as CS2 is a soil fumigant, the potential for residential bystander exposures needs to be assessed under registration review. If a drinking water assessment indicates potential exposures to CS_2 in drinking water, an aggregate risk assessment combining potential residential bystander exposures with drinking water exposures may be warranted.

Cumulative Risk: Sodium tetrathiocarbonate has not been identified as a member of a common mechanism group. However, it breaks down to CS_2, as do dithiocarbamates. A common mechanism of toxicity across these compounds has not been established.

Environmental Justice

The Office of Pesticide Programs (OPP) typically considers the highest potential exposures from the legal use of a pesticide when conducting human health risk assessments, including, but not limited to, people who obtain drinking water from sources near agricultural areas, the variability of diets within the U.S. (including different ages, regions, and ethnicities), and people who may be exposed when harvesting crops. Should these highest exposures indicate potential risks of concern, OPP further refines the risk assessments to ensure that the risk estimates are based on the best available information.

As part of the California Environmental Justice Action Plan, the CDPR is currently conducting an environmental monitoring program in the town of Parlier, CA. Parlier is a small agricultural town in the San Joaquin Valley of CA 20 miles southeast of Fresno. Fruit orchards and grape vineyards are the dominant crops grown in the area. This program is a pilot project designed to measure air quality in the area. CS2 is included in the list of pesticides to be monitored under the pilot project. Findings from this project related to CS_2's impact on air quality and environmental justice issues will be considered in HED's updated risk assessments for CS_2.

Human Studies. No toxicity studies involving human subjects exposed intentionally to sodium tetrathiocarbonate, or CS_2 have been used or mentioned in any of the HED assessments or memoranda on sodium tetrathiocarbonate to date. A field volatility study in which air monitoring was conducted after application of sodium tetrathiocarbonate may require an ethics review. Additional ethics reviews may be needed depending on the data used to update existing assessments and develop a new residential bystander risk assessment.

Data Requirements:

New data may be required on $CS_{2.}$ Specifically, a "flux" study for use in setting appropriate off-site exposure mitigation buffer zones may be required. However, HED believes that available toxicity and exposure data (field volatility and flux studies and air monitoring) already identified in the open literature and through the CDPR may be sufficient to update existing CS_2 assessments to today's standards for the fumigants. HED will wait until the available literature on toxicity and exposure, air monitoring databases developed by the California Air Resources Board (CARB), and other information available on CS_2 have been reviewed prior to determining what data requirements, if any, are warranted.

Tolerance Harmonization:

No MRLs for sodium tetrathiocabonate have been established or proposed by Codex for any agricultural commodities. There are no Canadian or Mexican tolerances for carbon disulfide. Consequently, at this time, there are no harmonization issues. The US tolerances for CS_2 are listed under 40 CFR 180.467 and summarized in the attached tolerance status table.

US		**Canada**	**Mexico**	**Codex**
Residue Definition:				
Registrations include 66300-63 and 66330-69. Tolerances established for **carbon disulfide** from the use of sodium tetrathiocarbonate, 40CFR.180.467		None (including both sodium tetrathiocarbonate and sodium disulfide)	None (including both sodium tetrathiocarbonate and sodium disulfide)	None (including both sodium tetrathiocarbonate and sodium disulfide)
Commodity Tolerance (ppm) /Maximum Residue Limit (mg/kg)				
Almond	0.1	N/A	N/A	N/A
Almond, hulls	0.1			
Grapefruit	0.1			
Grape	0.1			
Lemon	0.1			
Orange, sweet	0.1			
Peach	0.1			
Plum, prune, fresh	0.1			

References

Blondell, J., "Review of incident reports – sodium tetrathiocarbonate", August 15, 1994.
California Air Resources Board, Annual Statewide Toxics Summary, Carbon Disulfide.

California Department of Pesticide Regulation, Environmental Justice Pilot Project, Pesticide Air Monitoring in Parlier, Second Progress Report, December 2006.

California Department of Pesticide Regulation, Environmental Justice Pilot Project, Pesticide Air Monitoring in Parlier, Addendum, ARB Monitoring Results, September 2007.

"Carbon Disulfide; Pesticide Tolerances", Federal Register Notice, Volume 62, Number 95, 26946-26949, May 16, 1997.

Dang, W., "Ground-Level Concentrations Study of Carbon Disulfide in Air During and After Application of GY-81", December 31, 1992.

Hawkins, M., "Review of Sodium Tetrathiocarbonate Incident Reports, DP Barcode D343827, Chemical # 128904", August 31, 2007.

Morales, J., "PP#5F4482; ID#000612-00005. Sodium Tetrathiocarbonate(GY-81) in/on Almonds, Peaches, and Plums (Fresh Prunes), Evaluation of Residue Data and Analytical Methodology, MRID# 435717-01, 435901-01 through -05. DP Barcodes: D213554 and 213557. CBTS Nos. 15344 and 15345", September 25, 1995.

Morales, J., "PP#5F4482; ID#000612-00005. Sodium Tetrathiocarbonate(GY-81) in/on Almonds, Peaches, and Plums (Fresh Prunes). Amendment in Response to CBTS memo of 9/25/95", April 8, 1996.

Olinger, C., "PP#9G3800; GY-81 (Sodium Tetrathiocarbonate solution) on Almonds, Prunes, Tomatoes, Lemons, And Apricots; Temporary Tolerances and Experimental Use Permit; MRID Nos. 412173 – 01 through -06; Record Nos. 250714 and 251358; 612-EUP-U; DEB nos. 5770 and 5771.", December 11, 1989.

Olinger, C., "PP#9G3800; GY-81 (Sodium TEtrathiocarbonate solution) on Almonds, Prunes, Tomatoes, Lemons, And Apricots; Temporary Tolerances and Experimental Use Permit; Record Nos. 258610 and 258611; EUP-U; DEB nos. 6281 and 6282. February 16, 1990.

Roush, T., "Use Information and Air Monitoring Recommendations for the Pesticide Active Ingredients Sodium Tetrathiocarbonate", Environmental Hazards Assessments Program, California Department of Pesticide Regulation, September 2006.

Segawa, R. "Literature Review of the Environmental Fate of Sodium Tetrathiocarbonate (Enzone)", Environmental Hazards Assessments Program, California Department of Pesticide Regulation, January 18, 1991.

Taylor, L., "GY-81 - Responses to DEB Review Dated August 6, 1990 and NDEB Reviews Dated August 2 and 27, 1990", October 22, 1990.

Taylor, L., "Carbon Disulfide – 90-Day Inhalation Toxicity Studies in Rats and Mice", December 4, 1990.

Taylor, L., "Two 90-Day CS2 Inhalation Studies in Rats", December 23, 1991.

V. GLOSSARY of TERMS and ABBREVIATIONS

ai	Active Ingredient
AR	Anticipated Residue
CFR	Code of Federal Regulations
cPAD	Chronic Population Adjusted Dose
CSF	Confidential Statement of Formula
CSFII	USDA Continuing Surveys for Food Intake by Individuals
DCI	Data Call-In
DEEM	Dietary Exposure Evaluation Model
DFR	Dislodgeable Foliar Residue
DNT	Developmental Neurotoxicity
DWLOC	Drinking Water Level of Comparison
EC	Emulsifiable Concentrate Formulation
EDWC	Estimated Drinking Water Concentration
EEC	Estimated Environmental Concentration
EPA	Environmental Protection Agency
EUP	End-Use Product
FDA	Food and Drug Administration
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FFDCA	Federal Food, Drug, and Cosmetic Act
FQPA	Food Quality Protection Act
FOB	Functional Observation Battery
GENEEC	Tier I Surface Water Computer Model
IR	Index Reservoir
LC_{50}	Median Lethal Concentration. A statistically derived concentration of a substance that can be expected to cause death in 50% of test animals. It is usually expressed as the weight of substance per weight or volume of water, air or feed, e.g., mg/l, mg/kg or ppm.
LD_{50}	Median Lethal Dose. A statistically derived single dose that can be expected to cause death in 50% of the test animals when administered by the route indicated (oral, dermal, inhalation). It is expressed as a weight of substance per unit weight of animal, e.g., mg/kg.
LOC	Level of Concern
LOAEL	Lowest Observed Adverse Effect Level
µg/g	Micrograms Per Gram
µg/L	Micrograms Per Liter
mg/kg/day	Milligram Per Kilogram Per Day
mg/L	Milligrams Per Liter
MOE	Margin of Exposure
MRID	Master Record Identification (number). EPA's system of recording/tracking submitted studies.
MUP	Manufacturing-Use Product
NA	Not Applicable
NAWQA	USGS National Ambient Water Quality Assessment
NPDES	National Pollutant Discharge Elimination System
NR	Not Required
NOAEL	No Observed Adverse Effect Level
OPP	EPA Office of Pesticide Programs
OPPTS	EPA Office of Prevention, Pesticides and Toxic Substances
PAD	Population Adjusted Dose
PCA	Percent Crop Area
PDP	USDA Pesticide Data Program
PHED	Pesticide Handler's Exposure Data

PHI	Preharvest Interval
ppb	Parts Per Billion
PPE	Personal Protective Equipment
ppm	Parts Per Million
PRZM/ EXAMS	Tier II Surface Water Computer Model
Q_1*	The Carcinogenic Potential of a Compound, Quantified by the EPA's Cancer Risk Model
RAC	Raw Agriculture Commodity
RED	Reregistration Eligibility Decision
REI	Restricted Entry Interval
RfD	Reference Dose
RQ	Risk Quotient
SCI-GROW	Tier I Ground Water Computer Model
SAP	Science Advisory Panel
SF	Safety Factor
SLN	Special Local Need (Registrations Under Section 24©) of FIFRA)
TGAI	Technical Grade Active Ingredient
USDA	United States Department of Agriculture
UF	Uncertainty Factor
WPS	Worker Protection Standard