ABDK CONSULTING

SMART CONTRACT AUDIT

ZeroPool

EVM smart

Solidity

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SMART CONTRACT AUDIT CONCLUSION

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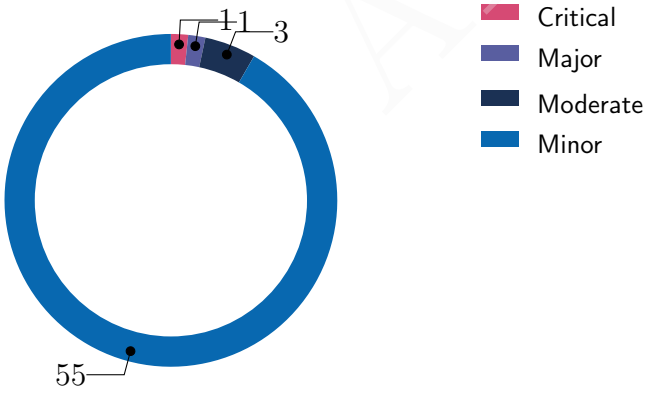
29th June 2022

We've been asked to review the following files:

- Pool.sol
- Parameters.sol

We found 1 critical, and a few less important issues. The critical issue and a few other ones were fixed.



Findings

ID	Severity	Category	Status
CVF-1	Minor	Procedural	Info
CVF-2	Minor	Documentation	Fixed
CVF-3	Minor	Procedural	Fixed
CVF-4	Minor	Bad naming	Info
CVF-5	Minor	Procedural	Info
CVF-6	Minor	Bad naming	Info
CVF-7	Minor	Bad naming	Info
CVF-8	Minor	Bad datatype	Fixed
CVF-9	Minor	Suboptimal	Info
CVF-10	Minor	Suboptimal	Info
CVF-11	Minor	Suboptimal	Info
CVF-12	Minor	Suboptimal	Info
CVF-13	Minor	Procedural	Info
CVF-14	Minor	Procedural	Info
CVF-15	Minor	Suboptimal	Info
CVF-16	Minor	Suboptimal	Info
CVF-17	Major	Suboptimal	Info
CVF-18	Minor	Suboptimal	Info
CVF-19	Minor	Suboptimal	Info
CVF-20	Minor	Suboptimal	Info
CVF-21	Minor	Suboptimal	Info
CVF-22	Minor	Bad datatype	Info
CVF-23	Minor	Suboptimal	Info
CVF-24	Minor	Suboptimal	Info
CVF-25	Minor	Suboptimal	Info
CVF-26	Minor	Unclear behavior	Info
CVF-27	Minor	Readability	Fixed

ID	Severity	Category	Status
CVF-28	Moderate	Flaw	Info
CVF-29	Minor	Procedural	Fixed
CVF-30	Minor	Procedural	Info
CVF-31	Minor	Procedural	Fixed
CVF-32	Minor	Procedural	Info
CVF-33	Minor	Procedural	Fixed
CVF-34	Minor	Procedural	Info
CVF-35	Minor	Procedural	Fixed
CVF-36	Minor	Documentation	Info
CVF-37	Minor	Bad naming	Info
CVF-38	Minor	Readability	Info
CVF-39	Minor	Bad datatype	Info
CVF-40	Minor	Bad datatype	Info
CVF-41	Minor	Documentation	Info
CVF-42	Minor	Readability	Info
CVF-43	Minor	Unclear behavior	Info
CVF-44	Minor	Suboptimal	Info
CVF-45	Minor	Procedural	Info
CVF-46	Minor	Unclear behavior	Info
CVF-47	Minor	Documentation	Info
CVF-48	Minor	Suboptimal	Info
CVF-49	Minor	Overflow/Underflow	Info
CVF-50	Minor	Suboptimal	Info
CVF-51	Minor	Suboptimal	Info
CVF-52	Minor	Bad datatype	Info
CVF-53	Minor	Suboptimal	Info
CVF-54	Moderate	Flaw	Info
CVF-55	Moderate	Flaw	Fixed
CVF-56	Minor	Flaw	Fixed
CVF-57	Critical	Flaw	Fixed

ID	Severity	Category	Status
CVF-58	Minor	Bad datatype	Fixed
CVF-59	Minor	Documentation	Fixed
CVF-60	Minor	Suboptimal	Fixed

Contents

1 Document properties

Version

Version	Date	Author	Description
0.1	January 31, 2022	D. Khovratovich	Initial Draft
0.2	January 31, 2022	D. Khovratovich	Minor revision
1.0	January 31, 2022	D. Khovratovich	Release
1.1	June 28, 2022	D. Khovratovich	New issues are added
1.2	June 28, 2022	D. Khovratovich	Minor revision
2.0	June 29, 2022	D. Khovratovich	Release

Contact

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2 Introduction

The following document provides the result of the audit performed by ABDK Consulting at the customer request. The audit goal is a general review of the smart contracts structure, critical/major bugs detection and issuing the general recommendations.
We have reviewed the repository with the following files:

- Parameters.sol
- Pool.sol

The fixes were provided in a new commit.

2.1 About ABDK

ABDK Consulting, established in 2016, is a leading service provider in the space of blockchain development and audit. It has contributed to numerous blockchain projects, and co-authored some widely known blockchain primitives like Poseidon hash function. The ABDK Audit Team, led by Mikhail Vladimirov and Dmitry Khovratovich, has conducted over 40 audits of blockchain projects in Solidity, Rust, Circom, C++, JavaScript, and other languages.

2.2 Disclaimer

Note that the performed audit represents current best practices and smart contract standards which are relevant at the date of publication. After fixing the indicated issues the smart contracts should be re-audited.

2.3 Methodology

The methodology is not a strict formal procedure, but rather a collection of methods and tactics that combined differently and tuned for every particular project, depending on the project structure and and used technologies, as well as on what the client is expecting from the audit. In current audit we use:

- **General Code Assessment**. The code is reviewed for clarity, consistency, style, and for whether it follows code best practices applicable to the particular programming language used. We check indentation, naming convention, commented code blocks, code duplication, confusing names, confusing, irrelevant, or missing comments etc. At this phase we also understand overall code structure.
- **Entity Usage Analysis**. Usages of various entities defined in the code are analysed. This includes both: internal usages from other parts of the code as well as potential external usages. We check that entities are defined in proper places and that their visibility scopes and access levels are relevant. At this phase we understand overall system architecture and how different parts of the code are related to each other.
- **Access Control Analysis**. For those entities, that could be accessed externally, access control measures are analysed. We check that access control is relevant and is done properly. At this phase we understand user roles and permissions, as well as what assets the system ought to protect.

- **Code Logic Analysis**. The code logic of particular functions is analysed for correctness and efficiency. We check that code actually does what it is supposed to do, that algorithms are optimal and correct, and that proper data types are used. We also check that external libraries used in the code are up to date and relevant to the tasks they solve in the code. At this phase we also understand data structures used and the purposes they are used for.

3 Detailed Results

3.1 CVF-1

- **Severity** Minor
- **Status** Info
- **Category** Procedural
- **Source** Parameters.sol

Description Should be "^0.8.0" unless there is something special about this particular version.
Client Comment Will not fix. 0.8.0 compiler gets internal compiler error when try to compile the source code.

Listing 1:

```
pragma solidity ^0.8.10;
```

3.2 CVF-2

- **Severity** Minor
- **Status** Fixed
- **Category** Documentation
- **Source** Parameters.sol

Description This comment is confusing. Consider either removing it or adding some explanation about how to read it.

Listing 2:

```
/*
uint256;*;32;transfer_nullifier;
uint256;*;32;transfer_out_commit;
uint48;*;6;transfer_index;
int112;*;14;transfer_energy_amount;
int64;*;8;transfer_token_amount;
uint256[8] calldata;*;256;transfer_proof
uint256;32;*;tree_root_after
uint256[8] calldata;*;256;tree_proof
uint256;*;2;tx_type
uint256;*;2;memo_data_size
bytes calldata;*;memo_data_size();memo_data
bytes32;*;32;sign_r
bytes32;*;32;sign_vs
uint256;{transfer_index};28;transfer_delta
bytes calldata;{memo_data}+memo_fixed_size();memo_data_size()-
    ↪ memo_fixed_size();memo_message
uint256;{memo_data};8;memo_fee
uint256;*;8;memo_native_amount
uint256;*;20;memo_receiver
*/
```

3.3 CVF-3

- **Severity** Minor
- **Status** Fixed
- **Category** Procedural
- **Source** Parameters.sol

Description This contract should be moved to a separate file named "CustomABIDecoder.sol".

Listing 3:

```
25 contract CustomABIDecoder {
```

3.4 CVF-4

- **Severity** Minor
- **Status** Info
- **Category** Bad naming
- **Source** Parameters.sol

Description There is no access level specified for these variables and constants, so internal access will be used by default.
Recommendation Consider explicitly specifying an access level.
Client Comment Will not fix.

Listing 4:

```
26 uint256 constant transfer_nullifier_pos = 4;
   uint256 constant transfer_nullifier_size = 32;

46 uint256 constant transfer_index_pos = transfer_out_commit_pos +
     ↪ transfer_out_commit_size;
   uint256 constant transfer_index_size = 6;

53 uint256 constant transfer_energy_amount_pos = transfer_index_pos
     ↪  + transfer_index_size;
   uint256 constant transfer_energy_amount_size = 14;

60 uint256 constant transfer_token_amount_pos =
     ↪ transfer_energy_amount_pos + transfer_energy_amount_size;
   uint256 constant transfer_token_amount_size = 8;

67 uint256 constant transfer_proof_pos = transfer_token_amount_pos
     ↪ + transfer_token_amount_size;
   uint256 constant transfer_proof_size = 256;

77 uint256 constant tree_root_after_pos = transfer_proof_pos +
     ↪ transfer_proof_size;
   uint256 constant tree_root_after_size = 32;

84 uint256 constant tree_proof_pos = tree_root_after_pos +
     ↪ tree_root_after_size;
   uint256 constant tree_proof_size = 256;

94 uint256 constant tx_type_pos = tree_proof_pos + tree_proof_size;
   uint256 constant tx_type_size = 2;
   uint256 constant tx_type_mask = (1 << (tx_type_size*8)) - 1;

102 uint256 constant memo_data_size_pos = tx_type_pos + tx_type_size
     ↪ ;
   uint256 constant memo_data_size_size = 2;
   uint256 constant memo_data_size_mask = (1 << (
     ↪ memo_data_size_size*8)) - 1;
```

(... 107, 125, 135, 161, 169, 177)

3.5 CVF-5

- **Severity** Minor
- **Status** Info
- **Category** Procedural
- **Source** Parameters.sol

Description There is no access level specified for these constants, so internal access will be sued by default. Consider explicitly specifying an access level.
Recommendation Constants are usually named IN_UPPER_CASE.
Client Comment Will not fix.

Listing 5:

```
26 uint256 constant transfer_nullifier_pos = 4;
   uint256 constant transfer_nullifier_size = 32;

39 uint256 constant transfer_out_commit_pos =
     ↪ transfer_nullifier_pos + transfer_nullifier_size;
40 uint256 constant transfer_out_commit_size = 32;

46 uint256 constant transfer_index_pos = transfer_out_commit_pos +
     ↪ transfer_out_commit_size;
   uint256 constant transfer_index_size = 6;

53 uint256 constant transfer_energy_amount_pos = transfer_index_pos
     ↪  + transfer_index_size;
   uint256 constant transfer_energy_amount_size = 14;

60 uint256 constant transfer_token_amount_pos =
     ↪ transfer_energy_amount_pos + transfer_energy_amount_size;
   uint256 constant transfer_token_amount_size = 8;

67 uint256 constant transfer_proof_pos = transfer_token_amount_pos
     ↪ + transfer_token_amount_size;
   uint256 constant transfer_proof_size = 256;

77 uint256 constant tree_root_after_pos = transfer_proof_pos +
     ↪ transfer_proof_size;
   uint256 constant tree_root_after_size = 32;

84 uint256 constant tree_proof_pos = tree_root_after_pos +
     ↪ tree_root_after_size;
   uint256 constant tree_proof_size = 256;

94 uint256 constant tx_type_pos = tree_proof_pos + tree_proof_size;
   uint256 constant tx_type_size = 2;
   uint256 constant tx_type_mask = (1 << (tx_type_size*8)) - 1;
```

(... 102, 107, 125, 135, 161, 169, 171, 188)

3.6 CVF-6

- **Severity** Minor
- **Status** Info
- **Category** Bad naming
- **Source** Parameters.sol

Recommendation Functions are usually named inCamelCase.

Listing 6:

```
29 function _loaduint256(uint256 pos) pure internal returns(uint256
   ↪  r) {

35 function _transfer_nullifier() pure internal returns(uint256 r)
   ↪ {

42 function _transfer_out_commit() pure internal returns(uint256 r)
   ↪  {

49 function _transfer_index() pure internal returns(uint48 r) {

56 function _transfer_energy_amount() pure internal returns(int112
   ↪ r) {

63 function _transfer_token_amount() pure internal returns(int64 r)
   ↪  {

70 function _transfer_proof() pure internal returns (uint256[8]
   ↪ calldata r) {

80 function _tree_root_after() pure internal returns(uint256 r) {

87 function _tree_proof() pure internal returns (uint256[8]
   ↪ calldata r) {

98 function _tx_type() pure internal returns(uint256 r) {

108 function _memo_data_size() pure internal returns(uint256 r) {

112 function _memo_data() pure internal returns(bytes calldata r) {

121 function _sign_r_vs_pos() pure internal returns(uint256) {

127 function _sign_r_vs() pure internal returns(bytes32 r, bytes32
   ↪ vs) {

138 function _transfer_delta() pure internal returns(uint256 r) {

142 function _memo_fixed_size() pure internal returns(uint256 r) {
```

(... 151, 165, 173, 193, 198, 206, 213)

3.7 CVF-7

- **Severity** Minor
- **Status** Info
- **Category** Bad naming
- **Source** Parameters.sol

Description The function name doesn't give a clue about where the function loads a value form. Consider renaming to "calldataload". It would make it obvious that the function is just a wrapper for the opcode with the same name.
Client Comment Will not fix. We use it, because inline assembly is not compatible with constant variables. Seems, it is issue of the compiler.

Listing 7:

```
29 function _loaduint256(uint256 pos) pure internal returns(uint256
   ↪  r) {
```

3.8 CVF-8

- **Severity** Minor
- **Status** Fixed
- **Category** Bad datatype
- **Source** Parameters.sol

Description Constant '32' should be named

Listing 8:

```
50 r = uint48(_loaduint256(transfer_index_pos+transfer_index_size
   ↪ -32));

64 r = int64(uint64(_loaduint256(transfer_token_amount_pos+
   ↪ transfer_token_amount_size-32)));

99 r = _loaduint256(tx_type_pos+tx_type_size-32) & tx_type_mask;
```

3.9 CVF-9

- **Severity** Minor
- **Status** Info
- **Category** Suboptimal
- **Source** Parameters.sol

Recommendation This line could be simplified as: r = uint48(_loaduint256(transfer_index_pos) » 208);
Client Comment Will not fix.

Listing 9:

```
50 r = uint48(_loaduint256(transfer_index_pos+transfer_index_size
   ↪ -32));
```

3.10 CVF-10

- **Severity** Minor
- **Status** Info
- **Category** Suboptimal
- **Source** Parameters.sol

Recommendation This line could be simplified as: r = int112(uint112(_loaduint256(transfer_energy_amount_pos) » 144);
Client Comment Will not fix.

Listing 10:

```
57 r = int112(uint112(_loaduint256(transfer_energy_amount_pos+
   ↪ transfer_energy_amount_size-32)));
```

3.11 CVF-11

- **Severity** Minor
- **Status** Info
- **Category** Suboptimal
- **Source** Parameters.sol

Recommendation This line could be simplified as: r = int64(uint64(_loaduint256(transfer_token_amount_pos) » 192));
Client Comment Will not fix.

Listing 11:

```
64 r = int64(uint64(_loaduint256(transfer_token_amount_pos+
   ↪ transfer_token_amount_size-32)));
```

3.12 CVF-12

- **Severity** Minor
- **Status** Info
- **Category** Suboptimal
- **Source** Parameters.sol

Description These non-elegant "pos+size-32" formulas wouldn't be needed in case the "_loaduint256" would return bytes32 instead of uint256.
Recommendation Consider the following code chunk: https://gist.github.com/3sGgpQ8H/87ab4df1c7b7ab91cbfd0f4b249a26be
Client Comment Will not fix.

Listing 12:

```
50  r = uint48(_loaduint256(transfer_index_pos+transfer_index_size
      ↪ -32));

57  r = int112(uint112(_loaduint256(transfer_energy_amount_pos+
      ↪ transfer_energy_amount_size-32)));

64  r = int64(uint64(_loaduint256(transfer_token_amount_pos+
      ↪ transfer_token_amount_size-32)));

99  r = _loaduint256(tx_type_pos+tx_type_size-32) & tx_type_mask;

109 r = _loaduint256(memo_data_size_pos+memo_data_size_size-32) &
      ↪ memo_data_size_mask;

139 r = _loaduint256(transfer_index_pos+transfer_delta_size-32) &
      ↪ transfer_delta_mask;

166 r = _loaduint256(memo_fee_pos+memo_fee_size-32) & memo_fee_mask;

174 r = _loaduint256(memo_native_amount_pos+memo_native_amount_size
      ↪ -32) & memo_native_amount_mask;

181 r = address(uint160(_loaduint256(memo_receiver_pos+
      ↪ memo_receiver_size-32)));
```

3.13 CVF-13

- **Severity** Minor
- **Status** Info
- **Category** Procedural
- **Source** Parameters.sol

Description This constant must be related to ‘transfer_proof_size‘
Client Comment Will not fix.

Listing 13:

```
70 function _transfer_proof() pure internal returns (uint256[8]
   ↪ calldata r) {
```

3.14 CVF-14

- **Severity** Minor
- **Status** Info
- **Category** Procedural
- **Source** Parameters.sol

Description This constant must be related to ‘tree_proof_size‘
Client Comment Will not fix.

Listing 14:

```
87 function _tree_proof() pure internal returns (uint256[8]
   ↪ calldata r) {
```

3.15 CVF-15

- **Severity** Minor
- **Status** Info
- **Category** Suboptimal
- **Source** Parameters.sol

Description These variables are redundant, as Solidity allows using named constants inside assembly blocks.
Client Comment Will not fix.

Listing 15:

```
71  uint256 pos = transfer_proof_pos;

88  uint256 pos = tree_proof_pos;

113 uint256 offset = memo_data_pos;
```

3.16 CVF-16

- **Severity** Minor
- **Status** Info
- **Category** Suboptimal
- **Source** Parameters.sol

Recommendation This line could be simplified as: r = _loaduint256(tx_type_pos) » 240;
Client Comment Will not fix.

Listing 16:

```
99 r = _loaduint256(tx_type_pos+tx_type_size-32) & tx_type_mask;
```

3.17 CVF-17

- **Severity** Major
- **Status** Info
- **Category** Suboptimal
- **Source** Parameters.sol

Description These functions return a 256-bit value, whereas internally the number is smaller. Handling 256-bit numbers in the caller functions is error-prone and requires more overflow checks.
Recommendation Consider returning 128- or 192-bit values.
Client Comment Will not fix.

Listing 17:

```
108 function _memo_data_size() pure internal returns(uint256 r) {

121 function _sign_r_vs_pos() pure internal returns(uint256) {

138 function _transfer_delta() pure internal returns(uint256 r) {

142 function _memo_fixed_size() pure internal returns(uint256 r) {

165 function _memo_fee() pure internal returns(uint256 r) {

173 function _memo_native_amount() pure internal returns(uint256 r)
    ↪ {
```

3.18 CVF-18

- **Severity** Minor
- **Status** Info
- **Category** Suboptimal
- **Source** Parameters.sol

Recommendation This line could be simplified as: r = _loaduint256(memo_data_size_pos) » 240;
Client Comment Will not fix.

Listing 18:

```
109 r = _loaduint256(memo_data_size_pos+memo_data_size_size-32) &
    ↪ memo_data_size_mask;
```

3.19 CVF-19

- **Severity** Minor
- **Status** Info
- **Category** Suboptimal
- **Source** Parameters.sol

Description Assembly is unnecessary here.
Recommendation Just use the "_loaduint256" function and convert results to "bytes32".
Client Comment Will not fix.

Listing 19:

```
129 assembly {
130     r := calldataload(offset)
    vs := calldataload(add(offset, 32))
}
```

3.20 CVF-20

- **Severity** Minor
- **Status** Info
- **Category** Suboptimal
- **Source** Parameters.sol

Recommendation This line could be simplified as: r = _loaduint256(transfer_index_pos) » 32;
Client Comment Will not fix.

Listing 20:

```
139 r = _loaduint256(transfer_index_pos+transfer_delta_size-32) &
    ↪ transfer_delta_mask;
```

3.21 CVF-21

- **Severity** Minor
- **Status** Info
- **Category** Suboptimal
- **Source** Parameters.sol

Recommendation This function could be optimized as: require (_tx_type < 3); return uint8 (0x240808 » (_tx_type « 3));
Client Comment Will not fix.

Listing 21:

```
142 function _memo_fixed_size() pure internal returns(uint256 r) {
```

3.22 CVF-22

- **Severity** Minor
- **Status** Info
- **Category** Bad datatype
- **Source** Parameters.sol

Description These constants should be named or, even better, belong to some enumerated type.
Client Comment Will not fix.

Listing 22:

```
145 r = 8;

147 r = 36;
```

3.23 CVF-23

- **Severity** Minor
- **Status** Info
- **Category** Suboptimal
- **Source** Parameters.sol

Recommendation This line could be simplified as: r = _loaduint256(memo_fee_pos) » 192;
Client Comment Will not fix.

Listing 23:

```
166 r = _loaduint256(memo_fee_pos+memo_fee_size-32) & memo_fee_mask;
```

3.24 CVF-24

- **Severity** Minor
- **Status** Info
- **Category** Suboptimal
- **Source** Parameters.sol

Recommendation This line could be simplified as: r = _loaduint256(memo_native_amount_pos) » 192;
Client Comment Will not fix.

Listing 24:

```
174 r = _loaduint256(memo_native_amount_pos+memo_native_amount_size
    ↪ -32) & memo_native_amount_mask;
```

3.25 CVF-25

- **Severity** Minor
- **Status** Info
- **Category** Suboptimal
- **Source** Parameters.sol

Recommendation This line could be simplified as: r = address(uint160(_loaduint256(memo_receiver_pos) » 96));
Client Comment Will not fix.

Listing 25:

```
181 r = address(uint160(_loaduint256(memo_receiver_pos+
    ↪ memo_receiver_size-32)));
```

3.26 CVF-26

- **Severity** Minor
- **Status** Info
- **Category** Unclear behavior
- **Source** Parameters.sol

Description This silently drops the leftmost 28 bytes of the pool ID. If these bytes are always zero, consider changing the pool ID type to "uint32".
Client Comment Will not fix, _pool_id assumed to be uint24 (range check implemented in the constructor).

Listing 26:

```
202 r[3] = _transfer_delta() + (_pool_id()<<(transfer_delta_size*8))
    ↪ ;
```

3.27 CVF-27

- **Severity** Minor
- **Status** Fixed
- **Category** Readability
- **Source** Parameters.sol

Description This should be ‘S_MAX‘

Listing 27:

```
219 uint256(s) <= 0
    ↪ x7FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF5D576E7357A4501DDFE92F46681B20A0
    ↪ ,
```

3.28 CVF-28

- **Severity** Moderate
- **Status** Info
- **Category** Flaw
- **Source** Parameters.sol

Description This will return 0 for invalid signature.
Recommendation Consider reverting in this case. Not reverting here allows anyone to sign anything on behald of the zero address.
Client Comment Will not fix. Zero address cannot grant to the pool anything to spent.

Listing 28:

```
223 return ecrecover(prefixedHash, v, r, s);
```

3.29 CVF-29

- **Severity** Minor
- **Status** Fixed
- **Category** Procedural
- **Source** Pool.sol

Description Should be "^0.8.0" unless there is something special about this particular version.

Listing 29:

```
2 pragma solidity ^0.8.10;
```

3.30 CVF-30

- **Severity** Minor
- **Status** Info
- **Category** Procedural
- **Source** Pool.sol

Description We did not review this file
Client Comment Will not fix.

Listing 30:

```
8 import "./consensus/IOperatorManager.sol";
```

3.31 CVF-31

- **Severity** Minor
- **Status** Fixed
- **Category** Procedural
- **Source** Pool.sol

Description This interface should be moved to a separate file named "ITransferVerifier.sol".

Listing 31:

```
12 interface ITransferVerifier {
```

3.32 CVF-32

- **Severity** Minor
- **Status** Info
- **Category** Procedural
- **Source** Pool.sol

Description This constant should relate to ‘transfer_proof_size‘
Client Comment Will not fix.

Listing 32:

```
15 uint256[8] memory p
```

3.33 CVF-33

- **Severity** Minor
- **Status** Fixed
- **Category** Procedural
- **Source** Pool.sol

Description This interface should be moved to a separate file named "ITreeVerifier.sol".

Listing 33:

```
19 interface ITreeVerifier {
```

3.34 CVF-34

- **Severity** Minor
- **Status** Info
- **Category** Procedural
- **Source** Pool.sol

Description This constant should relate to ‘tree_proof_size‘
Client Comment Will not fix.

Listing 34:

```
22 uint256[8] memory p
```

3.35 CVF-35

- **Severity** Minor
- **Status** Fixed
- **Category** Procedural
- **Source** Pool.sol

Description This interface should be moved to a separate file named "IMintable.sol".

Listing 35:

```
26 interface IMintable {
```

3.36 CVF-36

- **Severity** Minor
- **Status** Info
- **Category** Documentation
- **Source** Pool.sol

Description The semantics of the returned value is unclear.
Recommendation Consider documenting.
Client Comment Will not fix.

Listing 36:

```
27 function mint(address,uint256) external returns(bool);
```

3.37 CVF-37

- **Severity** Minor
- **Status** Info
- **Category** Bad naming
- **Source** Pool.sol

Recommendation Variables are usually named inCamelCase.
Client Comment Will not fix.

Listing 37:

```
33 uint256 immutable public pool_id;

35 IMintable immutable public voucher_token;

37 uint256 immutable public energy_denominator;
   uint256 immutable public native_denominator;
   ITransferVerifier immutable public transfer_verifier;
40 ITreeVerifier immutable public tree_verifier;

42 uint256 immutable internal first_root;

55 uint256 public pool_index;
   bytes32 public all_messages_hash;
```

3.38 CVF-38

- **Severity** Minor
- **Status** Info
- **Category** Readability
- **Source** Pool.sol

Recommendation For readability, consider explicitly initializing this variable to zero.
Client Comment Will not fix.

Listing 38:

```
55 uint256 public pool_index;
```

3.39 CVF-39

- **Severity** Minor
- **Status** Info
- **Category** Bad datatype
- **Source** Pool.sol

Description Consider using the "uint32" type for pool ID.
Client Comment Will not fix. We have already MAX_POOL_ID check and it is uint24.

Listing 39:

```
33 uint256 immutable public pool_id;

44 uint256 constant internal MAX_POOL_ID = 0xffffff;

60 constructor(uint256 __pool_id, IERC20 _token, IMintable
   ↪ _voucher_token, uint256 _denominator, uint256
   ↪ _energy_denominator, uint256 _native_denominator,
```

3.40 CVF-40

- **Severity** Minor
- **Status** Info
- **Category** Bad datatype
- **Source** Pool.sol

Description This constant would be redundant in case the "uint32" type would be used for pool IDs.
Client Comment Will not fix.

Listing 40:

```
44 uint256 constant internal MAX_POOL_ID = 0xffffff;
```

3.41 CVF-41

- **Severity** Minor
- **Status** Info
- **Category** Documentation
- **Source** Pool.sol

Description The semantics of the keys in these mappings is unclear.
Recommendation Consider documenting.
Client Comment Will not fix.

Listing 41:

```
53 mapping (uint256 => uint256) public nullifiers;
   mapping (uint256 => uint256) public roots;
```

3.42 CVF-42

- **Severity** Minor
- **Status** Info
- **Category** Readability
- **Source** Pool.sol

Description These variables are used without being initialized.
Recommendation Consider initializing explicitly in the constructor.
Client Comment Will not fix. These variables initialized with zero value.

Listing 42:

```
55 uint256 public pool_index;
   bytes32 public all_messages_hash;
```

3.43 CVF-43

- **Severity** Minor
- **Status** Info
- **Category** Unclear behavior
- **Source** Pool.sol

Description There are no range checks for denominator arguments.
Recommendation Consider adding appropriate checks. E.g. ensure that the denominators are not zero.
Client Comment Will not fix.

Listing 43:

```
60 constructor(uint256 __pool_id, IERC20 _token, IMintable
   ↪ _voucher_token, uint256 _denominator, uint256
   ↪ _energy_denominator, uint256 _native_denominator,
```

3.44 CVF-44

- **Severity** Minor
- **Status** Info
- **Category** Suboptimal
- **Source** Pool.sol

Description The function always returns true.
Recommendation Consider returning nothing.
Client Comment Will not fix.

Listing 44:

```
93 function transact() external payable returns(bool) {
```

3.45 CVF-45

- **Severity** Minor
- **Status** Info
- **Category** Procedural
- **Source** Pool.sol

Description This function should probably emit an event
Client Comment Will not fix.

Listing 45:

```
75 function initialize() public initializer{
       roots[0] = first_root;
```

3.46 CVF-46

- **Severity** Minor
- **Status** Info
- **Category** Unclear behavior
- **Source** Pool.sol

Description Consider reverting if the retrieved value is 0
Client Comment Will not fix. zkSNARKs cannot be proved with zero root hash.

Listing 46:

```
82 return roots[pool_index];

86 return roots[_transfer_index()];
```

3.47 CVF-47

- **Severity** Minor
- **Status** Info
- **Category** Documentation
- **Source** Pool.sol

Description It is worth documenting what exactly these proofs verify and which contract variables are involved.
Client Comment Will not fix.

Listing 47:

```
95 require(transfer_verifier.verifyProof(_transfer_pub(),
     ↪ _transfer_proof()), "bad transfer proof");

137 require(tree_verifier.verifyProof(_tree_pub(), _tree_proof()), "
     ↪ bad tree proof");
```

3.48 CVF-48

- **Severity** Minor
- **Status** Info
- **Category** Suboptimal
- **Source** Pool.sol

Description The expression "_transfer_nullifier()" is calculated twice.
Recommendation Consider calculating once and reusing.
Client Comment Will not fix. CALLDATALOAD cost 3 gas, and we does not use stack slots for all variables.

Listing 48:

```
96  require(nullifiers[_transfer_nullifier()]==0,"doublespend
        ↪ detected");

133 nullifiers[_transfer_nullifier()] = (1<<255) | (uint64(
        ↪ _transfer_token_amount()) << 160) | (uint112(
        ↪ _transfer_energy_amount()) << 48) | _pool_index;
```

3.49 CVF-49

- **Severity** Minor
- **Status** Info
- **Category** Overflow/Underflow
- **Source** Pool.sol

Description Overflow is possible here for the uint256 type of ‘fee‘.
Recommendation Consider using a shorter type for fee.
Client Comment Will not fix. token_amount is uint64

Listing 49:

```
101 int256 token_amount = _transfer_token_amount() + int256(fee);
```

3.50 CVF-50

- **Severity** Minor
- **Status** Info
- **Category** Suboptimal
- **Source** Pool.sol

Description The expression "_transfer_token_amount()" is calculated twice.
Recommendation Consider calculating once and reusing.
Client Comment Will not fix. CALLDATALOAD cost 3 gas, and we does not use stack slots for all variables.

Listing 50:

```
101 int256 token_amount = _transfer_token_amount() + int256(fee);

133 nullifiers[_transfer_nullifier()] = (1<<255) | (uint64(
    ↪ _transfer_token_amount()) << 160) | (uint112(
    ↪ _transfer_energy_amount()) << 48) | _pool_index;
```

3.51 CVF-51

- **Severity** Minor
- **Status** Info
- **Category** Suboptimal
- **Source** Pool.sol

Description The expression "_transfer_energy_amount" is calculated twice.
Recommendation Consider calculating once and reusing.
Client Comment Will not fix. CALLDATALOAD cost 3 gas, and we does not use stack slots for all variables.

Listing 51:

```
102 int256 energy_amount = _transfer_energy_amount();

133 nullifiers[_transfer_nullifier()] = (1<<255) | (uint64(
    ↪ _transfer_token_amount()) << 160) | (uint112(
    ↪ _transfer_energy_amount()) << 48) | _pool_index;
```

3.52 CVF-52

- **Severity** Minor
- **Status** Info
- **Category** Bad datatype
- **Source** Pool.sol

Description There should be named constants for the valid transaction types.
Client Comment Will not fix.

Listing 52:

```
104 if (_tx_type()==0) { // Deposit

107 } else if (_tx_type()==1) { // Transfer

110 } else if (_tx_type()==2) { // Withdraw
```

3.53 CVF-53

- **Severity** Minor
- **Status** Info
- **Category** Suboptimal
- **Source** Pool.sol

Description The expression "_memo_receiver()" is calculated several times.
Recommendation Consider calculating once and reusing.
Client Comment Will not fix. CALLDATALOAD cost 3 gas, and we does not use stack slots for all variables.

Listing 53:

```
114 token.safeTransfer(_memo_receiver(), uint256(-token_amount)*
    ↪ denominator);

119 voucher_token.mint(_memo_receiver(), uint256(-energy_amount)*
    ↪ energy_denominator);

123 payable(_memo_receiver()).transfer(msg.value);
```

3.54 CVF-54

- **Severity** Moderate
- **Status** Info
- **Category** Flaw
- **Source** Pool.sol

Description This check makes it impossible to withdraw in case the voucher token is not set and a deposit has non-zero energy amount.
Recommendation Consider implementing some way to withdraw in such a case.
Client Comment User could keep energy amount inside the pool or burn it. Will not fix.

Listing 54:

```
118 require(address(voucher_token)!=address(0), "no voucher token");
```

3.55 CVF-55

- **Severity** Moderate
- **Status** Fixed
- **Category** Flaw
- **Source** Pool.sol

Description The returned value is ignored. the exact semantics of the returned value is unclear, but if it is the error indicator, then consider reverting in case the returned value is false.
Recommendation Consider using "send" instead and protect against reentrancy in some other way..

Listing 55:

```
119 voucher_token.mint(_memo_receiver(), uint256(-energy_amount)*
    ↪ energy_denominator);
```

3.56 CVF-56

- **Severity** Minor
- **Status** Fixed
- **Category** Flaw
- **Source** Pool.sol

Description Using "transfer" is discouraged, as operation gas costs could change in the future, and operation that fit in 2300 gas in the past a not guaranteed to fit going forward.

Listing 56:

```
123 payable(_memo_receiver()).transfer(msg.value);
```

3.57 CVF-57

- **Severity** Critical
- **Status** Fixed
- **Category** Flaw
- **Source** Pool.sol

Description Reentrancy attack is possible, as the nullifier is marked after calling external contracts. Note, that some token contracts, namely those implementing ERC-777, may call hook on receiving smart contracts, making simple token transfer unsafe from the reentrancy point of view.
Recommendation Consider calling external contracts after updating the state and/or implementing some other kind of reentrancy protection.

Listing 57:

```
133 nullifiers[_transfer_nullifier()] = (1<<255) | (uint64(
    ↪ _transfer_token_amount()) << 160) | (uint112(
    ↪ _transfer_energy_amount()) << 48) | _pool_index;
```

3.58 CVF-58

- **Severity** Minor
- **Status** Fixed
- **Category** Bad datatype
- **Source** Pool.sol

Recommendation The value "128" should be a named constant.

Listing 58:

```
139 _pool_index +=128;
```

3.59 CVF-59

- **Severity** Minor
- **Status** Fixed
- **Category** Documentation
- **Source** Pool.sol

Description It is unclear why the pool index is incremented by 128 here.
Recommendation Consider documenting.

Listing 59:

```
139 _pool_index +=128;
```

3.60 CVF-60

- **Severity** Minor
- **Status** Fixed
- **Category** Suboptimal
- **Source** Pool.sol

Description The function always returns true.
Recommendation Consider returning nothing.

Listing 60:

```
150 return true;
```