# Security Assessment
# Draft Report v1

# Lido Oracle

August 2025

Prepared for Lido

certora

LIDO

# Table of contents

# Project Summary

## Project Scope

| Project Name | Repository Link | Branch/PR/Commit Hash | Platform |
|---|---|---|---|
| Lido Oracle | lidofinance/lido-oracle/ | Branch: feat/vaults-pectra → develop<br>PR 665<br>8ad1b43 | Off-chain |

## Project Overview

This document describes the manual code review of **Lido Oracle**. The work was undertaken from **July 31 2025** to **August 20 2025**

The following script list is included in our scope:

- src/constants.pya
- src/main.py
- src/metrics/prometheus/accounting.py
- src/modules/accounting/accounting.py
- src/modules/accounting/events.py
- src/modules/accounting/types.py
- src/modules/submodules/consensus.py
- src/modules/submodules/types.py
- src/providers/consensus/client.py
- src/providers/consensus/types.py
- src/providers/execution/contracts/accounting.py
- src/providers/execution/contracts/lazy_oracle.py
- src/providers/execution/contracts/lido.py
- src/providers/execution/contracts/lido_locator.py
- src/providers/execution/contracts/oracle_daemon_config.py
- src/providers/execution/contracts/staking_router.py
- src/providers/execution/contracts/vault_hub.py
- src/services/bunker.py
- src/services/staking_vaults.py
- src/utils/apr.py

- src/utils/deposit_signature.py
- src/utils/validator_state.py
- src/variables.py
- src/web3py/extensions/contracts.py
- src/web3py/types.py
- src/providers/ipfs/storacha.py
- src/providers/ipfs/lido_ipfs.py
- src/providers/ipfs/types.py
- src/providers/http_provider.py

During the manual audit, the Certora team discovered the bugs listed on the following page.

## Protocol Overview

The oracle is the operational backbone of the Lido protocol on Ethereum. It acts as the bridge between the Ethereum consensus layer, execution layer, and the Lido smart contracts, ensuring accurate state reporting, reward distribution, and protocol safety mechanisms.
The oracle operates through a committee-based consensus mechanism where multiple oracle nodes must agree on protocol state before updates are committed to the blockchain. This ensures:

- Fault Tolerance: Protection against malicious or faulty oracle nodes
- Data Integrity: Multiple validations before state changes
- Network Resilience: Redundancy across multiple oracle instances

The oracle collects off-chain data about validator performance, balances in the consensus Layer of Ethereum, and vault states in Execution Layer, then submits periodic reports on-chain (on Execution Layer) that trigger, the idea is to track and update :

- Total Value Locked (TVL) Calculation: Real-time computation of protocol assets across all vaults and validators
- Share Rate Updates: Maintaining accurate stETH:ETH exchange rates
- Multi-Vault Support: Handles complex vault structures with different fee models
- Slashing Reserve Management: Tracks and manages slashing penalties across the validator set
- Performance Attribution: Detailed tracking of validator performance for reward calculations
- Protocol health and rebasing (stETH supply adjustments)
- Validator exits
- Vault System (V3 Addition) :
    - individual vault performance tracking
    - separate accounting for vault validators
    - performance based fee calculations
    - merkle tree building
- Withdrawal Management (withdrawals work in queue so it manages what to finalize, how much eth it requires, which validators should exit to get access to ETH to finalize etc)

- Node Operator Performance and Rewards Distribution (NO = handling 1 or more validators on consensus layer) : the oracle tracks attestation performance, rewards/penalties, limits and keys availabilities and distribute rewards

## Security Considerations

The team considered risks and attack vectors that could potentially compromise the integrity, availability, and financial security of the Lido oracle system, with particular focus on the stVaults feature and its associated vault management operations. The oracle takes a critical role in managing stVaults data, including vault total values, fee calculations, liability shares, and slashing reserves.

The analysis encompasses both technical vulnerabilities in the oracle's stVaults data processing and broader systemic risks arising from the oracle's position as the authoritative source for vault state information. Specific attention was given to the merkle tree validation processes for vault data, the stVaults service integration, and the cross-vault consistency mechanisms, as these represent critical attack surfaces with high potential impact on vault operations and user funds.

Specifically, the team looked for risks regarding:

- Errors and/or malicious actors that can lead to:
  - Incorrect data to be reported by the Oracle
  - Denial of service on the Oracle, by preventing reports from being generated, preventing Oracles of reaching quorum, or crashing the Oracles
  - Possibility to bypass security mitigations
- While auditing, the following types of attackers were considered:
  - External attackers that target the Oracle directly
  - Malicious vault owners.
  - Malicious stakers.
  - Malicious node operators and/or validators.
  - A single malicious Oracle.
  - A quorum of malicious Oracles, with regard to bypassing mitigations.
  - Malicious public IPFS gateways.

## Audit Goals

The primary goal of this security audit is to comprehensively assess the security posture of the Lido oracle system, with particular emphasis on the stVaults feature and its associated vault management operations. The audit aims to identify potential vulnerabilities, attack vectors, and security weaknesses that could compromise the integrity, availability, and financial security of the stVaults ecosystem introduced in PR-665.

1. Enumerate the attack surfaces related to newly introduced code.
2. Find specific risks and attack vectors which could realistically lead to incorrect behavior and/or denial of service of the Oracle due to newly introduced code.
3. Suggest limited and accurate fixes for such risks.

## Key Focus Areas

The audit's scope was limited to PR#665 (stVaults Oracle), and this was the main focus area of the audit. Additional code (outside of the PR) that is directly related to the stVaults addition was reviewed for context, including other parts of the Oracle, and relevant smart contracts. Specifically, the team looked into the following areas of interest:

- IPFS usage
- Accounting, calculations and report generation
- Handling of transactions and events originating from the blockchain, with emphasis on events that can be triggered by malicious actors
- stVaults Data Integrity Assessment
  Objective: Evaluate the security of vault data processing and validation mechanisms
  Scope: Merkle tree validation, vault data submission, and cross-vault consistency checks
  Focus Areas:
  - Merkle tree structure validation for vault data
  - Cross-vault invariant enforcement
  - Bad debt handling and socialization mechanisms
- stVaults Economic Security Analysis
  Objective: Evaluate the security of vault economic operations and fee mechanisms
  Scope: Fee calculations, reward distributions, and vault health assessments
  Focus Areas:
  - Vault fee manipulation resistance
  - Reward distribution algorithm security
  - Vault health assessment accuracy
  - Economic parameter manipulation prevention

## Findings Summary

The table below summarizes the findings of the review, including type and severity details.

| Severity | Discovered | Confirmed | Fixed |
|---|---|---|---|
| Critical | - | - | - |
| High | 2 | - | - |
| Medium | 3 | - | - |
| Low | 7 | - | - |
| Informational | 6 | - | - |
| **Total** | 18 | - | - |

## Severity Matrix

| | | | | |
|---|---|---|---|---|
| **Impact** | High | Medium | High | Critical |
| | Medium | Low | Medium | High |
| | Low | Low | Low | Medium |
| | | Low | Medium | High |
| | | **Likelihood** | | |

certora

LIDO

# Detailed Findings

| ID | Title | Severity | Status |
|---|---|---|---|
| H-01 | Negative APR Leads to DOS | High | Fixed |
| H-02 | Double Counting of end-of-frame block When Calculating Liquidity Fees | High | Fixed |
| M-01 | Missing IPFS CID Verification | Medium | Fixed |
| M-02 | Missing Fees Calculation on VaultConnectionUpdated Event | Medium | Fixed |
| L-01 | Merkle Tree Validation Missing Leaf Count | Low | Acknowledged |
| L-02 | Lack of Validation in Event Handling | Low | Acknowledged |
| L-03 | Kubo RPC API Bound to 0.0.0.0 | Low | Acknowledged |
| L-04 | Prometheus Server Bound to 0.0.0.0 | Low | Acknowledged |
| L-05 | Missing IPFS Data Validation | Low | Acknowledged |
| L-06 | Double Counting of end-of-frame block When Calculating Liquidity Fees (Partial Fix) | Low | Fixed |
| L-07 | Storacha Upload URL Leak in | Low | Fixed |

| | | | |
|---|---|---|---|
| | Oracle Logs | | |
| I-01 | oz_merkle_tree Proof Verification on Internal Node (Informational) | Informational | Acknowledged |
| I-02 | Division by Zero in get_steth_by_shares Function | Informational | Acknowledged |
| I-03 | Consensus-critical contract methods should use finalized block by default | Informational | Acknowledged |
| I-04 | Incorrect Events Order Leads to Wrong Fees Calculation | Informational | Fixed |
| I-05 | Missing reservation_fee_bp and infra_fee_bp Updates Within Frame Lead to Incorrect Fees Calculation | Informational | Acknowledged |
| I-06 | Oracle HTTP Provider follows HTTP Redirects (30x) | Informational | Acknowledged |

# High Severity Issues

## H-01 - Negative APR Leads to DOS

| Severity: **High** | Impact: **Medium** | Likelihood: **High** |
|---|---|---|
| Files: src/services/staking_vaults.py, src/utils/apr.py | Status: Fixed | Violated Property: N/A |

**Description:**

calculate_steth_apr() can return a negative APR (when pre_rate > post_rate). In that case, get_core_apr_ratio() would return a negative core apr ratio the negative core_apr_ratio is then used in get_vaults_fees() -> calc_fee_value()

staking_vaults.py::get_vaults_fees():622

```python
infra_fee=int(vault_infrastructure_fee.to_integral_value(ROUND_UP)),

reservation_fee=int(vault_reservation_liquidity_fee.to_integral_value(ROUND_UP)),
                liquidity_fee=int(vault_liquidity_fee.to_integral_value(ROUND_UP)),
```

The fees calculated here would be negative, and ROUND_UP would round small negatives away from zero (-0.1 rounds to -1).
These fees are later used in build_tree_data() to build the Merkle Tree:

staking_vaults.py::build_tree_data():263

```python
tree_data.append(
                (
                    vault_address,
```

```
                Wei(vaults_total_values[vault_address]),
                vaults_fees[vault_address].total(),
                vault.liability_shares,
                vaults_slashing_reserve.get(vault_address, 0),
            )
        )
```

The Merkle trees use uint256 values, but in this case a negative value (vaults_fees[vault_address].total()) is passed.

Tree building process fails, resulting in failed reporting. These failures can happen ‘naturally’, or be intentionally triggered by malicious actors aiming to DOS the Oracle.

### Recommendations

- Round negative apr_ratio values to 0
- Verify calc_fee_value() doesn’t return negative values
- Consider adding a regression test that covers this case (current tests check for negative apr_ratios calculation correctness, but nothing else)

**Lido's response:** Fixed in 7582f00

**Fix Review:** Fixed. Negative APR is clamped to zero.

lido-oracle/src/utils/apr.py::calculate_gross_core_apr()

Python

```
    rate_diff: Decimal = post_share_rate_no_fees - pre_share_rate

    if rate_diff < 0:
        return Decimal(0)
```

## H-02 - Double Counting of end-of-frame block When Calculating Liquidity Fees

| Severity: **High** | Impact: **Medium** | Likelihood: **High** |
|---|---|---|
| Files: src/services/staking_vaults.py | Status: Fixed | Violated Property: N/A |

**Description:**

In calc_liquidity_fee events are used to calculate prev_liability_shares from the liability_shares of the current block by applying the events to liability_shares in reverse order.
The prev_liability_shares from the last report reflects the EL/CL state after the transactions in the last block of the frame.

staking_vaults.py::_get_start_point_for_fee_calculations:486

```python
_get_start_point_for_fee_calculations(...)
...
ref_block = get_blockstamp(self.w3.cc, last_processing_ref_slot, …)
prev_block_number = ref_block.block_number
```

When fetching the events, the range includes the prev_block already used in the last report's calculations.

events.py::get_events_in_range():67

```python
def get_events_in_range(event: ContractEvent, l_block: BlockNumber, r_block: BlockNumber) ->
Iterator[EventData]:
...
 for e in event.get_logs(from_block=l_block, to_block=to_block):
```

```
if not l_block <= e["blockNumber"] <= to_block:
raise InconsistentEvents
yield e
...
```

So events are counted twice: once in the report(as seen in the final value in the report) and once again in the reverse event calculation.

This leads to tripping an assertion and failing the report here:
staking_vaults.py::get_vaults_fees():616

```
Python
if prev_liability_shares != liability_shares:
                raise ValueError(
                    f"Wrong liability shares by vault {vault_address}. Actual
{liability_shares} != Expected {prev_liability_shares}"
                )
```

### Recommendations

- when fetching the events for calculation, omit the prev_block, i.e. use l_block+1 in get_events_in_range

**Lido's response:** Fixed in 7582f00

**Fix Review:** Fixed. _get_start_point_for_fee_calculations now returns ref_block.block_number + 1

## Medium Severity Issues

### M-01 - Missing IPFS CID Verification

| Severity: **Medium** | Impact: **High** | Likelihood: **Low** |
|---|---|---|
| Files: src/services/staking_vaults.py | Status: Fixed | Violated Property: N/A |

**Description:**

The code fetches the report based on tree_cid and immediately parses it, without verifying that the fetched report data actually matches the CID.
This is fine when using a trusted IPFS provider. However, the Oracle can be configured to use a public IPFS gateway as a fallback to Kubo and Pinata:

In staking_vaults.py::get_vault_report():369

```python
def get_vault_report(self, tree_cid: str) -> StakingVaultIpfsReport:
      bb = self.w3.ipfs.fetch(CID(tree_cid))
      return StakingVaultIpfsReport.parse_merkle_tree_data(bb)
```

main.py::ipfs_providers:142

```python
yield PublicIPFS(timeout=variables.HTTP_REQUEST_TIMEOUT_IPFS)
```

**Impact:**

The core data within the Merkle Tree remains safe. However, values outside of the Merkle Tree - extraValues and others, could be tampered with.

**Recommendations:**

- The current prioritization is correct: Kubo first, Pinata next, and the Public IPFS as a fallback.
- If Public IPFS remains an option, add a verification of the fetched report data against the provided CID - after fetching the report data and before parsing it.

**Lido's response:** Fixed in 7582f00

**Fix Review:** IPFS CID Validation Implemented.

## M-02 - Missing Fees Calculation on VaultConnectionUpdated Event

| Severity: **Medium** | Impact: **High** | Likelihood: **Low** |
|---|---|---|
| Files: VaultHub.sol, src/services/staking_vaults.py | Status: Fixed | Violated Property: N/A |

### Description:

VaultConnectionUpdated event includes fields related to fee changes (infraFeeBP, liquidityFeeBP, reservationFeeBP)
However, there is no code that handles these types of events in the Oracle (particularly within calc_liquidity_fee())

VaultHub.sol::VaultConnectionUpdated():1577

```python
event VaultConnectionUpdated(
        address indexed vault,
        uint256 shareLimit,
        uint256 reserveRatioBP,
        uint256 forcedRebalanceThresholdBP,
        uint256 infraFeeBP,
        uint256 liquidityFeeBP,r
        uint256 reservationFeeBP
```

### Impact:

The calculated fees could be incorrect.

**Recommendations:**

Add handling of such events during fees calculation.

**Lido's response:** Fixed on-chain by adding VaultFeesUpdated event to `updateConnection` method.

**Fix Review:** Fixed.

## Low Severity Issues

### L-01 - Merkle Tree Validation Missing Leaf Count

| Severity: **Low** | Impact: **Low** | Likelihood: **Low** |
|---|---|---|
| Files: lido-oracle/src/services/staking_vaults.py | Status: Acknowledged | Violated Property: N/A |

**Description:**

The oracle's is_tree_root_valid() function rebuilds a merkle tree from vault data but only validates that the root hash matches. It does not verify that the number of leaves in the reconstructed tree matches the number of leaves in the original tree structure. This allows attackers to manipulate vault data while maintaining the same root hash.

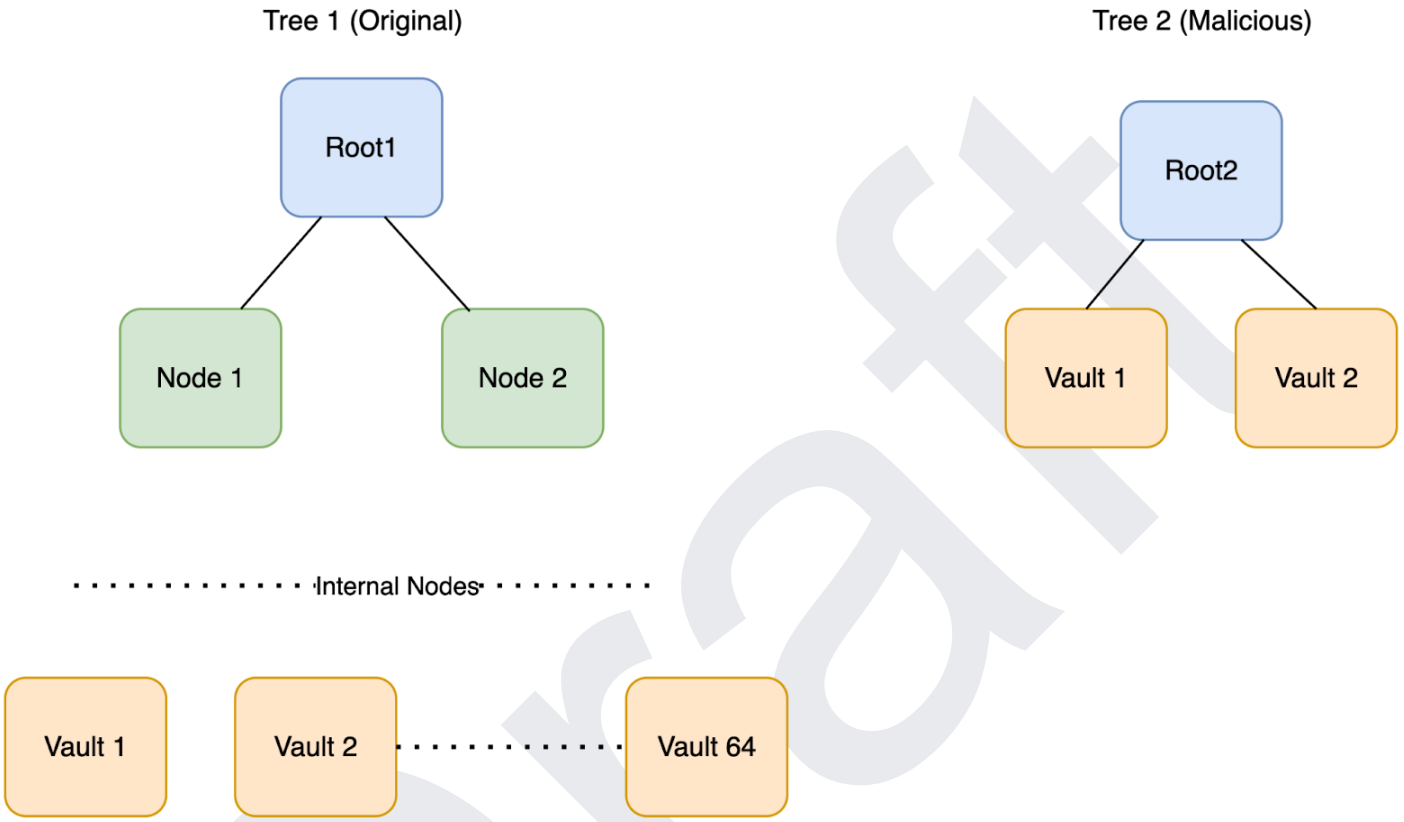
lido-oracle/src/services/staking_vaults.py:373

```python
   def is_tree_root_valid(self, expected_tree_root: str, merkle_tree: StakingVaultIpfsReport)
-> bool:
        # .... rebuild the tree ...
        return merkle_tree.tree[0] == root_hex and root_hex == expected_tree_root  # Leaf
count check not included.
```

Tree 1 and Tree 2 in the diagram below can provide the same hash. To exploit the vulnerability, an attacker has to calculate two vault data that hashes to the same value of the original Tree1 root.

$$\text{Hash}(\text{Node1}, \text{Node2}) = \text{Hash}(\text{Vault1}, \text{Vault2})$$

is_tree_root_valid() function returns True for both Tree1 and Tree2.




**Recommendation:**

Modify the is_tree_root_valid() function to validate the number of leaves.

**Lido's response:** Creating different leaf values that still lead to the exact same root would require solving a Keccak-256 second-preimage problem.

## L-02 - Lack of Validation in Event Handling

| Severity: **Low** | Impact: **Low** | Likelihood: **Low** |
|---|---|---|
| Files: src/modules/accounting/events.py | Status: Acknowledged | Violated Property: N/A |

**Description:**

Oracle's event processing system lacks proper input validation when parsing blockchain event logs. All event parsing methods directly access dictionary keys without validation, making the Oracle vulnerable to crashes when processing malformed or corrupted event data. This vulnerability can be exploited through malicious RPC node responses or network data corruption, leading to Oracle downtime and potential disruption of the Lido protocol's reporting mechanism.

src/modules/accounting/events.py:38-46

```python
@classmethod
def from_log(cls, log: EventData) -> "MintedSharesOnVaultEvent":
    args = log["args"]  # ← NO VALIDATION: KeyError if 'args' missing
    return cls(
        vault=args["vault"],  # ← NO VALIDATION: KeyError if 'vault' missing
        amount_of_shares=args["amountOfShares"],  # ← NO VALIDATION: KeyError/TypeError
        locked_amount=args["lockedAmount"],  # ← NO VALIDATION: KeyError/TypeError
        **cls._extract_common(log),
    )
```

src/modules/accounting/events.py:20-29

```python
@classmethod
def from_log(cls, log: EventData) -> "MintedSharesOnVaultEvent":
    args = log["args"]  # ← NO VALIDATION: KeyError if 'args' missing
    return cls(
        vault=args["vault"],  # ← NO VALIDATION: KeyError if 'vault' missing
        amount_of_shares=args["amountOfShares"],  # ← NO VALIDATION: KeyError/TypeError
```

```
        locked_amount=args["lockedAmount"],  # ← NO VALIDATION: KeyError/TypeError
        **cls._extract_common(log),
    )
```

All Event Classes Affected

- MintedSharesOnVaultEvent.from_log() - Lines 38-46
- BurnedSharesOnVaultEvent.from_log() - Lines 55-61
- VaultFeesUpdatedEvent.from_log() - Lines 75-85
- VaultRebalancedEvent.from_log() - Lines 97-103
- BadDebtSocializedEvent.from_log() - Lines 115-121
- BadDebtWrittenOffToBeInternalizedEvent.from_log() - Lines 133-139

**Exploit Scenario**

Malicious RPC Node Response

1. Attacker compromises or controls an RPC node that the Oracle uses for event fetching
2. RPC node returns corrupted event data with missing or malformed fields
3. Oracle processes the corrupted event during fee calculation in calc_liquidity_fee()
4. KeyError exception crashes the Oracle when trying to access log["args"]
5. Oracle stops processing reports, disrupting the Lido protocol

**Recommendations**

1. Add Validation to Common Field Extraction:

Python

```python
@classmethod
def _extract_common(cls, log: EventData) -> Dict[str, Any]:
    """Extract common fields with validation."""
    try:
        required_fields = [
            "event", "logIndex", "transactionIndex",
            "transactionHash", "address", "blockHash", "blockNumber"
        ]

        for field in required_fields:
            if field not in log:
                raise ValueError(f"Missing required field: {field}")

        return {
            "event": log["event"],
            "log_index": log["logIndex"],
```

```
            "transaction_index": log["transactionIndex"],
            "transaction_hash": log["transactionHash"],
            "address": log["address"],
            "block_hash": log["blockHash"],
            "block_number": log["blockNumber"],
        }
    except Exception as e:
        logger.error(f"Failed to extract common fields: {e}, log: {log}")
        raise ValueError(f"Invalid event log structure: {e}")
```

2. Add Graceful Error Handling in Event Processing
3. Add Event Validation Tests

### L-03 - Kubo RPC API Bound to 0.0.0.0

| Severity: **Low** | Impact: **Low** | Likelihood: **Low** |
|---|---|---|
| Files: kubo/010-set-conf.sh | Status Acknowledged | Violated Property: N/A |

**Description:**

The Kubo API is bound within the container, and has no authentication. This API allows full control over the IPFS node.

kubo/010-set-conf.sh:11

```python
ipfs config Addresses.API /ip4/0.0.0.0/tcp/$API_PORT
```

Impact is limited since this isn't internet exposed, but it is reachable within the same docker network, and could get published by Oracle operators unaware of the risk.

The API allows malicious actors to fully control the IPFS node. As configured now, it can be targeted in a lateral movement (attackers that reached the docker network can target it), and could easily be misconfigured to face the internet.

**Recommendations**

1. Prefer using 127.0.0.1 instead of 0.0.0.0 to limit exposure if possible

## L-04 - Prometheus Server Bound to 0.0.0.0

| Severity: **Low** | Impact: **Low** | Likelihood: **Low** |
| --- | --- | --- |
| Files: src/main.py, Dockerfile | Status: Acknowledged | Violated Property: N/A |

**Description:**

src/main.py:56

```python
start_http_server(variables.PROMETHEUS_PORT)
```

Dockerfile:67

```python
ENV PROMETHEUS_PORT=9000
..
EXPOSE $PROMETHEUS_PORT
```

The Prometheus HTTP server is bound to all interfaces within the container, and the port is exposed.
This allows for various information to be disclosed to attackers, and is available as a potential DDOS target.
Impact is limited since this isn't internet exposed, but it is reachable within the same docker network, and could get published by Oracle operators unaware of the risk.

The Prometheus HTTP server allows for information disclosure. As configured now, it can be targeted in a lateral movement (attackers that reached the docker network can target it), and could easily be misconfigured to face the internet (which would make this critical).

**Recommendations**

1. Prefer using 127.0.0.1 instead of 0.0.0.0 to limit exposure if possible

## L-05 - Missing IPFS Data Validation

| Severity: **Low** | Impact: **Low** | Likelihood: **Low** |
|---|---|---|
| Files: src/modules/accounting/types.py, src/services/staking_vaults.py | Status: Acknowledged | Violated Property: N/A |

**Description:**

Oracle lacks proper validation of IPFS data before processing, making it vulnerable to malicious IPFS nodes that can return corrupted or malformed data. This vulnerability can cause the Oracle to crash with JSON parsing errors, IndexError due to empty merkle tree or other exceptions, leading to denial-of-service attacks and potential disruption of the entire Lido staking protocol.

src/modules/accounting/types.py:324

```python
def from_ipfs_data(cls, raw_bytes: bytes) -> "StakingVaultIpfsReport":
    data = json.loads(raw_bytes.decode("utf-8"))  # ← No validation
    return cls(
        format=data["format"],
        leaf_encoding=data["leafEncoding"],
        tree=data["tree"],  # ← Assumes tree exists and is valid
        values=data["values"],
        extra_values=data["extraValues"],
    )±
```

src/services/staking_vaults.py:388

```python
def is_tree_root_valid(self, expected_tree_root: str, merkle_tree: StakingVaultIpfsReport) ->
bool:
    # ... build tree_data ...
```

```
    rebuild_merkle_tree = self.get_merkle_tree(tree_data)
    root_hex = f'0x{rebuild_merkle_tree.root.hex()}'
    return merkle_tree.tree[0] == root_hex and root_hex == expected_tree_root  # ←
IndexError if tree is empty
```

**Exploit Scenario**

- Malicious IPFS node returns valid JSON but with empty tree data:

```
Python
{
  "format": "standard-v1",
  "leafEncoding": ["address", "uint256", "uint256", "uint256", "int256"],
  "tree": [],  // ← Empty array
  "values": [],  // ← Empty array
  "extraValues": {}
}
```

IndexError when accessing merkle_tree.tree[0], causing Oracle crash

- Malicious IPFS node returns invalid JSON, causing *json.loads* to raise json.decoder.JSONDecodeError exception
- Malicious IPFS node returns non UTF-8 characters causing *raw_bytes.decode('utf-8')* to raise UnicodeDecodeError.

## Recommendations

In parse_merkle_tree_data:

- Require IPFS data size limits

```
Python
        if len(raw_bytes) > MAX_IPFS_DATA_SIZE:
            logger.warning(f"IPFS data too large: {len(raw_bytes)} bytes")
            return None
```

- Handle UTF-8 decoding errors

```python
        try:
            decoded_str = raw_bytes.decode("utf-8")
        except UnicodeDecodeError as e:
            logger.warning(f"Invalid UTF-8 encoding: {e}")
            return None
```

- Handle JSON parsing errors

```python
        try:
            data = json.loads(decoded_str)
        except json.JSONDecodeError as e:
            logger.warning(f"Invalid JSON data: {e}")
            return None
        except Exception as e:
            logger.warning(f"Unexpected error parsing JSON: {e}")
            return None
```

- Validate required JSON fields

```python
        required_fields = ["format", "leafEncoding", "tree", "values", "extraValues"]
        for field in required_fields:
            if field not in data:
                logger.warning(f"Missing required field: {field}")
                return None
```

- Validate Tree Structure

```python
       if not isinstance(data["tree"], list) or len(data["tree"]) == 0:
            logger.warning("Invalid tree structure")
            return None
```

**Lido's response:** CID Validation reduces this risk as the oracle processes only validated IPFS report data. While CID Validation is not mandatory, disabling it should be used only for testing.

## L-06 - Double Counting of end-of-frame block When Calculating Liquidity Fees (Partial Fix)

| Severity: **Low** | Impact: **Low** | Likelihood: **Low** |
|---|---|---|
| Files: src/modules/accounting/types.py, src/services/staking_vaults.py | Status: Fixed | Violated Property: N/A |

**Description:**

This is a continuation issue of "H-02: Double Counting of end-of-frame block When Calculating Liquidity Fees", covering only the main code path. Double Counting is still feasible when the ipfs report is unavailable. Fix should be applied to this case as well.

staking_vaults.py:_get_start_point_for_fee_calculations():511

Python

```
            # Prevent double-counting of vault events:
             # If any vault-related event occurred in the same block as the previous IPFS
report,
             # it has already been included in that report. To avoid overlapping calculations,
             # we shift the starting point by one block forward.
             return prev_ipfs_report, ref_block.block_number + 1

        ## When we do NOT HAVE prev IPFS report => we have to check two branches: for mainnet
and devnet (genesis vaults support)
        ## Mainnet
        ##   in case when we don't have prev ipfs report - we DO have previous oracle report
        ##   it means we have to take this point for getting fees at the FIRST time only
        last_processing_ref_slot =
accounting_oracle.get_last_processing_ref_slot(blockstamp.block_hash)
        if last_processing_ref_slot:
            ref_block = get_blockstamp(
```

```
                self.w3.cc, last_processing_ref_slot,
SlotNumber(int(last_processing_ref_slot) + slots_per_frame)
            )
            return None, ref_block.block_number      # <-- Double Counting Still Possible
```

### Recommendations

Use ref_block.block_number + 1 also when the ipfs report is unavailable.

**Lido's response:** Fixed in ecb54a9

**Fix Review:** Fixed.

## L-07 - Storacha Upload URL Leak in Oracle Logs

| Severity: **Low** | Impact: **Low** | Likelihood: **Low** |
|---|---|---|
| lido-oracle/src/providers/ipfs/storacha.py | Status: Not Fixed | Violated Property: N/A |

**Description:**

Storacha file upload URL used for the PUT operation is included in the exception logging and contain sensitive token. According to the example in the storacha API Bridge documentation, this is an ephemeral url which is used for submitting the file and no other credential is being used: https://docs.storacha.network/how-to/http-bridge/

lido-oracle/src/providers/ipfs/storacha.py:92

```python
        if store_result['status'] == 'upload':
            upload_url = store_result['url']
            upload_headers = store_result['headers']

            try:
                upload_response = requests.put(upload_url, headers=upload_headers,
data=car_file.car_bytes, timeout=self.timeout)
                upload_response.raise_for_status()
            except requests.RequestException as ex:
                logger.error({"msg": "Upload request failed", "error": str(ex)})   #
upload_url is logged
                raise UploadError(f"Upload request failed: {ex}") from ex
```

**Recommendations**

Sanitize the error message, filter out the sensitive upload URL.

**Lido's response:** Fixed in 0095fbe

**Fix Review:** Fixed.

# Informational Severity Issues

## I-01 - oz_merkle_tree Proof Verification on Internal Node (Informational)

**Description:** The `StandardMerkleTree.verify()` function in the `oz_merkle_tree` library accepts any 32-byte value as a "leaf" without validating that it represents actual leaf data. This allows internal tree nodes to be used as "leaves" in merkle proofs, potentially enabling data forgery attacks. The Lido oracle's security is not affected as it only uses this library for tree generation, not proof verification. However, if the `verify()` function is used in future oracle implementations, developers must be aware of this vulnerability.

## I-02 - Division by Zero in get_steth_by_shares Function

**Description:**

The get_steth_by_shares function lacks validation for zero total_shares, which can lead to a ZeroDivisionError when total_shares is 0.

src/utils/apr.py:31-33

```python
def get_steth_by_shares(shares: int, total_ether: int, total_shares: int) -> Decimal:
    return (Decimal(shares) * Decimal(total_ether)) / Decimal(total_shares)  # ← NO
VALIDATION
```

**Lido's response:** Acknowledged, total shares can't go below 10

## I-03 - Consensus-critical contract methods should use finalized block by default

### Description:

The Oracle system uses finalized blocks for all consensus-critical operations to ensure consistency and prevent race conditions between different Oracle instances. However, the contract interface methods default to 'latest' instead of 'finalized', creating an inconsistency that could lead to consensus failures if future code changes accidentally use the default parameter. While the current codebase doesn't issue any calls that use the default parameter, this design flaw makes the system prone to errors during future development.

src/providers/execution/contracts/lazy_oracle.py:35

```python
   def get_latest_report_data(self, block_identifier: BlockIdentifier = 'latest') ->
OnChainIpfsVaultReportData:
```

**Recommendation**:

Change the default parameter from 'latest' to 'finalized' for consensus-critical methods:

```python
   def get_latest_report_data(self, block_identifier: BlockIdentifier = 'finalized') ->
OnChainIpfsVaultReportData:
```

**Lido's response:** Acknowledged, will be fixed in future versions

## I-04 - Incorrect Events Order Leads to Wrong Fees Calculation

**Description:**

in staking_vaults.py::get_vaults_fees() (#533) events dict is generated by type:

```python
for fees_updated_event in fees_updated_events:
            events[fees_updated_event.vault].append(fees_updated_event)

        for minted_event in minted_events:
            events[minted_event.vault].append(minted_event)

        for burned_event in burn_events:
            events[burned_event.vault].append(burned_event)
...
```

staking_vaults.py::calc_liquidity_fee():449

```python
events[vault_address].sort(key=lambda x: x.block_number, reverse=True)
```

- get_vaults_fees() generates the events dict by type.
- calc_liquidity_fee() sorts the event lists by block numbers only.
- If two different event types take place at the same block, and affect fees - the fees calculated within that block can be wrong (yet deterministic for all Oracles).
- For example, if a block contains VaultFeesUpdated events as well as MintedSharesOnVault events, the fees calculated by the Oracle within that block may be incorrect (fees should be calculated by onchain chronological order)

**Impact**: If a block contains multiple fees related events, this issue leads to incorrect fees calculation. Vault owners and/or stakers may abuse this to minimize fees within blocks.

**Recommendation**:

Use a stable sort based on block number, tx index and log index.

**Lido's response:** Fixed in 7582f00

**Fix Review:** Fixed. Events are now sorted by log_index.

## I-05 - Missing reservation_fee_bp and infra_fee_bp Updates Within Frame Lead to Incorrect Fees Calculation

**Description:**

staking_vaults.py::calc_fee_value():391

```python
def calc_fee_value(value: Decimal, block_elapsed: int, core_apr_ratio: Decimal, fee_bp: int)
-> Decimal:
        return value * Decimal(block_elapsed) * core_apr_ratio * Decimal(fee_bp) /
Decimal(BLOCKS_PER_YEAR * TOTAL_BASIS_POINTS)
```

- get_vaults_fees() calculates vault_infrastructure_fee and vault_reservation_liquidity_fee using calc_fee_value()
- This ignores any fee changes within the frame.

This can lead to incorrect fee calculations within the frame. Malicious actors can abuse this to minimize fees, and all users might pay incorrect fees.

**Recommendation**:

Apply fee changes within the frame, similar to how calc_liquidity_fee() works

**Lido's response:** Works as intended.

### I-06 - Oracle HTTP Provider follows HTTP Redirects (30x)

**Description:**

The oracle uses the HTTProvider class for HTTP related operation on multiple components - fetching Consensus Layer Data, Validator Keys, IPFS operations, monitoring and alerts.

HTTPProvider uses requests.Session() which, by default, sets allow_redirects=True.
If an attacker manages to compromise a domain or an endpoint used by the oracle and make it redirect to a domain it controls, they would be able to provide malicious responses.

**Recommendation**:

1. By default, allow following redirects only to the same host.
2. If a specific component or service requires HTTP redirects then enable it specifically for that service.

**Lido's response:** Acknowledged, will be fixed in future versions.



# Disclaimer

Even though we hope this information is helpful, we provide no warranty of any kind, explicit or implied. The contents of this report should not be construed as a complete guarantee that the contract is secure in all dimensions. In no event shall Certora or any of its employees be liable for any claim, damages, or other liability, whether in an action of contract, tort, or otherwise, arising from, out of, or in connection with the results reported here.

# About Certora

Certora is a Web3 security company that provides industry-leading formal verification tools and smart contract audits. Certora's flagship security product, Certora Prover, is a unique SaaS product that automatically locates even the most rare & hard-to-find bugs on your smart contracts or mathematically proves their absence. The Certora Prover plugs into your standard deployment pipeline. It is helpful for smart contract developers and security researchers during auditing and bug bounties.

Certora also provides services such as auditing, formal verification projects, and incident response.